

Tammy Plotner

The Night Sky Companion

A Yearly Guide to Sky-Watching 2009

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Astronomy
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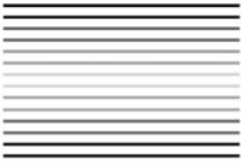
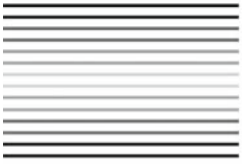
Astronomy with a Home Computer

Neale Monks

More Small Astronomical Observatories

Sir Patrick Moore (Ed.)

(Continued after Index)



**The Night Sky
Companion:
A Yearly Guide to
Sky-Watching
2009–2010**

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 Springer

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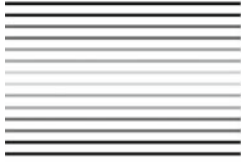


Star-Splitter (credit—Joe Orman).

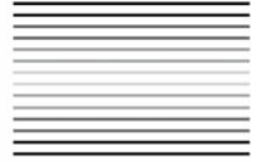
"The best thing that we're put here for's to see;
The strongest thing that's given us to see with's
A telescope"

...

I recollect a night of broken clouds
And underfoot snow melted down to ice,
And melting further in the wind to mud.
Bradford and I had out the telescope.
We spread our two legs as we spread its three,
Pointed our thoughts the way we pointed it,
And standing at our leisure till the day broke,
Said some of the best things we ever said.
That telescope was christened the Star-Splitter
—Robert Frost



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Acknowledgments

“When one has weighed the Sun in balance, and measured the steps of the Moon, and mapped out the seven heavens, there still remains oneself.”

“Who can calculate the orbit of his own soul?”

...

“We are all on our backs in the gutter, only some of us are looking at the stars.”

—Oscar Wilde

Throughout the years, it has been my great pleasure and privilege to know many professional and amateur astronomers. I have been inspired by countless books, magazines, and programs, and have spent years of starry nights at the eyepiece in study. It is a combination of all of these things that makes this book what it is. And makes me who I am.

For all of you out there, I thank you. Your support and kind words have made a dream come true. Now let me thank the people who made it come about.

Ricardo Borba is an amateur astronomer living in Ottawa, Ontario, and a member of the Royal Astronomical Society of Canada. Between observing sessions, he is an application software engineer at Natural Convergence. His photographic skills are becoming highly acclaimed, and his work is featured in various publications. www.borba.com

Alan Chu As a resident of Hong Kong, Alan might joke that the Moon is all he can observe thanks to light pollution, but Alan’s work is no laughing matter. He has produced one of the finest amateur photographic atlases of the Moon available, and it is a great honor to include his fine photography in these pages. www.alanchuhk.com

John Chumack With over 500 of his images published in such notable periodicals as *Science*, *National Geographic*, *Discover*, *Time*, and *Newsweek*, John has taken astrophotography to the realm of an art form. While you will find his work in fine art exhibitions, you will also find John busy as a serious astronomer—contributing to the Minor Planet Center



NGC 1579—(credit—R. Jay GaBany).

and studying lunar transient phenomena. With Chumack Observatories located in both Dayton and Yellow Springs, John is an active member of the Miami Valley Astronomical Society and helps to fund his research through image sales. www.galacticimages.com

R. Jay GaBany Born at the dawn of the Space Age, R. Jay GaBany has come of age during a time when humankind's fascination with the great mysteries beyond our home planet has surged. His interest in astronomy started at an early age, sparked by the *Apollo* moon landing program. While Neil Armstrong and Buzz Aldrin were bouncing around on the lunar surface, Jay was in his backyard observing the Moon through his first small refractor. But it was Carl Sagan's vision that ignited his adult enthusiasm for astronomy when the TV show "Cosmos" debuted, and shortly thereafter, he acquired his first 8" Schmidt-Cassegrain telescope. Today, his images are taken both from his light-polluted backyard using a portable 12" telescope and remotely, using Internet control, with a 20" reflector from a dark location in the south-central mountains of New Mexico. www.cosmotography.com

Wes Higgins Wes' interest in space and astronomy started while watching the first U.S. manned space shot on television. He continued to follow with great interest the NASA space program all the way through the *Apollo* Moon landings. While growing up, he yearned for a telescope, but the thought lay dormant through college, marriage, and the start of his own business. Eleven years ago his dream came true and, as he says, "I am sure that for the rest of my life I will be out observing and imaging every chance I get." <http://higginsandsons.com/astro>

International Occultation Timing Association (IOTA) Many thanks go to the International Occultation Timing Association for their OCCULT Ephemeris 3.6.0 freeware, which provided a look into this year's Solar System events. <http://www.lunar-occultations.com/iota/>

Greg Konkell Greg has many interests, among them astronomy and photography. Having recently made the transition from film to digital cameras, he is enthused about the potential of this new technology and has focused his attention lately on integrating these two interests. The purpose of his web site is twofold: to make a contribution regarding the technical issues surrounding digital astrophotography, and to share some of the best images he has acquired—both astronomical and general photographic. www.nwgis.com/greg

National Aeronautics and Space Administration (NASA) NASA explores. NASA discovers. NASA seeks to understand. But most of all, NASA shares. I would like to thank those good folks for providing all the wonderful resources available to amateur astronomers, and I express my personal thanks for the use of many archival photographs, illustrations, and other materials seen here. www.nasa.gov

Joe Orman As a hiker, biker, climber, caver, rock hound, and ghost-towner, Joe has been exploring and photographing the special places of the Southwest for more than 30 years. His sky shots are truly where photography and astronomy meet—in the middle ground between art and science. His list of credits is amazing, and the name Joe Orman has accompanied photographs in literally dozens of prestigious publications. . . and it is with great pride that his work is included here. <http://joorman.shutterstock.com/Gallery.html>

Palomar Observatory/Caltech I cannot adequately express my gratitude toward Palomar Observatory and Caltech for the use of the POSS II Sky Survey images that you see in many places throughout this book. Although amateur photography has come a long way over the years, no one can surpass this huge database of images. I would also like to thank Linda Buestos for helping me obtain permission to use and present them to you. May their use as illustrations inspire you, as much as their research has inspired me. My many, many thanks. www.astro.caltech.edu/palomar

US Naval Observatory (USNO) Some of the Solar System information found here is credited to the United States Naval Observatory's Multiyear Interactive Computer Almanac (MICA 3.0). Many thanks for their kind permission to use this software for this book. www.usno.navy.mil

Ken Vogt There is no one to whom I owe a deeper debt of gratitude than to my editor, Ken. By conventional standards, he swears his life has not been that successful, but he is more talented than he will admit. Living modestly in southern Indiana, he was able to retire from various menial employments in 1991 at age 45, but he's far from "retired." Since that time, Ken pursued his love of music (playing keyboards) and fascination (and frustration) with computers. Although the bright sky in his hometown has prevented any serious sky-watching, he is a devotee of astronomy.

Ken's help has been critical to the publication of this book. He has graciously spent uncounted hours reading text and offering advice. His encouragement through some rough times has been instrumental in the book's completion, and his support has kept me on track. Mr. Vogt is truly one of the bright stars in my sky.

Roger Warner Roger Warner lives in the UK in a town called Basildon in Essex. His interest in astronomy began 7 years ago, but the last 2 years have been dedicated to learning the art of

imaging. The Moon and planets were his starting point—images taken with a low-cost camera, which he still uses to this day.

The Moon became Roger's main challenge—waiting for moments of good seeing and grabbing those hidden secrets within. He began to get in close to capture those jaw-dropping pictures of the Moon's craters, valleys, and mountains. With the introduction of a modified webcam, he soon moved onto deep sky, learning the process all over again. His greatest wish is that the images he has produced will inspire others "to progress as well in this wonderful hobby." www.lupas.pwp.blueyonder.co.uk/rwnewastro/lunar.htm

My deepest appreciation goes once again to all of these fine folks and astronomers. May we all shine on. . .

—Tammy Plotner

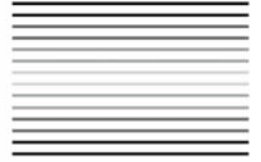
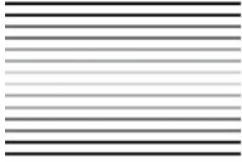


About the Author

An Ohio native, Tammy Plotner has spent many years with various telescopes and binoculars, both learning and teaching about the night sky. She is President of Warren Rupp Observatory, Executive Secretary of the Astronomical League, a founding member of Astronomy for Youth, a presenter and coordinator for the Night Sky Network, and a JPL/NASA Space Place editor and outreach speaker. Tammy is both friend and mentor to many astronomy groups, as well as an author of several popular books and articles, and she is a contributing author for the Astronomical League's *Reflector* magazine as well as a staff writer for *Universe Today*.

Although she loves viewing the distant cosmos with the observatory's 31" telescope, she is equally at home with a small refractor, and every size and type of telescope in-between. She has won numerous observing awards and was the first woman astronomer to achieve Comet Hunter's Gold status. She credits her love of science and the natural world to her parents and family, whose love and support has made her realize that dreams really do come true when you keep on reaching for the stars!

Although she finds writing about herself in the first person rather spooky, you'll find her friendly face at star parties, at every public outreach program, speaking at colleges and libraries, traveling to distant astronomy clubs, and right here in her own backyard doing what she loves best...looking at the stars. <http://theastronomer.tripod.com>



Welcome, fellow traveler to the stars! For the next year we will take a journey together across the night sky. In these pages you will find lunar features, planets, meteor showers, single and multiple stars, open and globular clusters, as well as distant galaxies. There will be astronomy history to explore, famous astronomers to meet, and science to learn. You'll find things here for those who enjoy stargazing with just their eyes, binoculars, or even the largest of telescopes!

Although these observing tips are designed with all readers in mind, not everyone lives in the same time zone—or the same hemisphere—and certainly no one has clear skies every night. But no matter where you live, or who you are, it is my hope that somewhere here you find something of interest to keep you looking up!

Learning the Night Sky

If you are new to astronomy, it might seem difficult to learn all those stars. Relax! It's much easier than you think. Just like moving to a new city, everything will seem unfamiliar at first, but with a little help from some maps, you'll soon be finding your way around like a pro. Once you become familiar with the constellations and how they appear to move across the night sky, the rest is easy.

If you do not have maps of your own, try visiting your local library or one of many online sites that can generate them. They give object positions in great detail, and most have a key of Greek letters to help you understand star hop instructions. Constellation charts are oriented by holding the map over your head, and star charts are printed with north up and east to the left.

These charts and maps also contain simple means of understanding relative positions and sizes in the sky. In some instances, you will find that the directions to certain objects include terms such as "handspan" or "finger-width." But what exactly do these terms mean? A *handspan* is measured from the tip of your little finger to the tip of your thumb when your arm is outstretched and covers about 20 degrees of sky. A *fist-width* is the width of your closed hand at arm's length, and covers around 10 degrees, while a *finger-width* is around 2 degrees. This type of instruction isn't foolproof, but it will help you find the right area to begin. Just remember that an object's relative direction will always remain the same. For example, southwest of Alpha will always be southwest of Alpha, no matter if a constellation is rising or setting.

Observing Equipment

Although we'd love to tell you which binoculars or telescope is perfect for you, we can't! Every person uses equipment differently and under different circumstances. But we can offer some guidelines. Let's start with binoculars.

Anyone remotely interested in the night sky should own a pair of binoculars—even if they are only inexpensive ones. They will never reveal the heavens in as much detail as a telescope, but their availability, ease of use, and portability make them a perfect companion. It takes no effort to aim them toward the stars and begin! But which ones? The very best size for astronomy are 7×50 and 10×50 models of the porro prism design, but even modest 5×30 models reveal a wealth of sky objects. It might be tempting to get a "monster" model, but large binoculars require a mount. There is no recommended brand, but when purchasing keep in mind they might be dropped or lost.

Don't be afraid to try binoculars before purchasing. They should be comfortable to hold, and when you look through the eyepieces, the field should be evenly illuminated. When looking into the main lens, white reflections mean poorly coated optics, while deep purple and green reflections indicate higher quality. Better models will have a right diopter adjustment, and check to see that both sets of lenses are well-collimated (no double images). As long as you're careful about comfort and clear optics, you're sure to enjoy these hand-held "twin" telescopes!

Now let's move onto telescopes. There are three basic designs. The refractor uses a lens to gather light, the reflector uses a mirror, and the catadioptric uses both. No matter which style you prefer, the goal is light-gathering ability—not magnification. The larger the aperture (diameter), the more light

the scope gathers and the more power it has to resolve objects. Stay away from small telescopes you see in department stores and most camera shops; these are almost invariably of low quality, and for about the same amount of money you can purchase a fine telescope that will give you years of use.

The refracting telescope is favored by those who enjoy high-power views of terrestrial subjects, as well as of the Moon and planets, and it provides suitable light-gathering ability for studying many deep sky objects. Because the eyepiece is located at the end of the scope, it is often necessary to use a right-angle attachment—called a star diagonal—to put the eyepiece in a comfortable location. Although many people claim a refractor is superior for seeing details, keep in mind that this style may put you in some very uncomfortable positions!

The reflecting telescope is the instrument of choice for deep-sky observing. A large aperture is far more affordable, and the performance on lunar and planetary objects is more dependent on the quality of the optics and seeing conditions rather than the design. With the eyepiece located on the top side of the body of the telescope, this type of telescope is primarily used by observers who prefer to stand. Even the smallest (4.5") reflector will provide enough deep-sky studies to keep the average sky watcher entertained for a lifetime! Do they have a flaw? Yes. With large aperture also comes large size, and portability may become an issue. Do not let the word "collimation" frighten you. It is just the act of occasionally adjusting the primary mirror and is no different from tuning a guitar.

The catadioptric design should thereby fulfill the best of both worlds, shouldn't it? The answer is yes—but it still doesn't come without drawbacks. This style telescope is very expensive and prone to dew up without preventative measures.

Now let's talk about mounts. There are three basic designs—the altazimuth, the equatorial, and the dobsonian. The *altazimuth* swings left/right and up/down—and requires manual adjustment to track the sky. These inexpensive and easy to use mounts are best suited to small refractors. The *equatorial* design moves in right ascension and declination—the proper movement and angle on the sky. When aligned to the pole, they only require a slight turn of a slow motion control to track and are capable of being fitted with automatic tracking devices. They come in a variety of weights and sizes suitable for any type telescope, and almost all come equipped with setting circles. The last type of mount is the *dobsonian*. Much like the altazimuth, it moves up, down, and side-to-side—but requires no tripod. It is nothing more than a simple, well-balanced rocker box. With small aperture dobs, this inexpensive design gives you total freedom to travel with your scope, but plan on having a backache while using it. Conversely, larger models have a more comfortable viewing position but lack portability.

So, how to choose?

You must ask yourself what type of observing you enjoy most and what scope meets your needs—and budget. There is no point in buying a large dobsonian if you need to travel to a dark-sky location to use it. You'll never be happy with a small refractor if you have dark skies outside your back door and an itch to galaxy hunt. I own models of every type, and there's a purpose for each one:

The small refractor (4") and its easy, lightweight mount is the perfect companion for travel. It's simple to carry, simple to set up, and provides great views—but not for everything I want to see. Its GoTo function is a wonderful aid when speed is of the essence, and its tracking feature makes it invaluable for doing outreach programs.

The small reflectors (4.5") are the workhorses of my fleet. They provide great lunar, solar, and double star views—along with the capability of capturing all the Messier objects and a goodly portion of the New General Catalog (NGC) targets. They are lightweight, portable enough, and I usually have at least two of the three I own always fully assembled and ready to be set outside at a moment's notice. They are all fine performers, but... I could still wish for just a little bit more.

The mid-size catadioptric (6") scope is more tedious set up, but it gives outstanding lunar and planetary views. It resolves tough double stars and provides crisp resolution on most star clusters. If astrophotography were a goal of mine, this would be the scope I would choose. But, given the telescope's expense, it's usually carefully packed away and seldom used on a whim.

The larger equatorially mounted reflector (8") is a superb tool for low surface brightness objects. With its big light grasp and resolution, this is a very fine scope with which to spend an evening—or many! It's fairly easy to transport, a little difficult to set up, but the views are worth the time and

effort. If I need a portable aperture, this is the one I choose. But it still can't quite reach those faint galaxies.

The dobsonian model (12.5") is my study scope. Far too large to be even remotely considered portable, it spends its life on a self-built mobile transporter nicknamed the "Grasshopper." Although newer models are much lighter, this scope needed a way of moving it from storage to an outdoor observing area without killing its owner. Once I had designed a way of getting it to the backyard with ease, the whole vista of the heavens opened up. Now I was able to totally resolve clusters, study very faint galaxies, home in on lunar and planetary features, and split intense double stars. The dobsonian design left me with total freedom of movement, and, after more than a decade of use, I have still not seen everything this scope is capable of. Of course, I have ridiculously large aperture at my disposal as well, but the 31" is housed in a professional observatory, and what it "sees" is almost unfair compared to backyard equipment! And now for the next major issue. . .

To "GoTo" or Not to "GoTo"

Again, this is a matter of personal preference. But you may be doing yourself a disservice by not learning to manually aim a telescope at an object. There is great joy to be had in studying the sky and finding a distant galaxy using nothing more than a map and your own two hands. So many folks have these wonderful systems gathering dust because they found out they require perfection in positioning as well as basic sky knowledge to use. Regardless of the claims of how many objects a database contains, only experience will tell you how many of these objects can be seen with your scope and under your sky conditions!

But do not be dismayed. There is also a beauty in these systems. For those with limited observing time, a GoTo telescope only takes a little learning to use. Many such systems are also able to identify objects by their coordinates, so they do have their good points.

And so, we come to eyepieces.

The bottom line is that you get what you pay for. A highly expensive eyepiece will not turn a bad telescope into a good one, but it will turn a good telescope viewing into an awesome experience. Our best advice is to start with mid-priced optics and a limited variety of sizes. A 32-millimeter eyepiece is great for wide-field views and locating objects. A 25-millimeter or 17-millimeter is fantastic for most studies. The 12- millimeter, 10- millimeter, and 5- millimeter eyepieces are the powerhouses. However, on a telescope without a drive unit, they provide so much magnification as to be uncomfortable. Like fishing lures in a tackle box, you will find yourself collecting a variety of eyepieces over the years—and each will favor certain uses. Only experimentation will provide the eyepieces that are right for you and for your telescope.

Now for Accessories

These are the fun things to have, but none of them is necessary to practice astronomy: a sturdy case, a barlow lens, a set of basic color filters, a Moon filter, a polarizing filter, and a nebula filter. Optics cleaning kits are great, but a word to the wise—don't stress about sparkling clean optics. Unless your primary is more than 20% obstructed, cleaning will probably do more harm than good. Condensation marks and dust will not stop you from observing!

The very best accessories are a comprehensive Moon map, an easy to read sky chart, a watch, a pad of paper, a mechanical pencil, and a red flashlight. They are the most important things you will ever use. Although basic photographic lunar maps are provided here, you may find charts you prefer. Although note keeping is not a necessity, it is highly recommended. Basic sketches are easy to do, and you'll refer to your own notes often. Keep track of what you do, what you use, and when you see it. There are many fine observing programs offered through the Astronomical League and other organizations that provide awards for your study. And who knows? You just might discover something new!

What to Observe

The Moon

Let's start with one of the easiest to find yet most rewarding objects to study—the Moon. Its rugged craters, high mountains, and vast “seas” offer some of the finest details observable in any astronomical target. It changes every night as the terminator—the line between sunset and shadow—progresses over the surface, revealing new details.

Unlike a star chart, Moon feature locations are based on lunar topography and not our Earthly cardinal directions. Although, these pages outline what features should be visible on any given night, the position of the terminator may be slightly different for viewers in various time zones. Let's start by discussing how and when the Moon can be seen.

The Moon and Earth both rotate at exactly the same speed, so we will always see the same “side.” Yet its elliptical orbit causes a kind of “wobble” referred to as “libration.” There may be times when you can see just a bit more along the Moon's limb—the visible edge. When the Moon's orbit carries it between Earth and the Sun, it is referred to as the New Moon. It's still there, but we cannot see it.

As its orbit progresses, the Moon slowly moves to its first position, appearing in the night sky just after the Sun sets. The sunlight on the lunar surface will begin its march, progressing from lunar east to lunar west. At either pole is the area called the cusp, which is the tip of the curve where the terminator ends. The progression of light is called the “waxing” phase.

When the Moon reaches its second position, it is directly opposite the Sun in our sky and the surface is totally illuminated—Full Moon. At this time, Earth is between the Sun and the Moon. Most of the time, the Moon's orbit will either carry it north or south of Earth's shadow, but about every 6 months it will slip inside that shadow and a lunar eclipse will occur. When it passes only partially into the cone of shadow, it is known as a penumbral eclipse, and when it is directly aligned, it is called a “full” or umbral eclipse.

Now the Moon is heading toward its third position and moving back toward the Sun. It will rise later each night, and the terminator will progress across the surface in the same direction—east to west—but this time the features will be seen at lunar sunset instead of sunrise! This is known as the “waning” phase. The Moon will become slimmer each night as it heads toward the rising Sun.

At first, the lunar landscape will look quite confusing, but keep in mind that lunar north has fewer craters than lunar south. As you study the Moon from month to month, craters will become more familiar to you, and it won't be long until you know their names and can often tell what features will be visible—without even looking!

The Planets

Just like the Sun and Moon, the planets dance along an orderly path in the sky known as the ecliptic plane. Their progression against the background stars will seem slowest when they are the furthest away. During an observing season, we may watch as Earth overtakes a planet, much like running past an object on a racetrack. As we approach it, it will seem to slow down, stand still, and then move backward as we go by. Once we have passed, it will then appear to resume forward motion.

Since Mercury and Venus are on the inside track of our racecourse, they orbit far more quickly than the outer planets do. They will always appear just ahead of the rising Sun, or just after the setting Sun, and like our Moon, will go through phases as they progress in their orbits.

Mars, Jupiter, and Saturn are three of the most highly observed planets, and at times, can offer up wonderful details to the telescope. But do not be disappointed if you do not see fantastic things on your first night out! There are many things to consider when viewing these planets. For example, you need to consider their distance from Earth at any given time and the effect of our own atmosphere on observing conditions. Do not be discouraged! Large binoculars and the smallest of telescopes will reveal Jupiter's equatorial bands and clockwork movement of the four Galilean Moons—even the

rings of Saturn! As aperture—the size of the optics—increases, so does the amount of detail that you can see. But, even the largest of telescopes cannot compensate for poor viewing conditions! The outer planets—Uranus and Neptune—also follow the ecliptic plane. Both Uranus’s and Neptune’s movements can be followed with binoculars, but even large telescopes offer little detail, due to their great distance.

Night Lights

Of course, there are other things within our own Solar System that we can easily study, such as asteroids, comets, and satellites. Given the nature of this book—which was created with limited use of a planetarium program—these types of observations are best undertaken with the aid of either software or magazines such as *Sky and Telescope* or *Astronomy*. There are also online tools available to assist you. You will find many of these listed in the *Resources* section of this book.

You’ll also have a chance to enjoy meteor showers throughout this observing year! While the dates that we pass through these cometary debris streams are predictable, the fall rates—the estimated amount that can be seen in a given time—are not. As a rule of thumb, you can see any given meteor shower from either hemisphere if you can see the constellation of the radiant, the general area from which they appear to originate. Keep in mind that ambient light (from the Moon or your location) plays a huge role in how many meteors can be seen, and the darker the skies, the better your chance for success.

Deep Sky

This is the term given to objects residing outside our Solar System. These include single stars, multiple-star systems, open or “galactic” star clusters, globular clusters, nebulae, and distant galaxies. Although many of these objects are within reach of small binoculars, just as many reside at the outer limits of the capabilities of a large telescope. It wouldn’t be such a delightfully challenging hobby if everything were easy!

There are a few things to keep in mind as you begin exploring deep sky, and the most important item is sky conditions. Even the largest of telescopes will have difficulty catching a faint galaxy through light-polluted skies or during poor atmospheric conditions (bad seeing). Nothing is a better teacher than experience, and it won’t be long before you learn what your equipment is capable of.

For example, from a dark-sky site with a favorable atmosphere, it is entirely possible to see the majority of the Messier catalog of objects with a pair of 5×30 binoculars, or even some objects with just the unaided eye. But binoculars are not the Hubble Telescope, and you need to understand what you might expect to see! A nebula will appear as a faint glowing cloud, a globular cluster as a round contrast change, and a star cluster as a “patch” of concentration. None of these will be particularly large given the fact that binoculars offer a wide field of view and little magnification. Yet, how wonderful it is that such simple equipment will allow you to view things so many light-years away!

A small-to-large telescope will increase the light grasp, and you’ll see progressively fainter and fainter objects—and in greater detail. Instead of a round “smudge” when looking at a globular cluster, individual stars will appear. A single bright star will reveal its tiny companion, nebulae will unfold, and the light of distant galaxies suddenly will become much closer. But all of this is dependent on one single thing—sky conditions. You cannot expect a small telescope to reveal an 11th magnitude galaxy, yet with the right conditions, it is possible for it to reach beyond its theoretical limitations. Do not stop trying because you’ve had a few disappointments—learning comes with time. The eye must be trained to discern very faint things, and the best advice we can offer are the three “P”s for success: Practice, Patience, and Persistence.

If you are having problems with something, improvise. If the equatorial mount on your telescope puts you in an awkward position, pick it and turn it around. If your small dobsonian telescope is hard on your back, set it up on something! If the legs on the tripod are too high or you can’t stand for a long period of time, lower them and find a stool. If you live in a light-polluted area, it won’t stop your

exploration of the Moon and the planets and perhaps there will be a time that will allow you to get away to a dark-sky location.

The telescope that is loved the most is the one that gets used. If at all possible, consider keeping it fully assembled in a spot where it may be set outside at a moment's notice, such as in a garage, an outdoor shed, or near a door. You will be far more likely to spend 15 minutes with the Moon, or a half hour out of your busy schedule with deep sky if you do not have to go through complicated set up procedures. Forget the stress factor. Unless you are using a GoTo model, a drive system, setting circles, or planning on photography it is not necessary to have everything perfectly aligned to enjoy the night sky or your telescope! If you reach the end of a slow motion cable's extent, turn it back and reset the scope on the object. The only hard and fast rule in practicing amateur astronomy is to enjoy what you are doing.

If it is not practical in your circumstances to keep your telescope assembled—then consider even an inexpensive pair of binoculars. If you believe you can't afford them, then think again. Many very suitable pairs of binoculars can be bought for about the price of an extra large pizza! These small, handheld twin telescopes will increase your love of astronomy and whet your appetite for more.

Ready . . . Set . . . Go!

Now we have our equipment, our maps, and our notes. . . What's next?

Start off with some common sense. Dress appropriately for the outdoors and allow your optics to reach ambient temperature.

The next step is probably the most important for any observer: allow your eyes time to dark-adapt. Picture yourself walking into a dark room. You can see nothing when you first enter, but after several minutes your eyes begin to adjust, and you can "see" the sofa you are about to stumble over! This is especially true when viewing the night sky. When you go from a brightly lit room to the outdoors, you will only see the brighter stars at first, but after several minutes, many more lights will begin to appear.

Everyone's eyes adjust at different rates. For some, it may only be a matter of minutes before you are able to spot faint objects, but for others it may take a lot longer. This is why you might find a faint galaxy, only to drag a friend or family member away from the television and discover they can't see it! Avoid bright lights, television, and computer screens as much as possible before observing. Darken the room or wear sunglasses. Although this may sound silly, you'll find it will greatly increase your chances of finding that difficult galaxy or faint comet!

This is also why astronomers use red flashlights or red lighting. It helps to preserve night vision while reading a map, taking notes, or preparing to observe. If you do not have a light like this, take a look around you at what might suffice. Keychain lights often come in red and are sufficiently bright to read a map. Even a bit of red cellophane rubber banded over a penlight will do!

Here are two more techniques that will help increase your observing abilities. The first is called averted vision. While it might seem strange to ask you to view an object without looking directly at it, you'll find you're avoiding the low sensitivity patch on your retina, and faint objects will appear in greater contrast. The second is tapping the eyepiece gently. Movement, even slight, will make a low-contrast target easier to spot. Be sure to keep both eyes open to avoid eyestrain!

So, what else do we need before we begin to observe? As we mentioned earlier, although the art of note taking or sketching is not for everyone, it is highly recommended. Imagine seeing Jupiter and its moons for the very first time! While you are taking notes about your sighting, it takes very little effort to draw a circle and a few dots and indicate which direction they are moving across the eyepiece field. Just this simple bit of information is enough to let you later identify which moons were in what position!

The same will hold true of everything you observe. By writing down dates and times—along with observing conditions—it won't be very long until you are able to accurately assess what can be seen on any given night. You'll quickly discover that the first night you could see M44 unaided was also the first night you spotted M33 in binoculars!

Outside is a whole wonderful night sky filled with things to explore! Our equipment is ready, and we are ready. So let's head out under the stars. . .

Together.

CHAPTER ONE



January, 2009

Thursday, January 1

This night in 1801, 55-year-old monk Giuseppe Piazzi, was quietly contemplating the night sky and updating catalogs when he noticed a puzzling starlike point not on Lacaille's list. He wrote: "The light was a little faint, and of the color of Jupiter, but similar to many others which generally are reckoned of the eighth magnitude." A discovery on the ecliptic plane was exciting. Could this be the fabled "lost planet?" Piazzi carefully noted its position for later confirmation. Although you might have a clue that the object was an asteroid, Piazzi did not!

At twilight, let's test our power of observation on the crescent Moon. Little detail can be seen with just your eyes, but you'll notice a large, round, dark grey area mistaken by early astronomers as a sea—Mare Crisium. Known best as the setting for Arthur C. Clarke's short story "The Sentinel," the Sea of Crises spans about 400 by 500 kilometers. Through binoculars it presents as smooth grey sands highlighted by the bright walls of Crisium basin. As Missouri and far younger than other maria, its mountainous borders isolate it from other planar features, but its real mystery lies below the surface—a mascon sufficiently large to cause gravity anomalies!

Now take a closer look at the ecliptic plane, where Venus is also visible to the west. If you trace the arc from the point where the Sun sets through Venus and then to the Moon, you are tracing the ecliptic plane. Using binoculars you may be able to spot Uranus, which will be a little more than a fist-width further east. The V-shape of Taurus straddles the ecliptic, while the hourglass-like shape of Orion is to the south. Perhaps you'll notice the brilliant star Sirius just rising and the Great Square of Pegasus fading west. Look for the pentagon of Auriga, and the "W" of Cassiopeia. By familiarizing yourself with the ecliptic and major constellations, even beginning astronomers will find an exciting year of discovery ahead!

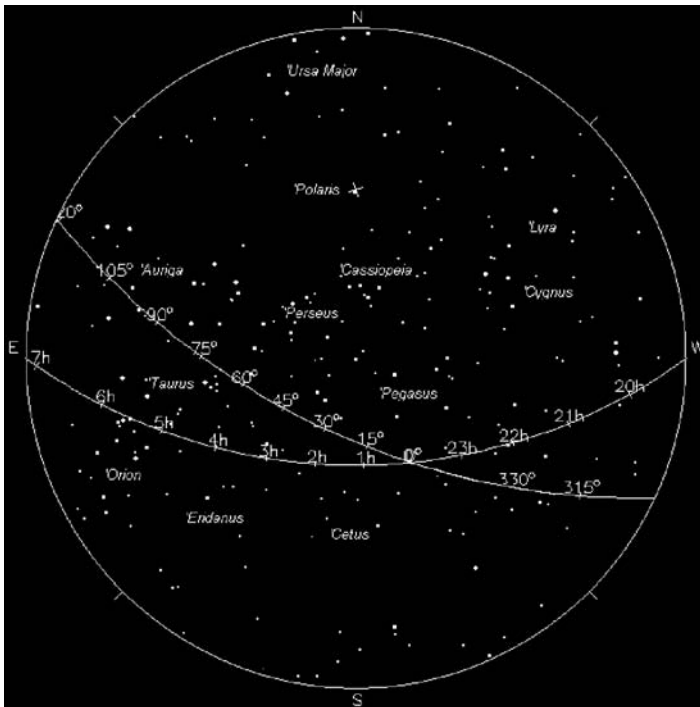


Figure 1.1a. The ecliptic plane.



Figure 1.1b. Giuseppe Piazzi.

Friday, January 2

Appearing before sunset, the waxing crescent Moon will dominate the early evening sky. Have you ever wondered if you could learn the names of all the lunar maria? The answer is yes! It's as easy as 1, 2, 3! Begin with last night's study, the round Mare Crisium in the lunar northeast (1) and continue southeast to identify 2, Mare Fecunditatis. Roughly the size of Greenland, the "Sea of Fertility" resembles a vast expanse of water, but this 909-kilometer stretch is anything but fertile. Comprised mainly of basalt, the plain contains clues about the Moon's volcanic origins. Along the terminator on its western edge lie fault lines called grabens—features shared by Earth.

Southwest is Mare Nectaris (3), the "Sea of Nectar." Like the other maria, it lies within its own 101,000 square kilometer impact basin, which is comparable in size to Wyoming. Like the state, Nectaris is also home to seismic activity and geological fault lines. Appearing slightly darker, Nectaris' basaltic surface is shallow—about 1,000 meters deep, similar to the depth of our own earthly seas. Science fiction fans might recognize Nectaris as the destination from *The Time Tunnel* episode "One Way Ticket to the Moon."

As you contemplate the Moon, think about the first extraterrestrial traveler—Luna 1, which also had a one-way ticket. In 1959 the little spherical Soviet spacecraft was onboard a rocket struggling to reach escape velocity. Carrying the Russian coat of arms, radio equipment, a tracking transmitter, and a telemetering system, this brave little traveler had everything but its own propulsion system. Luna 1's mission was to study interplanetary space and report findings from a magnetometer, Geiger counter, scintillation counter, and micrometeorite detector. Report, and never return.

If you'd like to explore further into space, use the Moon as your guide to blue-green Uranus, around 4 degrees south. At magnitude 8 it's about the same brightness as Piazzi's discovery; too faint for the eye, but not for binoculars or a small telescope. Make note of its position on the ecliptic.

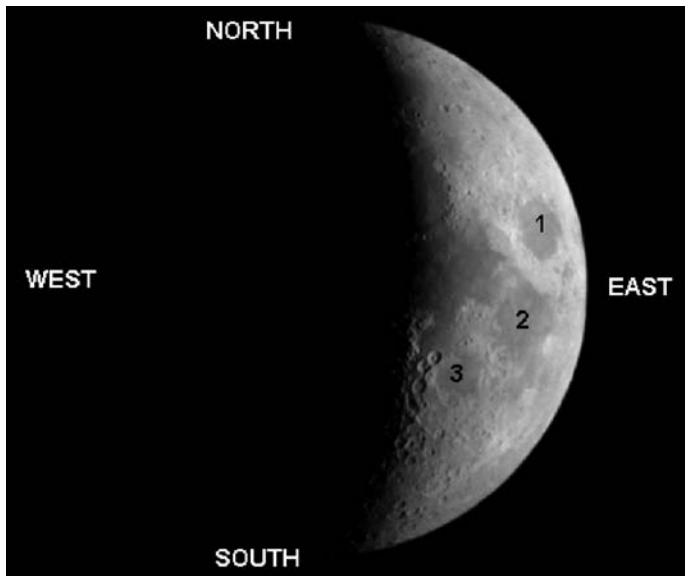


Figure 1.2a. "Easy as 1, 2, 3..." (credit—Greg Konkel).

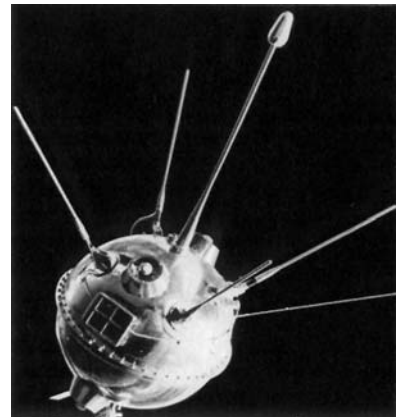


Figure 1.2b. Luna 1 (credit—NASA).

Saturday, January 3

On this date we celebrate the 1886 birth of Russian astronomer Grigori Neujmin, discoverer of the rotating asteroid Gaspra (shown here) and 73 others. Two periodic comets and three co-discoveries bear Neujmin's name, and 85 years before his birth Piazzi was wondering if his own discovery was also a comet: "The evening of the third, my suspicion was converted into certainty, being assured it was not a fixed star."

This is also the date in which Stephen Synnot discovered Juliet and Portia, two additional moons belonging to Uranus. If you remember Uranus' position from last night, why not look again? While even the largest of backyard telescopes don't reveal much detail on this outer planet, it's still fun!

Like a comet's tail, Luna 1 lit up this night in 1959 by releasing its first experiment 113,000 kilometers from Earth. The 1 kilogram payload of sodium gas glowed orange, reaching the brightness of a sixth magnitude star! Intended to test the behavior of gas in space, the visible trail allowed astronomers to track it. After 34 hours of flight, Luna 1 unfortunately missed its impact with the Moon, but scored a triumph for science by becoming the first satellite to "fly by" the Moon—approaching within 5,995 kilometers.

When you view Selene tonight, tip your hat toward our brave traveler, which still circles the Sun between the orbits of Earth and Mars. It provided new information on Earth's radiation belts, discovered the Moon had no magnetic field, and told us about the solar wind. *Savershyenstva!*



Figure 1.3. Gaspra (credit—NASA).

Sunday, January 4

Before the new day dawns, enjoy the first meteor shower of the year, the Quadrantids. Possibly a branch of the Aquarids, Jupiter's gravity continues to pull the stream apart, and it may one day be as extinct as the constellation for which it was named. By watching near Arcturus and with no Moon to interfere, your chances are good spotting a shooting star!

Now let's take a look at the first quarter Moon and see what we can discover. . . First repeat our litany: #1—Mare Crisium, #2—Mare Fecunditatis, and #3—Mare Nectaris. Head north to the huge area of #4, Mare Tranquillitatis, which appears with its irregular borders. Beneath the smooth-appearing regolith, the "Tranquil Sea" basin is cracked and overlapped by accompanying basins—lava spilling and flowing into other areas as large as the Kimberley region of Australia, or three times larger than England! Now, #5 Mare Serenitatis, the "Sea of Serenity." Home to a violent past, its outer edges appear darker than the interior—mute testimony to continued seismic and volcanic activity allowing the basin to fill with lava more than once. Take a telescopic look at the *rilles* adorning this lunar desert, whose surface is the size of Italy. Then go north for #6, Mare Frigoris, the "Sea of Cold."

We'll explore many wonders in depth over the coming months, but tonight we salute the 1797 birth of Wilhelm Beer (Figure 1.4b)—an amateur astronomer who (with Johann Mädler) created the first exhaustive map of the Moon, *Mappa Selenographia* . . . Zum Mond!

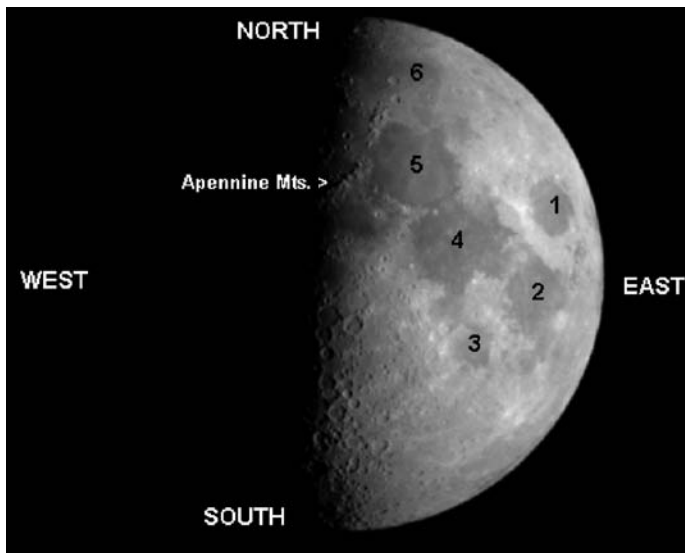


Figure 1.4a. "Easy as 4, 5, 6. . ." (credit—Greg Konkel).



Figure 1.4b. Wilhelm Beer (archival image).

Monday, January 5

By now in 1801, Piazzi's attempts to confirm the motion of his discovery had been clouded out. Our atmosphere and moonlight can work against our own observations, too. Tonight you'll notice the fainter stars have all but disappeared. For beginners, it's a good time to learn the constellations while only the brightest stars are visible.

When star charts were first being created 200 years before Piazzi's updates, it was important to label these primary stars so all astronomers could understand. A universal Greek lettering system was adopted, beginning with alpha assigned to the brightest star in each constellation and descending in order. While memorizing the Greek letters and star positions isn't easy, it's important to understand how to locate them on your own maps and relate them to what you see in the sky. Tonight let's take a look at Orion and its Alpha star—Betelgeuse.

Early in the evening, Orion the "Hunter" is beginning its journey across the night sky. Alpha stands out as an orangish star in the northeastern corner. It is a giant among stars! Betelgeuse has a long literary history and was one of the most massive stars known. In the mid-1800s, John Herschel observed that Betelgeuse varied in brightness, its light intensity changing by as much as a magnitude in under 6 years. The red giant is continually contracting and expanding to a formidable size—one that would fill the orbit of Jupiter around our own small star. But, it's not alone... Alpha also has four companion suns! Estimated to be 6 million years old, the light you see tonight from Betelgeuse left the star around the time Nostradamus was making his predictions. Should it go supernova tomorrow, it would be almost another half century before this spectacular sight would be seen in our night sky!

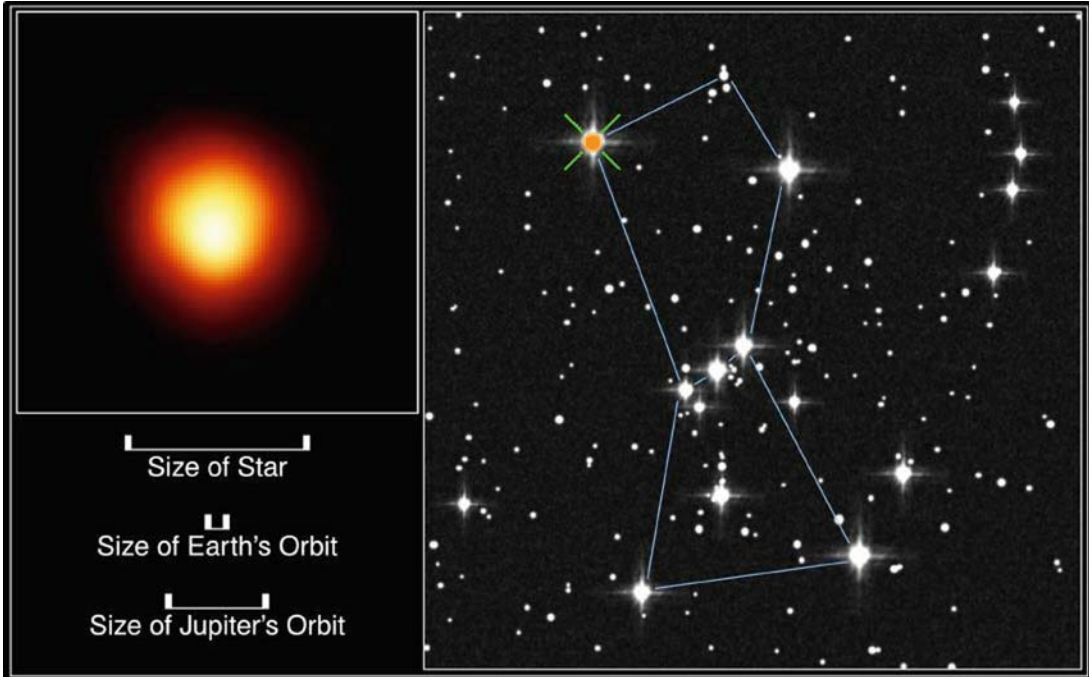


Figure 1.5. Alpha Orionis: Betelgeuse (credit—NASA).

Tuesday, January 6

On this date in 1949, the first atomic clock went into operation. Eight years later the first cesium beam device was built and is now keeping time to about one-millionth of a second per year. Like clockwork, astronomical objects can also keep incredibly accurate time. Tonight return to Orion and take a closer look at the westernmost star of Orion's "belt"—Mintaka. Located around 1,500 light-years away, Delta Orionis is a multiple star system: its companion star is almost equal in brightness and orbiting at a clockwork rate of 5.7325 days from only 8 million kilometers away. In astronomical terms, these two white-hot suns are nearly touching! Mintaka is a prime example of a spectroscopic binary star—a pair so close they are only detectable by changes in the stars' spectra. Its stationary spectral lines proved the existence of interstellar matter! Take a closer look, and Delta Orionis will reveal a visible 6.7 magnitude companion to its north—a challenge well suited to small optics.

On the Moon the clockwork movement of the terminator has slowly marched across the surface, revealing more lunar landscape and its 12 maria for exploration. While it ticks along the ecliptic, Luna is passing by other orbiting bodies. Want a challenge? Aim binoculars about a fist-width south of the Moon and take on an asteroid! Although Vesta isn't Piazzzi's discovery, now is a good time to practice observing these rocky Solar System bodies.

Spinning completely on its axis about every 5.5 hours and spanning 525 kilometers, this Arizona-sized minor planet is a treat for amateurs because its surface is highly reflective. At times Vesta can reach near unaided-eye visibility, but moonlight steals away fainter objects from easy view. Chances are very good that even in a starry field Vesta will be one of the brightest points visible. Take a cue from Piazzzi's description of his own discovery—reflected light appears different from starlight—and see if you can discover Vesta tonight!



Figure 1.6. Delta Orionis: Mintaka (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, January 7

On this date in 1610, Galileo discovered three moons of Jupiter. However, for sky watchers tonight, our own Moon is the most interesting place to be! In much of Eurasia, the Moon will glide silently across the large star cluster Pleiades in an occultation event. It's great fun to watch a star "disappear" behind the limb of the Moon! It may cover none, one, or several of its stars, so be sure to check the Resources section of the book for area-specific times and details. You won't want to miss this!

The Moon near the Pleiades is a picturesque view in binoculars or very low-power telescope fields. While you're admiring the celestial scenery, take time to work toward learning more major lunar features by sailing across 12 seas. The key to learning is to repeat these again and again: #1: Mare Crisium, #2: Mare Fecunditatis, #3: Mare Nectaris, #4: Mare Tranquillitatis, #5: Mare Serenitatis, and #6: Mare Frigoris. Excellent work! Now let's go have a closer look at #7: Mare Imbrium.

Identical in size to Saudi Arabia and about one-fourth the size of the United States, the "Sea of Rains" basin was formed 38 million years ago during a dramatic impact causing a Moon-wide series of faults. The massive strike shattered the lithosphere to a depth of 100 kilometers, embedding the impactor as a mascon. Seismic waves traveled through the interior—re-shaping the far side and creating magnetic anomalies—while the basin floor rebounded and flung ejecta 800 kilometers away. Over 500 million years, at least three areas of distinct lava flow poured into the impact basin (the oldest and largest about 1,200 kilometers long), far out-producing any earthly volcano. The youngest and smallest is about 400 kilometers in length, matching our terrestrial Columbia River Flood Basalt, an area stretching from Idaho to the Pacific Ocean!

Now, here are some more to learn: #8: Mare Vaporum, #9: Mare Insularum, #10: Mare Cognitum, #11: Mare Nubium, and #12: Mare Humorum. Remember: repeat, repeat, repeat!

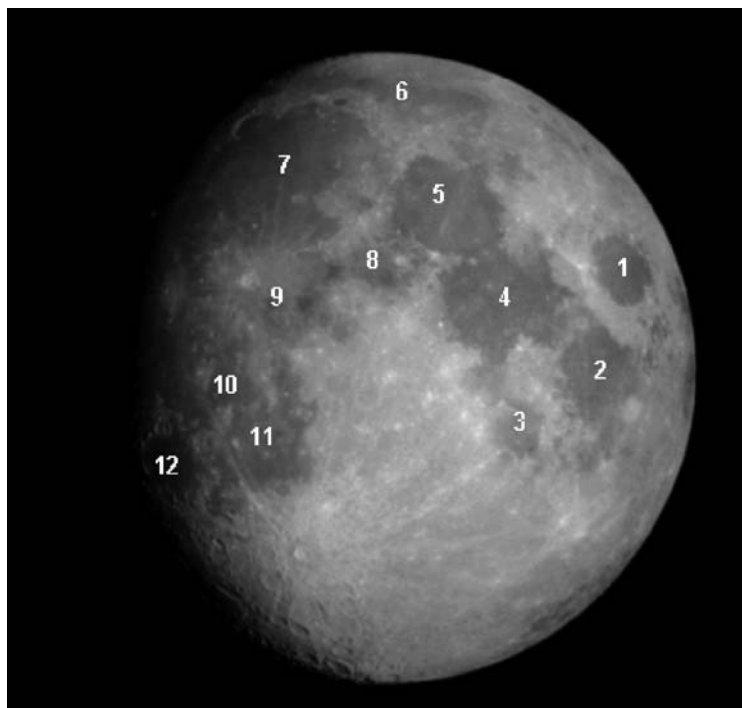


Figure 1.7. Gibbous Moon (credit—Greg Konkel).

Thursday, January 8

Tonight we begin by celebrating two births—first Johannes Fabricius (1587). In 1616 he returned from the Netherlands with a telescope to observe with his father David, the discoverer of Mira. The father–son team studied sunspots, and Johannes was the first to submit work on the Sun’s rotation. Precisely 300 years later (and on the anniversary of Galileo’s death), Stephen Hawking was born. Hawking went on to become one of the world’s leaders in cosmological theory.

Journey into the night and look for the Moon near the 4th hour. The starry canopy above is divided into 24 west–east sections called *hours*. Alpha Pegasi, the brightest star in the Great Square, is near the 0 hour. Move east and the hours increase in *Right Ascension (RA)*. Betelgeuse is near the 6th hour, while Sirius is closer to the seventh. Sections of north–south sky are labeled by degrees. Our previous study, Delta Orionis, is located near 0 degrees, while Betelgeuse stands near +10 and Rigel is closer to –10 degrees. As you go north, degrees increase positively in *Declination (Dec)*, and negatively as you go south. Polaris resides at +90, while Sigma Octanis is near –90.

Let’s experiment with Orion. Stretch out your hand to arm’s length, placing your thumb on Rigel and little finger on Betelgeuse. The difference between these two stars is approximately 20 degrees, and your handspan is close to the same size. Now do the same with Alpha Pegasi and the Moon. What did you discover? That’s right! A *handspan* covers about 1 hour and 30 minutes of sky.

Use binoculars to locate the Pleiades near the Moon. Astronomical instructions to find M45 would read: *RA 03 47 24 Dec +24 07 00*. It might be difficult at the beginning, but it’s no harder than reading an ordinary road map. These sets of numbers are addresses to the wonders of the night sky...and all it takes is practice! As Stephen Hawking said, “All of this was for nothing if we don’t go to the stars...”

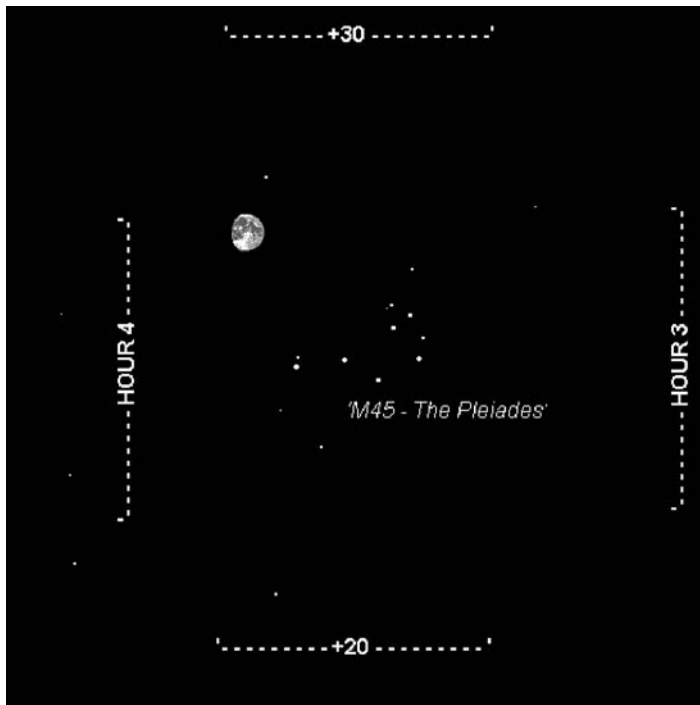


Figure 1.8a. Discovering sky directions (credit—Tammy Plotner).



Figure 1.8b. Stephen Hawking (widely used public image).

Friday, January 9

Tonight it's time to get serious about lunar observing. Look to the southwestern limb along the terminator and take on a challenge crater named for our asteroid discoverer, Giuseppe Piazzi. Viewable in binoculars, this 101 kilometer-long, shallow oval comes to resolution through a telescope at high magnification. To Piazzi's north is the walled plain Lagrange, which shares a common border and a whole lot more. During the Moon's violent past, the impact that formed Mare Orientale basin to the northwest slung ejecta across the two older formations, forming ridges and valleys. Look closely at Piazzi's northeast rim where areas of the original interior floor appear darker.

Because of the Earthly viewing angle, we're unable to determine the true width of this magnificent old crater with the broken and eroded rim, but we can tell the height of its most intact wall. Although it looks shallow, it stretches up above the floor 2,300 meters—as high as Scoglio della Metamorfosi (the Yosemite of Europe) in Valle di Mello, Italy. *Bellissimo!*

Tonight in 1839, Scottish astronomer Thomas Henderson (whose impressive list of 60,000 star positions earned him the title of Astronomer Royal of Scotland) became the first to measure the distance to a known fast-moving star using geometric *parallax*. Taking a cue from the terrestrial effect, where closer objects seem to move faster than those farther away, Henderson's calculations were within 30% of modern measurements, and his intuition was absolutely spot on. Alpha Centauri is indeed the closest star to our own Solar System.

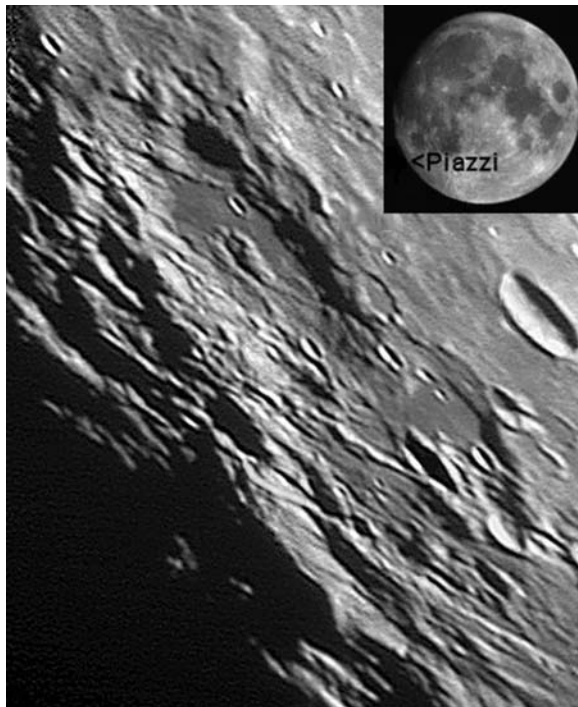


Figure 1.9. Crater Piazzi Crater Piazzi (credit—Alan Chu). Inset: Piazzi's approximate location (credit—Roger Warner).

Saturday, January 10

On this date in 1946, Lt. Col. John DeWitt, a handful of full-time researchers, and the U.S. Army's Signal Corps were about to become the first group to successfully employ radar to bounce radio waves off the Moon. It might sound like a minor achievement, but let's look into what it really meant.

Believed impossible at the time, scientists were hard at work trying to find a way to pierce Earth's ionosphere with radio waves. Project Diana used a modified SCR-271 bedspring radar antenna aimed at the rising Moon. Radar signals were broadcast, and the echo was picked up in exactly 2.5 seconds. Discovering that communication was possible through the ionosphere opened the way to space exploration. Although a decade would pass before the first satellites were launched into space, Project Diana paved the way for these achievements, so send your own "wave" to the rising Moon tonight!

Let's note the 1936 birth of Robert W. Wilson, the co-discoverer (along with Arno Penzias) of the cosmic microwave background. Although the discovery was a bit of a fluke, Wilson's penchant for radio was no secret. As he once said, "I built my own hi-fi set and enjoyed helping friends with their amateur radio transmitters, but lost interest as soon as they worked."

Don't you lose interest in the night sky just because the Moon is out! Look towards Cassiopeia, which contains the strongest known radio source in our own galaxy—Cassiopeia A. Although traces of the 300-year-old supernova can no longer be seen in visible light, radiation noise still emanates from 10,000 light-years away—an explosion still expanding at 16 million kilometers per hour! So, where is the source of this radio beauty? Just a little bit north of the constellation's center star.

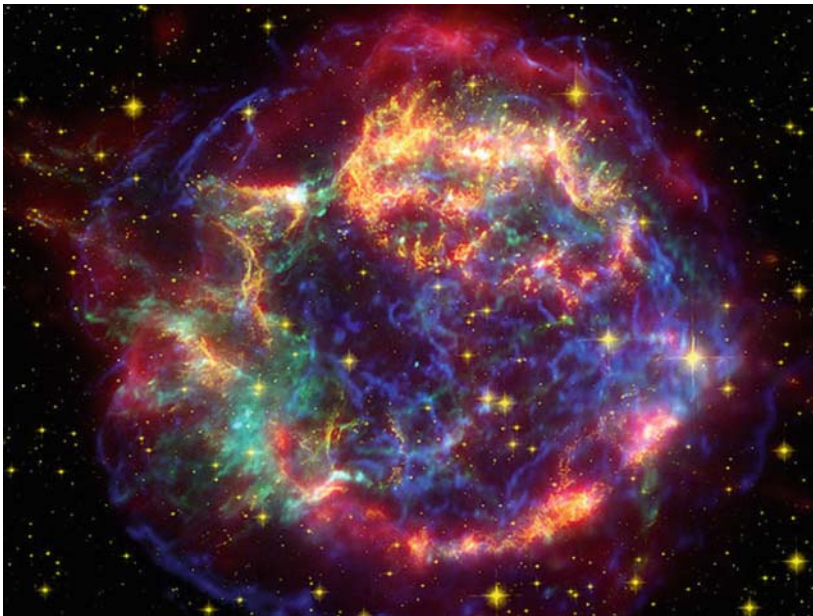


Figure 1.10a. "Light echoes" from Cassiopeia A (credit—Spitzer Space Telescope Team, courtesy of NASA).



Figure 1.10b. Project Diana (widely used public image).

Sunday, January 11

Rising opposite the setting Sun is a beautiful sight: the Hunger Moon, a name from Native American folklore. In the Northern Hemisphere, this was a time of snow and deep winter, when hunting was poor and wild dogs would roam by Moonlight searching for food. Let's take a closer look.

The vast dark area we have yet to identify is Oceanus Procellarum—the “Ocean of Storms.” Encompassing most of the northwest quadrant and stretching across 2,102,000 square kilometers of area, it rivals the Bering Sea in sheer size. No wonder the ancients considered it to be an ocean! Created by lava floods but never contained within an impact basin, it's similar to Earth's Siberian Traps—great upwellings of lava from our shared primeval history.

Oceanus Procellarum's name could refer to its vivid volcanic past, but it originated from a myth claiming stormy weather ahead if it was visible during the second quarter. Although the Moon doesn't play a role in our Earthly weather, what could cause such a myth to arise? Factually, if skies are clear enough to see the Ocean of Storms during the night, they'll allow heat to escape directly into our upper atmosphere. Rising air can cause clouds to form. Water vapor molecules cool and begin coalescing faster than they can be scattered by thermal energy, condensing and forming clouds where only one of two things can happen. Water molecules will either evaporate, changing back into vapor, or join to grow liquid drops, whose critical mass will fall back to Earth as either rain or snow.

On this date in 1787, Sir William Herschel was also looking at a moon, but not ours. This is the date he discovered two of Uranus' many moons—Oberon and Titania!



Figure 1.11. Full Moon (credit—NASA).

Monday, January 12

Today celebrates the founding of the Royal Astronomical Society. Conceived by John Herschel, Charles Babbage, James South, and several others, the society has published its *Monthly Notices* continuously since 1831. Believed to have been born today in 1907 was Sergei Pavlovich Korolev. Although few people recognize the name, the Soviet rocket engineer's contributions to science led to Sputnik, Vostok, Voskhod, and eventually the Soyuz program.

Before Moonrise, use the early dark to locate and study our destination—the hazy, triangular patch of stars that marks Orion's "head." The brightest, Lambda or Meissa, is a young, spectral type O star located 1,100 light-years away. Given the great distance, "the Shining One" becomes one of the most luminous stars known. Use a telescope for a closer look! Formed from the molecular clouds in Orion, Meissa is young, hot, and massive, emitting enough ultraviolet light to transform all the hydrogen into ions within a 100 light-year radius. The faint nebulosity is the remnant of the cloud that spawned Lambda. But, look very closely. . . Meissa is a binary star system that has a magnitude 6 companion—a white hot, blue dwarf!

Now scope out the bigger picture. Lambda appears associated with a group of stars. But is it? The answer is yes. Take a closer look with binoculars or a telescope at the open cluster Collinder 69 (RA 05 35 12 Dec +09 42 00). Estimated to be 10 million years old, this group of around 20 stars can be considered young on the stellar timescale. Containing little interior obscuring dust, clusters of its type are extremely important to studies of star formation. The young stars have not moved far from their original locations, and the group contains low-mass stars (close to the planetary limit), short-term variables, and brown dwarfs. You might not see everything Collinder 69 has to offer with good reason: associated with this interesting region are the dark nebulae Barnard 30/35 and Lynds 1588/1603!



Figure 1.12a. Collinder 69 (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.12b. Sergei Korolev (credit—NASA).

Tuesday, January 13

Although volumes could be written about tonight's study, no winter's night is complete without observing the Great Orion Nebula. With moderately dark skies, the eye can perceive a glow below Orion's belt in the "sword," but add an optical aid, and the vision of Messier Object 42 (RA 5 35 17 Dec -05 23 28) will blow your mind!

Glowing silently 1,600 light-years away, this huge complex of gas, dust, and stars was noted in Ptolemy's time, but not identified as nebular until about 400 years ago because of its brain-boggling size! Astronomers from Hodierna to Huygens to Halley have been credited with discovering different parts of the whole. Galileo saw interior stars, but not the nebula. It may seem unlikely a comet hunter would bother listing such a well-known object, but even Charles Messier wasn't immune to its allure.

"The sky perfectly serene. . . One saw it perfectly well. . ." said Messier, "and I drew the extension of the nebula." He used his sketches "to recognize it again, provided that it is not subject to change with time." Nearly a century would pass before the gaseous nature of the Orion Nebula was confirmed, and only recently has it been understood as a star-forming region. But Sir William Herschel described it—with uncanny accuracy—as "an unformed fiery mist, the chaotic material of future suns."

If this is your first (or thousandth) time viewing the Orion Nebula, let the true beauty sink in. It covers 20,000 times as much space as our Solar System and contains enough material to create 10,000 suns. Buried within its rifts and folds are 2,300 stars containing proto-planetary disks, and 200 stars still in the embryonic stage. Temperatures soar as high as 60 million degrees, and interstellar winds cruise along at 110 kilometers per second. What you see is nothing more than a snapshot in time, for the light you see tonight left the Orion Nebula during the Roman Empire!

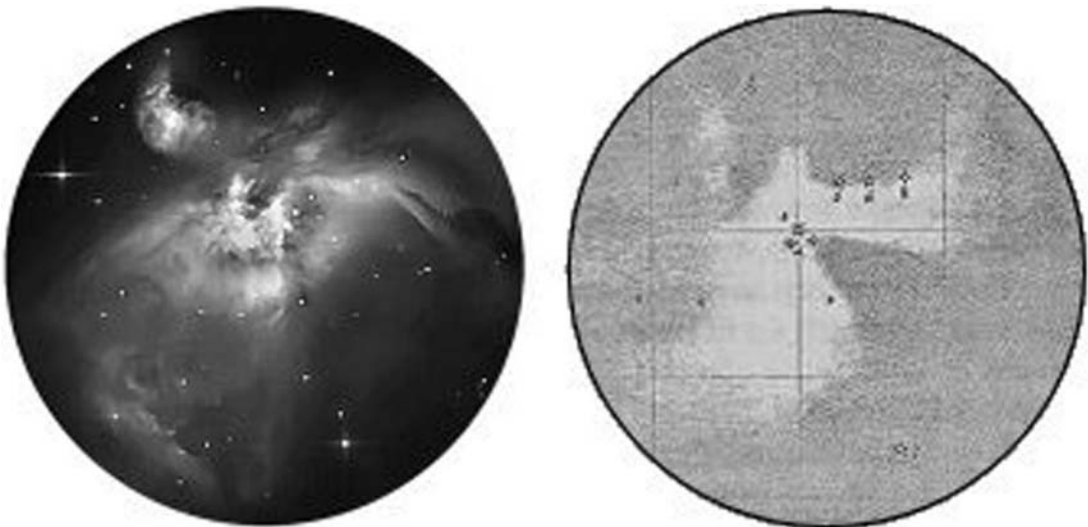


Figure 1.13. (a) The Great Orion Nebula (credit—Roger Warner); (b) Messier's drawing of M42 (archival image from *Memoirs of the Academy*, 1771).

Wednesday, January 14

If you haven't looked for Venus lately, sunset would be a great opportunity! The brilliant planet has reached its highest point in the early evening sky. Now, let's think back to 2 million years ago. Near the heart of the Orion Nebula, two massive binary stars were involved in a head-on collision, exchanging stars. Iota Orionis became a new binary system, but two "runaways" left the scene of the accident at a speed of 200 kilometers per second. Tonight we'll look at these two challenging stars—one to the north and one to the south.

North is AE Aurigae (RA 05 16 18 Dec +34 18 44). Its two-letter designation shows AE is a variable star, and it flirts with unaided visibility between magnitudes 5 and 6. On a dark night, you can usually spot AE hanging out on the northwestern perimeter of a spangle of stars about two finger-widths east of Iota Aurigae. With a distance of 1,450 light-years, it's not surprising that it's faint, but AE would be a full magnitude brighter if it weren't in a dust cloud! AE Aurigae is a hot star, and its simple spectrum and rapid movement against the interstellar medium make it ideal for studying these primal gases. Examined with a telescope at low magnification, you can enjoy the illumination created by the "Flaming Star"!

To the south is our runaway collision victim Mu Columbae (Figure 1.14b). Draw an imaginary line due south from the Orion Nebula past Lepus, and you'll encounter dim Mu (RA 05 45 59 Dec -32 18 23) just northeast of Alpha Columbae. Cruising along at 117 kilometers per second, this white-hot star sheds about one-tenth of a millionth of its mass every year. Holding a steady magnitude 5, and now 1,300 light-years distant, Mu is one of the very few of its type easily seen by the unaided eye. What can't be seen, however, is the signature left by the star in the warm interstellar medium. Like footprints in the sand, high-resolution spectrographs show the moving star left a trail in its wake!



Figure 1.14a. AE Aurigae (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.14b. Mu Columbae (credit—Palomar Observatory, courtesy of Caltech).

Thursday, January 15

In 2006, Stardust was nearing Earth with its payload of cometary dust particles from Comet Wild 2. It released a capsule of aerogel and landed successfully—providing us with an opportunity to contribute to science through the “Stardust@Home” project.

Tonight, our “stardust” project begins at the tip of Orion’s sword—Iota Orionis—the third player in our “runaway” drama (RA 05 35 25 Dec -05 54 35). Hatsya (Bright One of the Sword) is a spectroscopic binary resulting from the collision we studied yesterday. Iota consists of two powerful, white-hot suns, orbiting less than one Astronomical Unit (AU) apart and nearly touching at one point during their monthly orbit—a powerful X-ray source! In binoculars, Hatsya appears in a charming collection of stars, while small telescopes reveal a colorful red/blue triple system. Surrounding Iota is a faint stardust nebula, NGC 1980, often mistaken as part of M42.

Back in Piazzi’s time, clouds had at last departed, and he was again able to study his own runaway “star”—the asteroid Ceres. To his colleagues he wrote:

I have announced this star as a comet, but since it is not accompanied by any nebulosity and, further, since its movement is so slow and rather uniform, it has occurred to me several times that it might be something better than a comet. But I have been careful not to advance this supposition to the public. Its motion in the Zodiac, from which it only departs a little way in the greatest latitudes, and its position between Mars and Jupiter, leave no doubt that this new star is a true planet. . . . But how to recover the now-lost planet at some future date?

The “future date” has also arrived for us, and tonight the late rising Moon and Saturn will be your guide to Ceres. For most observers, the bright asteroid will be located slightly less than a handspan north of the Moon and Saturn about one-third the distance from the Moon to Ceres!



Figure 1.15a. Iota Orionis and NGC 1980 (credit—Palomar Observatory, courtesy of Caltech).

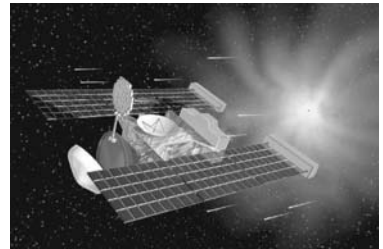


Figure 1.15b. Artist’s conception of stardust (credit—NASA).

Friday, January 16

In 1978 on this date, NASA named 35 candidates for space shuttle missions, including Sally Ride as the first female U.S. astronaut and Guion Bluford, Jr., as the first black. In 1973, the Lunokhod 2 mission was beginning its robotic lunar expedition, and in 1969 Soyuz 4 and 5 became the first vehicles to dock in space and exchange cosmonauts. The year 1730 saw the birth of Jean Bochard—publisher of Laplace's planet/ecliptic theory. Although eventually beheaded for his politics, Bochard put together Europe's largest collection of astronomical instruments and was renowned for his calculations of cometary orbits, made jointly with long-time friend and co-observer Charles Messier.

Tonight, venture into Lepus for a faint, round, fuzzy object that might easily be mistaken for a comet in a small telescope or binoculars—Messier Object 79 (RA 05 24 10 Dec +24 31 27). The true beauty of this object is revealed in large telescopes. Behold a globular cluster, one of many densely packed balls of stars that mainly congregate near our galactic center. Discovered by Pierre Méchain and cataloged by Messier in 1780, M79 is on the opposite side of our galaxy, and about 4,200 light-years away. Spanning 118 light-years, this starry sphere may not be an original member of our galaxy at all but an import. Although we can't see it happening, the Canis Major Dwarf galaxy is slowly being incorporated into our own system, and M79 might very well be a product of this union!

Thanks to Méchain and Messier's careful notes, William Herschel later recovered M79 and resolved its stars. Although the practice of maintaining an astronomy diary isn't for everyone, keeping simple records is very rewarding. Make note of the object's appearance, equipment used, and sky conditions. Observing diaries just like those of Messier and Méchain have led countless astronomers along the road of discovery to all the deep-sky objects we know today!



Figure 1.16a. M79 (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.16b. Sally Ride (credit—NASA).

Saturday, January 17

Celebrate the 1723 birthday of Johann Tobias Mayer, the German astronomer who created the first lunar tables for determining longitudes at sea. His calculations were accurate to within a half degree! If you're up before sunrise, look at the Moon now nearing third quarter. How many lunar seas can you still identify? Can you navigate to Spica nearby?

Tonight let's go from one navigational extreme to another as viewers in the Northern Hemisphere try their hand (and eye) at 390 light-year distant Polaris. Its fame as a "fixed star" is a bit undeserved, because it is approaching us at 25 kilometers per second. Only its sky position closest to the north celestial pole makes Polaris appear to "stand still" while the other stars revolve around it. Ranked the 49th brightest star, Alpha Ursae Minoris may look ordinary but is not. Polaris is a Cepheid variable, a star that expands and contracts on a regular basis, changing its brightness slightly. Modern interferometry has revealed it as slightly irregular—an "overtone pulsator"—and a multiple one at that. Polaris' triple system took the resolving power of the Hubble Space Telescope to reveal its spectroscopic component, but even a small telescope can spot its gravitationally bound blue companion!

The Southern Hemisphere also has a near-pole star—Sigma Octantis—but at magnitude 5 (300 times fainter than Polaris), it doesn't make a good guide star. Ancient navigators found better success with the constellation Crux, better known as the Southern Cross. Its two brightest stars, Gacrux and Acrux, are oriented north-south and point across the pole to brilliant Archenar. Splitting the distance between Gacrux and Archenar lands you within 2 degrees of the south celestial pole. A southern double star comparable to Polaris in appearance is Lambda Centauri. The difference in magnitude between components and separation are about the same!



Figure 1.17a. "Turning Still" (credit—Joe Orman).



Figure 1.17b. Tobias Mayer (historical image).

Sunday, January 18

"I have looked farther into space than ever a human being did before me," writes Sir William Herschel, discoverer of thousands of deep-sky objects. While 400 of these make up a popular observing list, many more deserve attention. This night in 1784, Herschel aimed his telescope toward Orion's stars, and he found two new sky gems! Starting with binoculars, aim about 2 degrees northwest of the northernmost star in Orion's "bow" (Pi1 Orionis) to view NGC 1662 (RA 04 48 24 Dec +10 56 00).

With a combined magnitude of 6, this small galactic cluster will show as a slight compression of the starfield, a challenging binocular deep-sky object. A small telescope at modest magnification will resolve NGC 1662 into a jewel-like chain of blue and gold stars. Astronomers have studied it extensively to refine its members' proper motions, and it may have once contained more stars during its 300-million-year evolution!

Now return to M42 and go slightly north (RA 05 35 15 Dec -04 53 12) to examine NGC 1977). Also discovered on this night by Herschel, seasoned sky veterans know this area by its nickname "the Running Man". Consisting of three separate areas of emission and reflection nebulae that seem to be visually connected, 1,500-light-year-distant NGC 1977/1975/1973 complex would be spectacular on its own if weren't so close to M42! The conjoining nebula is whispery soft, its dark lanes created by interstellar dust and fine needle-like shards of carbon. Illuminating the gases is its fueling source, the multiple star 42 Orionis—a prized double on many lists. Through a telescope, this lovely triangle of bright nebulae and its several enshrouded stars make a wonderful region for exploration. Can you see the Running Man within?



Figure 1.18a. NGC 1662 (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.18b. NGC 1977 (credit—Palomar Observatory, courtesy of Caltech).

Monday, January 19

Somewhere out there before dawn in the year 1779, Charles Messier was still awake at the eyepiece discovering M56! Maybe he was celebrating the 1747 birth on this date of Johann Bode, the publicizer of the Titius–Bode law, a weird mathematical relationship for measuring planetary distance. If you add 4 to each number in the series 0, 3, 6, 12, 24. . .and divide the answers by 10, the resulting sequence gives the approximate distances of the planets from the Sun in AUs. I told you it was weird! Unfortunately, it only worked until the discovery of Neptune, but his book, *Uranographia*, was the first to map all stars visible to the naked eye—without any fanciful interpretation of the constellations!

Then along came Jacobus Kapteyn in 1857, a Dutch astronomer whose goal was to determine the motions and distribution of a half-million stars. He described the density of space as a function of distance and arranged stars by magnitudes, gauging distance from proper motion. Kapteyn discovered that stars don't move randomly; they move in two streams, one moving towards Earth and one moving away! Although parallax keeps us from sensing stellar movement, we can observe two moving objects tonight as we look over the top of Orion's "bow" for Messier 45. See Pleiades, the Pleiades.

This visual cluster of stars was drawn together 100 million years ago. Its members show no measurable proper motion relative to each other; yet they move as a group in space. Journeying away from us, the Pleiades and a slower-moving molecular cloud known as the Merope Nebula are passing each other at a speed of 11 kilometers per second, reflecting the stars' spectra in blue light against the dark dust. What you see is how the Pleiades appeared 380 years ago. Through binoculars or a telescope, bright Merope's reflection nebula appears smeared. This isn't a trick of the light; it's the result of movement. In 250 million years, the Pleiades' stars will no longer be bound together, with the stars and molecular having long since parted ways. For now? Enjoy their beauty and our own brand of "star-streaming!"



Figure 1.19a. The Merope Nebula (credit—Palomar Observatory, courtesy of Caltech).

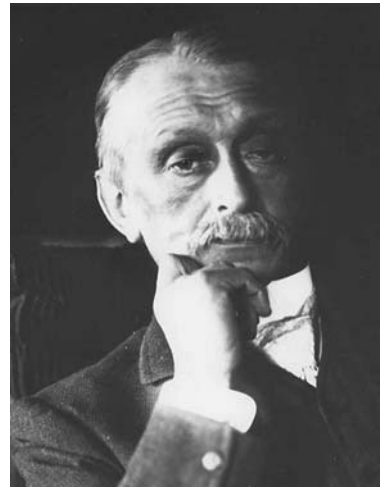


Figure 1.19b. Jacobus Kapteyn (historical image).

Tuesday, January 20

Awake during the wee hours of the morning? Try sky-watching for the peak of the Coma Berenicid meteor shower. Although activity is weak, with an average fall rate of about 7 per hour, it still warrants study. Noted first around 50 years ago, the stream was connected to another minor shower in the same orbit, the December Leo Minorids. Meteoroid streams are traditionally byproducts of comets, but in this case the comet had not been confirmed! Observed in 1912 by Australian amateur astronomer B. Lowe, it was officially designated as 1913 I and (much like Piazzi's asteroid) was only seen four times before being lost to the sunrise.

Using Lowe's observations, independent researchers computed the comet's orbit, but it was forgotten until Fred Whipple made the association between his photographic studies and the enigmatic comet. By observing the annual shower, Whipple placed the orbital period of Comet Lowe at 75 years, with the two major streams occurring about 27 and 157 years apart. Due to the uneven dispersion of material, it may be another decade before we see some real activity, but even one meteor can make your day!

While you are out, be sure to salute the Moon, as we wish E. "Buzz" Aldrin a very happy birthday! Also born today in 1573 was Simon Mayr, a student of Tycho Brahe. He observed Jupiter's Moons about the same time as Galileo, and assigned their Greek names.

For advanced stargazers, try your hand at NGC 1788 (RA 05 06 54 Dec -03 20 30). This cool little Herschel object is an isolated molecular cloud, probably formed from a supernova's shockwave, which compressed the cold material. Inside, pressure has ignited the beginnings of star birth with many confirmed proto-stars. Also part of this small complex (to the south) is Lynds 1616, a dark nebula. Perhaps this area is not yet compressed enough to form stars of its own. Seeing two different types of nebulae in one field makes this an extraordinary treat for large telescopes!



Figure 1.20a. NGC 1788 and Lynds 1616 (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.20b. Simon Mayr (historical image).

Wednesday, January 21

Celestial scenery alert! Before dawn look for the “kissin’ close” pairing of the Moon and Antares. This could be an occultation event, so check resources such as *IOTA* to obtain accurate times and locations. Today is also the 1908 birth date of Bengt Strömgren, developer of the theory of ionization nebulae (H II regions). Tonight we will honor his work by returning for an in-depth look at the Great Orion Nebula (RA 05 35 17 Dec -05 23 28).

M42 is a great cloud of fluorescent gases. The fueling core is the “Trapezium”—four easily seen stars which are the most celebrated multiple system in the night sky. In an area known as the Huygenian region, the Trapezium’s siblings are approaching main sequence and igniting their nuclear reactors. Buried in this cloud of mainly hydrogen gas, star-forming regions appear like “knots” amidst the bright ribbands and curls. These are Herbig-Haro objects—stars in their earliest states. They mingle with faint reddish stars and erratic variables, as well as young stars of the accreting T Tauri type and flare stars, whose rapid variations create new activity.

Study M42, and you’ll notice it appears very turbulent. Different regions move at different speeds, both in recession and approach. The expansion rate at the outer edges indicates radiation emitted from the very youngest stars known. Although it has been 23,000 years since the Trapezium came to “light,” new stars are still forming. Northeast is a segment with its own designation— M43 (RA 05 35 31 Dec -05 16 12). This emission nebula appears to be separate from M42, but the division known as the “Fish Mouth” is caused by dark gas and dust from within. At its heart is the seventh magnitude “Bond’s Star”—an unusually bright OB star creating a matter-bound Strömgren sphere!



Figure 1.21a. The Orion Nebula complex: M42 and M43 (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.21b. Bengt Strömgren (historical image).

Thursday, January 22

Start the astronomical day by observing the 1592 birth on this date of Pierre Gassendi, French scientist, mathematician, philosopher. . .and the first to use a Galilean telescope to observe a Mercury transit by the projection method. Gassendi was a prodigious observer, known for his humor, and was friends with Cassini, Galileo, Hevelius, and Kepler. His writings included work on falling bodies—a rare coincidence, since the only known piece of “space junk” to ever re-enter our atmosphere and strike a human occurred on the 405th anniversary of his birth!

Begin tonight with the star on Orion’s western shoulder, Gamma. Named Bellatrix, the 243 light-year distant “Amazon” is not actually part of the Orion association. Gamma is a foreground star and is the hottest of its type visually observable. Use binoculars to spot a fainter star about a half degree northeast and say hello to alternative catalog study Dolidze 21 (RA 05 26 50 Dec +06 58 30). This loose association of stars contains a few solar types, and many stars fainter than small optics can resolve—an unusual observation for your notes.

For a telescopic challenge, try NGC 1875 roughly the same distance northwest (RA 05 21 45 Dec +06 41 18). Ain’t easy, is it? This little 14th magnitude elliptical galaxy has a bright core and can be spotted in the average large telescope with averted vision. During 2004, it was home to a supernova event, but that’s not all. The challenging NGC 1875 is also called Arp 327—one to add to your “peculiar” list. Not enough? Then glue your eye to a very big telescope and look closely. NGC 1875 is part of Hickson compact galaxy group 34. You’ll need at least 30” in aperture to make out this chain of faint fuzzies!



Figure 1.22a. Dolidze 21 (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.22b. NGC 1875/Arp 327/HCG 34 (credit— Palomar Observatory, courtesy of Caltech).

Friday, January 23

Tonight travel a finger-width northeast of Zeta Orionis for a delightful area of bright nebulosity called M78 (RA 05 46 47 Dec +00 00 50). Discovered by Méchain in 1789, the 1,600 light-year distant M78 is part of the vast complex of nebulae and star birth comprising the Orion region. Fueled by twin stars, it resembles a “double comet” to binoculars, but telescopic observers will note two lobes (NGC 2067 north and NGC 2064 south) separated by a band of dark dust. Surrounded by a region of absorption, M78’s borders appear almost starless. Young T Tauri-type stars reflect against a cloud of interstellar dust, the brightest of which is HD 38563A. As of 1999, 17 Herbig-Haro objects (newly forming stars that are expelling jets of matter) have been associated with M78.

On January 23, 2004, a young backyard astronomer named Jay McNeil was taking some long-exposure photos of M78 with his new telescope and was about to make a huge discovery. When he developed his photographs, there was a nebulous patch with no designation! After reporting his findings to professionals, Jay realized he had stumbled onto something unique, a variable accretion disk around a newborn star—IRAS 05436-0007. Although McNeil’s Nebula may not be bright enough tonight to be seen (just south of M78), remember it *is* a variable, so circumstances play a big role in any observation of it.

Before you assume that being “just” a backyard astronomer has no real importance to science, remember this teenager in a Kentucky backyard with a 3” telescope. . . catching what professionals had missed!



Figure 1.23a. M78 (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.23b. “McNeil’s Nebula” (credit—Adam Block/NOAO/AURA/NSF).

Saturday, January 24

Today honor the 1882 birth of Harold Babcock, discoverer of the sunspot cycle, differential rotation, and the solar magnetic field. While you should NEVER look directly at the Sun, you can use binoculars or telescopes to see sunspots by using the “projection method”—just as Gassendi did to observe the Mercury transit. Cover additional optics such as a finderscope or one binocular tube, and use the shadow to aim the circle of light onto a makeshift screen, focusing until the image is sharp and details appear. It takes practice, but it’s safe and fun!

Tonight, journey two finger-widths northwest of Aldebaran (RA 04 21 57 Dec +19 32 07). In 1852, J.R. Hind reported observing nebulosity, but noted no catalog position. His observation included an uncharted star, which he surmised was variable. On each count, Hind was right. The pair was studied for several years until they faded in 1861, and then disappeared altogether in 1868. In 1890, E.E. Barnard and S.W. Burnham re-discovered them, only to see them vanish 5 years later—not to return until the 20th century. Our mystery guests are Hind’s Variable Nebula (NGC 1555), and its associated star—T Tauri—a prototype of a particular class of variables and totally unpredictable. For weeks its magnitude could fluctuate between 9 and 13—or remain constant for months. Although equal to Sol in temperature, mass, and spectral chromosphere signature, it is in the initial stages of birth! T Tauri types are pre-main sequence proto-stars, continuously contracting and expanding and shedding their mantle of gas and dust in jets. This is caught by the star’s rotation and spun into an accretion, or proto-planetary, disk. When the jets subside, gravity pulls the material back to the star. The proto-star has then cooled enough to reach the main sequence, and the pressure may even allow planetoids to form from the accreted material. How cool is that?!



Figure 1.24a. NGC 1555: Hind’s Variable Nebula (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.24b. Harold Babcock (historical image).

Sunday, January 25

On this date we celebrate the 1736 birth of Joseph Lagrange, a mathematician who made a very important contribution to celestial mechanics. No, we aren't talking about wrenches in space! He calculated five locations where the combined gravity of Earth and the Sun would balance the orbital motion of an object positioned there. A spacecraft located at one of these spots—the one about a hundredth of the distance from Earth to the Sun—requires little correction to maintain orbit and keep pace with Earth's rotation. Known as the *Lagrange Point 1*, it's a position currently occupied by the most prolific solar "observer" to date...the SOHO satellite!

How often do we look at something and not see what is really there simply because we don't know what to look for? Tonight, look north of Aldebaran for a small cluster of stars, and focus your attention toward the northernmost star, Nu Tauri. Surrounding this rather ordinary star is an overlooked nebula—Ce 34. In 1964, an industrious astronomer—Stefan Cederblad—began studying bright, diffuse galactic nebulae and their distribution. Chances are you may have seen a Cederblad catalog object at one time or another and not even have noticed it! In this circumstance, Ce 34 is illuminated by 72 Tauri, which looks like an apparent double for Nu. At first glance, you might think you were seeing diffraction or illumination from the Nu/72 pair, but Stefan was a true astronomer and repeated his observation until he was sure he had discovered nebulosity. Take time to study Ce 34 yourself. You might find catching it depends not so much on the size of your optics but rather you and your observing conditions! Just like the Merope Nebula, the art is not so much in the finding as it is in the seeing.

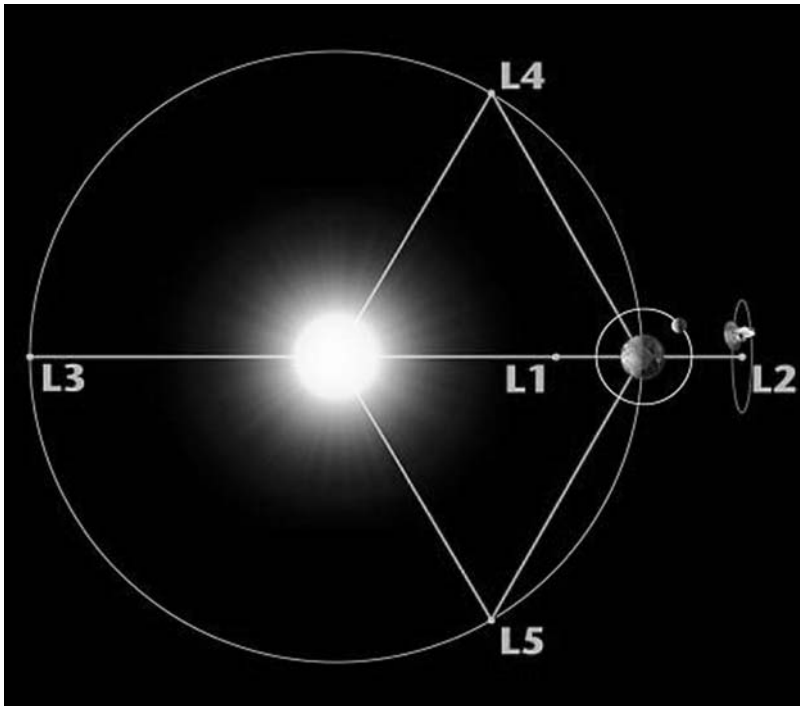


Figure 1.25a. Lagrange points (credit—NASA).



Figure 1.25b. Cederblad 34 (credit—Palomar Observatory, courtesy of Caltech).

Monday, January 26

Wish clear skies to viewers in South Africa, Sumatra, and Borneo for today's annular solar eclipse ! For sky-watchers in most of southern Africa, Southeast Asia, and western Australia, a partial solar eclipse is in store for you. Check resources such as *Mr. Eclipse* for times in your local area.

On this date in 1962, the U.S. lunar probe Ranger 3 was on its way, intending to image the Moon right up until impact. Its mission was to land a seismometer, study gamma rays, and report on surface reflectivity using radar. But it didn't happen. Two days after launch, the ill-fated Ranger 3 received an erroneous command and lost contact with Earth. As a result, it overshot its mark by 36,800 kilometers and remains in heliocentric orbit!

Tonight's New Moon is an excellent time for a very challenging open cluster, Bochum 1, located about a degree southwest of the star between Gemini's 2'—Nu Geminorum (RA 06 25 30 Dec +19 46 00). Like many alternative catalog studies, first glance finds this loose, dim, open cluster to be unimpressive, but the story behind it is awesome! Located 42,000 light-years from the galactic center, scientists have spectrographically studied the stellar evolution of two member stars and found them, well. . .rather ordinary. But this very fact makes Bochum 1 *extra*-ordinary, since other clusters residing at a similar distance are known to be metal-poor. Is it young? You betcha! The light you see tonight left Bochum 1's stars some 10 million years ago!



Figure 1.26a. Bochum 1 (credit—Palomar Observatory, courtesy of Caltech).



Figure 1.26b. Ranger 3 (credit—NASA).

Tuesday, January 27

On this date in 1967, tragedy struck at Pad 34 during a training exercise atop a Saturn IB rocket. U.S. astronauts Virgil “Gus” Grissom, Ed White, and Roger Chaffee died as fire broke out in the module named Apollo 1. The following is from the launch pad commemorative plaque:

“They gave their lives in service to their country in the ongoing exploration of human-kind’s final frontier. Remember them not for how they died but for those ideals for which they lived.”

To honor the brave souls of the Apollo 1 crew tonight, let’s observe the small star found just south of the easternmost “belt” star in Orion—Sigma (RA 05 38 44 Dec -02 36 00). Small optics close the 1,150 light-year gap and reveal this multiple-star system in all its red, white, and blue beauty. Fine optics at high magnification can resolve four members. The brightest, A/B, is one of the most massive binaries known and ignites the surroundings in a glow of interstellar gas. The D and E members are nearly identical in magnitude, yet E is, oddly, a helium-rich star, likely related to Cor Caroli types. Nearest to the primary A/B pair is C—a totally normal dwarf. As part of a larger grouping, Sigma’s fate is unclear. The A/B union is solid, but the orbits of its companion stars are highly unstable. Chances are that when the A/B pair has evolved fully and is ready to end its life quietly as a pair of white dwarfs, it will eject the others. The larger Sigma Orionis grouping also contains many low-mass stars about three times larger than Jupiter, and many planetary candidates. It’s an interesting area of the sky, and well worth your time!



Figure 1.27a. a. Apollo 1 crew (credit—NASA).



Figure 1.27b. Sigma Orionis (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, January 28

Today we honor shuttle commander Dick Scobee, pilot Mike Smith, astronauts Ellison Onizuka, Judy Resnik, Ron McNair, and Greg Jarvis, and teacher Christa McAuliffe—the crew onboard the space shuttle *Challenger* when it exploded on this day in 1986. Godspeed. . .

“We will never forget them, nor the last time we saw them, this morning, as they prepared for the journey and waved goodbye and slipped the surly bonds of Earth to touch the face of God,” said then-President Ronald Reagan.

Today also celebrates the 1611 birth of Johannes Hevelius. Hevelius produced the first detailed lunar maps, published as *Selenographia*, in 1647. Did you spot the Moon just after sunset? If so, your observation is called “The New Moon in the Old Moon’s Arms.” Rather romantic, don’t you think? Hevelius also named the constellation Lynx, saying an observer needed to have eyes like a lynx just to see it! Tonight we’ll honor his achievements as we search out the most distant object in our galaxy—NGC 2419. Telescopic only, this magnitude 11.5 study requires clear, dark skies and a minimum of 6” aperture. Lynx is a difficult constellation, but you’ll find 2419 more easily by looking 7 degrees north of Castor (RA 07 38 08 Dec +38 52 54), where two stars appear at the western edge of a hazy patch.

There’s a good reason why this elusive globular cluster is so special. Commonly known as the “Intergalactic Wanderer,” NGC 2419 is so distant it was once believed to be outside our galaxy. Almost all globular clusters are located within the galactic halo—a region that extends about 65,000 light-years from the galactic center. Our faint friend is 210,000 light-years from where it belongs! NGC 2419 is as distant as our galactic “neighbors,” the Magellanic Clouds! But don’t worry, our galaxy has sufficient gravity to keep the Intergalactic Wanderer around long enough for you to capture it for yourself!



Figure 1.28a. Challenger crew (credit—NASA).

Thursday, January 29

Today, salute the 1817 birth of William Ferrel. His equations, known as “Ferrel’s Law,” demonstrated how Earth’s rotation affects high and low pressure systems, and the deflection of air and water currents. Ferrel also studied solar and lunar gravity and the effects created on Earth’s rotation. Even with no proof, he was first to claim Earth’s axis had a wobble!

Tonight locate Uranus about a binocular field (4 degrees) south of the Moon. Unlike Earth’s 24-hour rotation, Uranus whizzes around completely in just slightly over 17 hours. Does it wobble? Wobble isn’t the word for it. Uranus orbits nearly on its side! This unusual tilt leaves one polar region pointed toward the Sun for decades, heating it far more than the equatorial region. Ferrel’s Law becomes dramatically apparent on Uranus, as the resulting imbalance in energy released between hemispheres causes the planet to have 720 kilometer-per-hour winds!

Now observe an area of incredibly large mass shifts about a thumb’s-width northwest of Betelgeuse. Here you’ll find Cederblad 59, Barnard 35, and FU Orionis (RA 05 46 00 Dec +09 00 00). If you think you’re seeing a whole lot of nothing around a hairy little star, you’d be right. The main area is the obscuring dark nebula Barnard 35, but focus on the peculiar little yellow star, FU Orionis, a “pre-main-sequence eruptive variable.” Over several months, they slowly brighten by as much as 6 magnitudes while shedding matter; then slowly decline over the years. The prototype FU Orionis may harbor a large accretion disk or an equally large planet—possibly the underlying reason for the huge mass shifts, which trigger its eruptions. No one is certain what causes their variations in brightness, but “FUors” are associated with reflection nebulae, in this case, Cederblad 59. If you think Uranus spins fast, consider FU Orionis, clocking in at 60 kilometers per second!



Figure 1.29a. Cederblad 59, B 35, and FU Orionis (credit—Palomar Observatory, courtesy of Caltech).

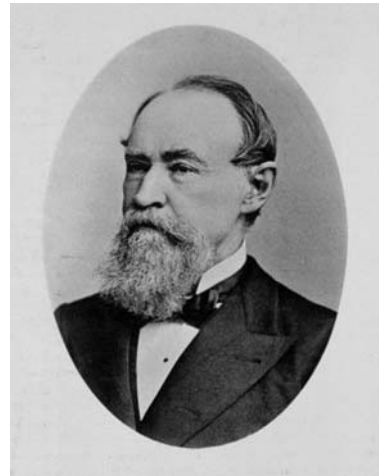


Figure 1.29b. William Ferrel (historical image).

Friday, January 30

Tonight's early evening Moon is high enough to warrant study. During the last lunar cycle, we reviewed maria large enough to be seen unaided, but many more can be revealed telescopically. Magnify the Crisium region and let's look around. . . Along the eastern side near the lunar limb is Mare Marginis, whose position between the nearside and farside will never allow us to see more than a thin gray line. Thanks to the lunar orbiters, we know it has an irregular border and shallow lava fill, which lead scientists to believe Marginis wasn't created from an impact. Located southeast is Mare Undarum, the "Sea of Waves." This highly elevated part of the Crisium basin is about the size of Massachusetts, and it probably filled with lava around the time of the Imbrium impact. Northeast, and separated by a mountain range, is Mare Anguis, or the "Serpent Sea." This Vermont-sized area of lunar landscape formed differently and may be home to a vast number of lava tubes.

Now look to Crisium's northwest for a new feature, Lacus Bonitatis, or the "Lake of Goodness." With features similar to those of maria, this small, irregularly shaped area has as much "coastline" as the Black Sea! Further south is Palus Somni, the "Marsh of Sleep." This curious feature is an upland area. Relatively flat—but very uneven—its high albedo (surface reflectivity) makes it a rewarding study. Last on tonight's tour is Sinus Concordiae, the "Bay of Harmony." Essentially part of the maria that spawned it, this inlet leads toward higher ground. Concordiae's small bay is roughly the size of Pedro Bank in Jamaica. Like its earthly counterpart, it may have mountain peaks that are just barely covered—but by lava flow, not seawater. Be sure to list your evening's observations in your lunar notes. We'll return here for more!

"Everything has a natural explanation. The moon is not a god, but a great rock."—
Anaxagoras (475 bc)

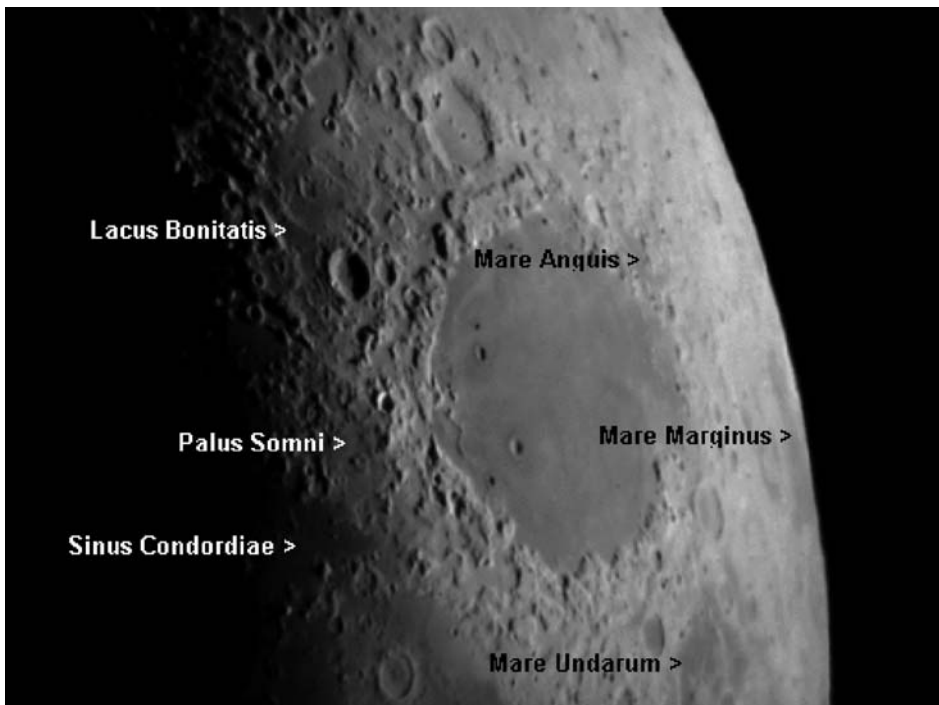


Figure 1.30. The Crisium Region (credit—Greg Konkell).

Saturday, January 31

What a busy date in astronomy history! In 1958 the United States launched its first satellite—*Explorer 1*—which discovered the bands of radiation now referred to as the Van Allen Belts. In 1961 the Mercury-Redstone 2 launched, carrying Ham the chimpanzee to fame. Cabin pressure failed during the suborbital flight, but inside his pressure suit, Ham remained safe and performed his tasks with a reaction time only a half second slower than on the ground, proving primates could function in space! Ham lived for another 17 years, and the celebrated chimp gave many performances—even guest starring in movies!

Luna 9 was launched in 1962 and 72 hours after its launch became the first craft to successfully touch down on the Moon and broadcast television from Oceanus Procellarum. Even Apollo 14 was Luna-bound today in 1971!

Alvan Graham Clark, Jr, made history at the eyepiece on this date in 1862. While watching Sirius and testing an 18" refractor his family built, Clark uncovered the intense star's faint companion—Sirius B. Friedrich Bessel had proposed its existence back in 1844, but this was the first visual confirmation.

Try your own hand at the "Scorching One." Alpha Canis Majoris has an amazing magnitude of -1.42 . Next to Alpha Centauri, 8.7 light-year distant Sirius is the closest visual star, but it's not standing still. Part of the Ursa Major moving stream, Sirius has changed position by one and half times the apparent width of the Moon in just 2,000 years! Telescopically, this main-sequence gem is dazzling white, tinged with blue and diffracts a rainbow of colors. For many of us, beautiful iridescence is all we'll ever see, but a 10" telescope under perfectly steady skies will reveal the secretive companion. In 20 years it will reach maximum separation of $11.5''$, so keep watching to Sirius' southeast when you observe—perhaps you'll spot B!



Figure 1.31a. Sirius Sirius (credit—John Chumack).

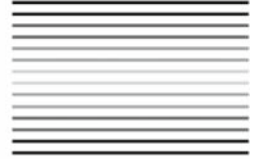
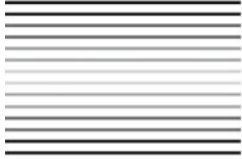


Figure 1.31b. Ham the Chimpanzee Ham the Chimpanzee (credit—NASA).

CHAPTER TWO



February, 2009



Sunday, February 1

On this day we celebrate the 1905 birth of Lloyd Berkner, the first person to measure Earth's ionosphere. His work with radar led to an understanding of radio wave propagation. He also served as administrator at Green Bank National Radio Astronomy Observatory. For his achievements in space science, NASA awarded Berkner the Distinguished Public Service Medal.

The broad crescent Moon dominates the early evening sky. Tonight we'll explore new features as we start in the lunar north with Mare Humboldtianum spanning 350 kilometers, this inconspicuous multi-ringed feature depends on libration for best views. Further south along the limb is Lacus Spei (the Lake of Hope), a diminutive feature so small it could be crossed at walking speed in 10 hours! West of Humboldtianum and Spei is a pair of lighter areas devoid of features—Lacus Temporis (the Lake of Time). These two small overlapping basins were filled by the same lava flow, thus forming this small mare. How long to walk across Temporis? Twice as much "Time" as "Hope"!

Relocate Mare Frigoris (the Cold Sea) and look south along the terminator for Lacus Mortis (the Lake of Death) and its counterpart Lacus Somniorum (the Lake of Dreams). Is there a connection here? You betcha! These two basin areas were filled from a basaltic flow, which might have united them, but a small mountain range kept them apart.

"There is something haunting in the light of the Moon; it has all the dispassionateness of a disembodied soul, and something of its inconceivable mystery."—Joseph Conrad

By the way, we believe Werner Heisenberg died on this day in 1976, but no one is certain.



Figure 2.1a. Hope, time, death, and dreams (credit—Greg Konkel).



Figure 2.1b. Lloyd Berkner (public image).

Monday, February 2

In 1962 on this date, eight planets lined up for the first time in 400 years. The dawning of the Age of Aquarius? No, just another normal aspect of the sky: a multiple planetary conjunction. Things don't truly "line up" in space; they just form associations. If you'd like an example, look to the Moon tonight as the bright asteroid Vesta appears about a fist-width south. Around magnitude 6, this traveling treat is well within range of small binoculars and telescopes! Now turn your optics toward the lunar surface to learn more major landmarks. Identify Mare Serenitatis, and let's take a closer look at what's around it.

Tonight reveals the first views of the mighty Caucasus Mountains bordering on Serenitatis's western shore. Emerging south along the terminator are the peaks of the Apennine Mountains; while to the north, major craters Eudoxus and Aristoteles are in full view. On Serenitatis's northeast bank is the shallow crater Posidonius, followed south by the round punctuation of Pliny, and Manilius to the west. If you'd like to continue with your "lacus" education, then power up on the region around Manilius for a closer look!

North toward the terminator is Lacus Felicitatis (the Lake of Happiness), which stretches some 90 kilometers in diameter. Farther south is 80-kilometer wide Lacus Odii (the Lake of Hatred) —the smallest of this group. Continue southeast for the largest— Lacus Doloris (the Lake of Sorrow), 110 kilometers across at its widest point. To its east is Lacus Gaudii (the Lake of Joy). Look closely for its upland region untouched by lava flow. Toward the south is Lacus Lenitatis (the Lake of Softness), and further east is Lacus Hiemalis (the Wintry Lake). Although these features seem minor compared to others, their combined area rivals that of the American Great Lakes!

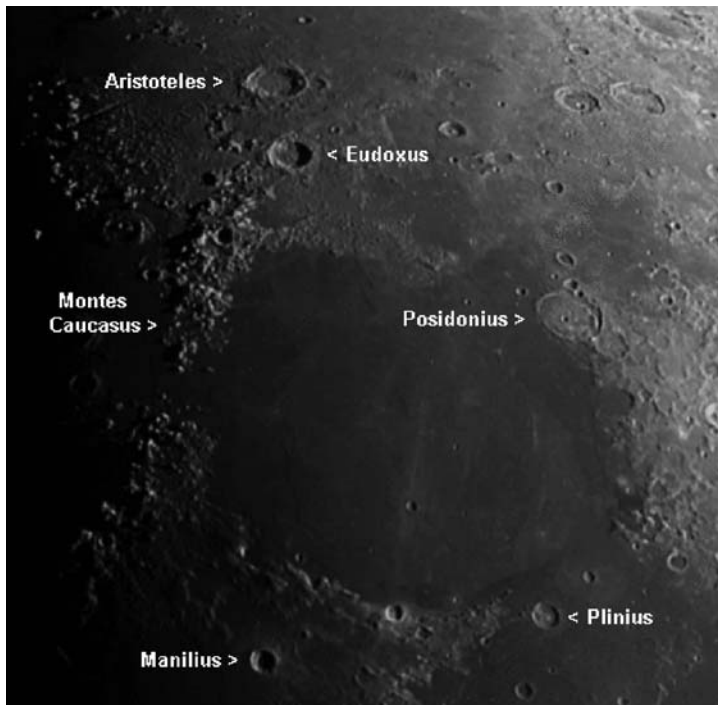


Figure 2.2a. The Serenitatis Region (credit—Dave Nash).

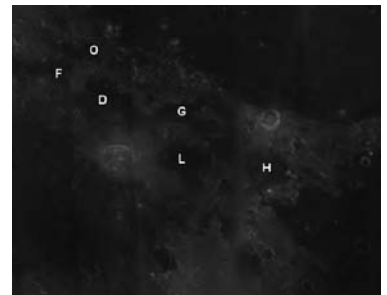


Figure 2.2b. Lunar Great Lakes (credit—Clementine Lunar Imaging/NASA).

Tuesday, February 3

Tonight we celebrate the 1966 first lunar landing success of Luna (Lunik) 9. Weighing in at 99 kilograms, the Soviet spacecraft landed in Oceanus Procellarum. Five minutes after touchdown, antennae sprang to life and television cameras began broadcasting the first panoramic images from the surface of another world. Take a telescopic look at a landing site tonight as we journey toward a dark, piano-shaped area named Palus Putredinus. Roughly the size of the English Channel, the “Rotten Swamp” is a region of nearly level lava flow bordered by rilles. Look closely at the center of the northern shore, where astronomers witnessed the impact of Luna 2 on September 13, 1959. The event cloud lasted 5 minutes and spread debris over 40 square kilometers!

When your lunar study is complete, identify the celestial “hare” Lepus hiding below the feet of Orion. Hop from bright Alpha to southern Beta and continue hopping the same distance southeast for multiple-star system Gamma (RA 05 44 27 Dec -22 26 54). In binoculars, Gamma Leporis A appears yellow with a faint orange companion, but a telescope will easily split and stabilize this colorful pair. The Gamma system (Figure 2.3b) belongs to the Sirius Moving Group and is currently about 29 light-years away. Its primary star—yellow A—is one of the top 100 targets for NASA’s planned Terrestrial Planet Finder (TPF). Slightly larger than our own Sun and over twice as bright, this 3-million-year-old star could have other companions apart from the smaller, less luminous B star—companions far too faint for us to see. Both the A and B stars’ systems may have “habitable zones”—areas where Earth-like or rocky planets might form. Although it could be many years before this is verified by the TPF, you can still enjoy this awesome double star for its vibrant colors!

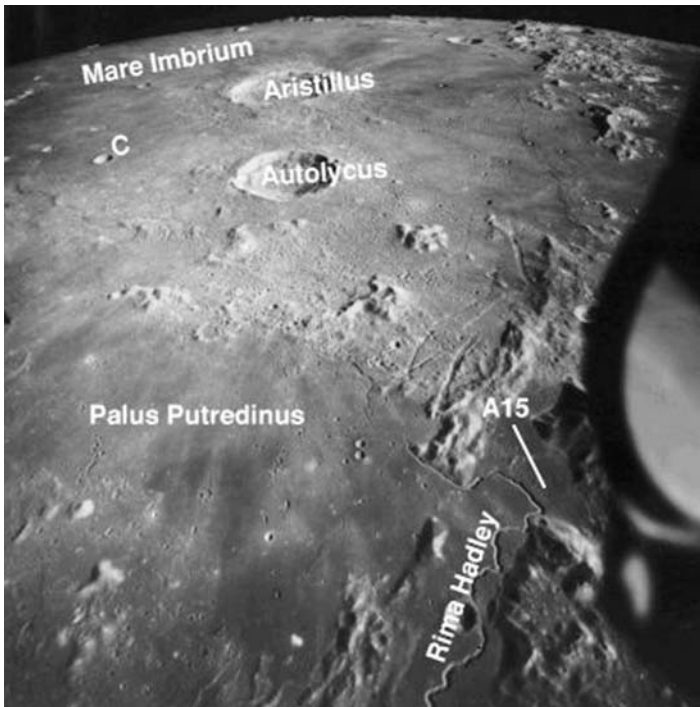


Figure 2.3a. Palus Putredinus (credit—Apollo/NASA).



Figure 2.3b. Gamma Leporis (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, February 4

The Pleiades and Moon will waltz together across the starry skies tonight and might present an Occultation event! Check the Resources section of this book or maps for locations. While waiting, try some lunar studies. You can view many features with binoculars, but a telescope at mid-range power is suggested. Our destination is the lunar north.

Now celebrate the 1906 birth on this date of Clyde Tombaugh, discoverer of Pluto and 14 asteroids. The Illinois-born astronomer built his own telescope, and his observations and sketches of Jupiter and Mars led him to find work at Lowell Observatory. Tombaugh continued his search for *trans*-Neptunian objects, knowing more discoveries lay in the future. To honor his memory, let's journey to Gemini, near where Pluto was discovered. About a fist-width southwest of Castor and Pollux is fainter Delta Geminorum (RA 07 20 07 Dec +21 58 56). Named Wasat, this 3.5-magnitude K-type star is around 53 light-years distant and has a visual companion easily seen with binoculars. Turn a telescope its way, and you'll find Wasat is a very beautiful binary with a disparate 8.2 magnitude red companion! The stars orbit each other extremely slowly—taking about 1,200 years—and the primary itself may be a binary.

Tombaugh's ashes are even now sailing toward that distant world aboard the New Horizons probe, but tonight as you look toward Gemini where he discovered it, salute a visionary astronomer:

"On those nights at home, I learned how to use a telescope and how to find objects in the sky. You don't do that by going to a bar and drinking beer."—Clyde Tombaugh

To Clyde, long may your own star shine on. . .



Figure 2.4a. Plato region (credit—Greg Konkel). (1) Eudoxus, (2) Aristotle, (3) Caucasus Mountains, (4) Lunar Alps, (5) Vallis Alpes, (6) Aristillus, (7) Autolycus, (8) Archimedes, (9) Mons Piton, (10) Mons Pico, (11) Straight Range, (12) Plato, (13) Mare Frigoris, (14) W. Bond, (15) Barrow, (16) Meton, (17) Cassini, (18) Alexander, (19) Montes Spitzbergen, and (20) Mons Blanc.



Figure 2.4b. Delta Geminorum (credit—Palomar Observatory, courtesy of Caltech).

Thursday, February 5

On this date in 1963, Maarten Schmidt measured the first quasar redshift, and in 1974, Mariner 10 took the first close-up images of Venus. See if you can spot the brilliant planet gracing the rose-hued skies at sunset, but take a closer look at the Moon. This date in 1971 was important for two men named Shepard and Mitchell, whose Apollo 14 module had just touched down in the Fra Mauro highlands. At 14:54 UTC, Alan Shepard stepped onto the surface and said, "It's been a long way, but we're here."

To binoculars, the Fra Mauro highlands are a lighter-colored area south of Mare Imbrium. Telescopically the shallow remains of Fra Mauro crater reveal soft hills, long rilles, and a barren landscape flanked by the southern craters Bonpland and Parry. Thanks to a seismometer left by Apollo 12, scientists believe a "moonquake" occurred on the northern shore near recent impact crater Cone, exposing "stuff" originating 161 kilometers below the original Imbrium basin crust! Shepard and Ed Mitchell climbed the slopes of Cone, photographing the 76-meter-deep interior and sampling boulders at its edge. Can you imagine what it was like? Said Mitchell:

"Large craters which we expected to be able to see standing out on a reasonably flat plane were not on a flat plane. They were hidden behind other craters, ridges, and old, worn-down mounds. ... It looked like we were in a large group of sand dunes. ... I never knew what to expect when I went over the ridge on the sand dune, or what I was going to see on the other side of it."

Have a look for yourself at this awesome area of lunar landscape. It will be years before the Fra Mauro area again appears close to the terminator on the very same date Apollo 14 made history there!

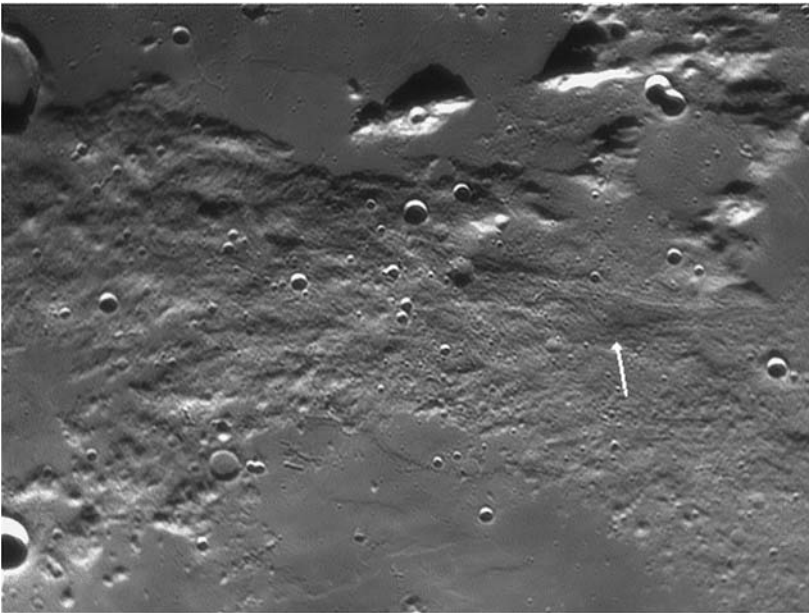


Figure 2.5a. Apollo 14 landing site (credit—Wes Higgins).

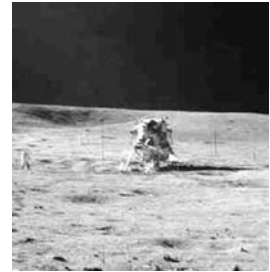


Figure 2.5b. Apollo 14 on the Moon (credit—NASA).

Friday, February 6

This date marks the 1991 fiery return of the Soviet space station Salyut 7. Launched in 1982, electrical and maneuvering problems plagued the mission, but cosmonauts were able to stay onboard for as long as 8 months before returning. Abandoned in 1986, equipment and supplies were transferred to the orbiting Mir. If you'd like to spot a space station, check the Resources in this book on how to get information for your area.

Return to the Moon tonight and explore the outstanding ring of crater Gassendi on the north shore of Mare Humorum. It's over 3.6 billion years old, and about the size of the state of Arkansas! Roughly 110 kilometers in diameter and 2,010 meters deep, this ancient crater contains a central triple mountain peak and forms one of the most "perfect circles" on the Moon. Lava flows have eroded Gassendi's south wall, and its floor is covered with ridges and rilles. Look for small crater Gassendi A on the northern rim. The northwestern section of the crater wall is slightly higher, saving it from the lava that formed Mare Humorum. Look carefully at the lower southern rim to find the gap where lava spilled over the walls. It's only 200 meters above the surface, while other areas rise as much as 2,500 meters. The fact that some parts of the rim escaped the lava is what makes this an interesting area for science!

On January 13, 2006, the Advanced Moon Imaging Experiment (AMIE) on board ESA's SMART-1 spacecraft imaged Gassendi from about 1,220 kilometers above the surface. Previous spectroscopic studies had shown that the central peaks might have experienced their own volcanic period—earlier than the event that filled the lower floors. These ancient highland rocks may one day give us significant insight into the thermal history of the Mare Humorum impact basin and the processes that formed Gassendi. Enjoy this ancient beauty!



Figure 2.6a. Gassendi (credit—Wes Higgins).



Figure 2.6b. Salyut 7 (credit—NASA).

Saturday, February 7

On this date in 1889, the Astronomical Society of the Pacific was born. In 1926 celebrated cosmonaut Konstantin Feoktistov, who flew Voskhod 1 and helped design Salyut and Mir, was born. Yet most noteworthy today is the 1824 birth of amateur astronomer William Huggins. By age 30, he'd built his own private observatory and through his studies made important contributions to astronomy. According to scientists Kirchoff and Bunsen, the chemical composition of minerals could be determined from their spectral signatures. The inquisitive Huggins began comparing mineral samples to the spectra of celestial objects. Although his experimental methods were crude by today's standards, his calculations were perfect. Huggins proved the spectrum of the Orion Nebula was like that of a pure gaseous emission, while the spectrum of the Andromeda Nebula was similar to that of starlight—and this long before confirmation of its galactic nature!

Huggins was also the first amateur to measure the radial velocities of stars from their spectral shifts. Although most people assume only professional scientists can make such measurements, many of today's amateurs (unpaid, but not unskilled!) have measured spectra. Tonight let's look at a star whose radial velocity has been studied both professionally and personally—Kappa Orionis (RA 05 47 45 Dec -09 40 10). Named Saiph, it's the often-overlooked eastern "foot" of Orion. According to spectral analysis, this 722 light-year distant blue supergiant is moving away from us at 21 kilometers per second. Roughly the same type, size, and distance as Rigel, it looks far fainter. But why? Oddly enough, Saiph has an extremely high temperature, burning more than 1,500 K hotter. Near the point where helium fusion replaces hydrogen fusion, the majority of its variable light output is in the ultraviolet band. And as Huggins once said: "It is remarkable that the elements diffused through the host of stars are some of the most closely connected with the living organisms of our globe."



Figure 2.7a. Kappa Orionis: Saiph (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.7b. William Huggins (historical image).

Sunday, February 8

On this date in 2001, the Sayh al Uhaymir 094 Mars Meteorite was discovered. Some space-born debris from Martian impact craters is eventually captured by Earth's gravity. The surviving meteorites can be identified by their mineral composition, as well as from tiny gas deposits matching Viking lander samples of Mars's atmosphere. Tonight, aim your optics toward the Moon and study an impact crater large enough to have blasted lunar material back to Earth. Its name is Tycho. . .

Take one glance at the lunar Southern Hemisphere, and you can't miss the dazzling display of 85-kilometer-wide Tycho, and its brilliant splash ray pattern. Perhaps 100 million years ago a comet, an asteroid, or a large meteorite impacted the Moon, flinging debris far and wide. One of Tycho's ejecta paths (rays) crosses the *Apollo 17* landing site almost 2,000 kilometers away, where it caused a landslide, revealing deeper materials. Shining like a beacon in Tycho's center is a mountain peak originating from below the surface crust. The crater floor is lumpy and the rim broken by the force of the impact.

Could a collision like Tycho's create Earth-bound meteoroids? Indeed, you may have walked on one unaware! The first confirmed lunar meteorite was found in 1979 in Antarctica, but it was many years before its true identity was known. Confirmation required comparison of its chemical composition to that of Apollo lunar samples. To date, only around 40 confirmed lunar meteorites are known, but as many as one in every thousand may have originated from our nearest neighbor. Noble gas measurements show some of these materials may have left the lunar surface up to 20 million years ago, but most are around 100,000 years old. They might resemble terrestrial rocks, but ones with their chemical composition are found only on the Moon. Have a look at Tycho and imagine the power that sculpted this mighty crater!

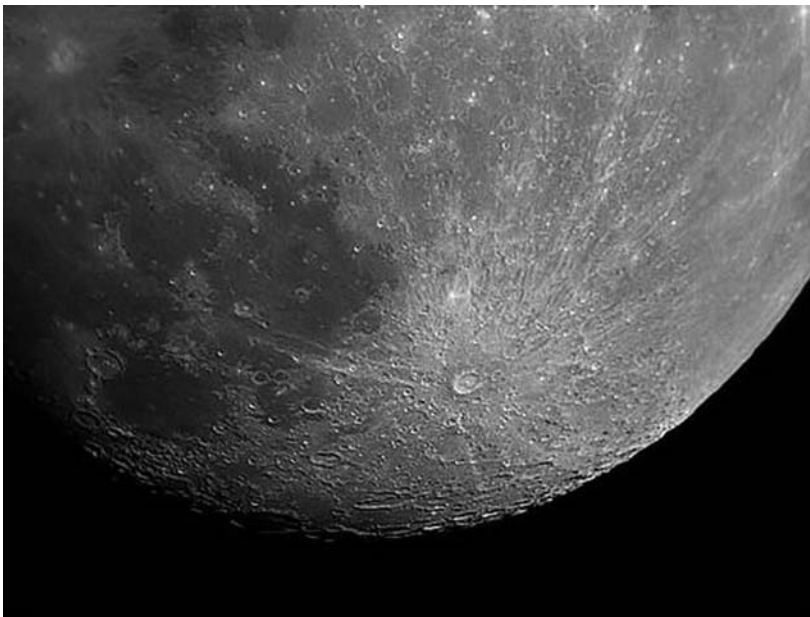


Figure 2.8a. Tycho (credit—Roger Warner).

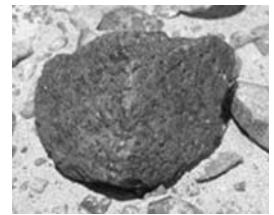


Figure 2.8b. The Mars meteorite (historical image).

Monday, February 9

On this date in 1995, Bernard Harris became the first African–American to spacewalk into the history books. Only 512 years before, Copernicus was observing the Moon occult Aldebaran! Cool facts, but the real daily scoop came from the Deep Space Probe Science Experiment (DSPSE), a lunar orbiter called “Clementine.” On this date in 1994, Clementine was cruising above the surface when it received the command to open its four cameras and start clicking the first of over a million images. With superior photographs at 125–250 meters per pixel resolution, and Clementine’s onboard laser altimeter gathering data, both science and the public shared the first lunar topographic maps!

Rising opposite the Sun tonight is the Full Snow Moon, but is the Moon as white as snow? For viewers in Eastern Europe, Africa, Asia, and most of North America the Moon will be slightly shadowed as it passes through Earth’s penumbral cone between the hours of 12:36 and 16:39 UTC. Normally penumbral eclipses are more of academic interest than occasions for spectacular viewing, but this time it’s different. If we projected Earth’s shadow cone on a screen, we’d see the Moon passing fully into the penumbra—just missing the edge of the deeper umbra shadow. Although it’s a subtle difference, it’s a wonderful way of watching celestial mechanics happen firsthand!



Figure 2.9a. Clementine’s view from the Shadows (credit—NASA).

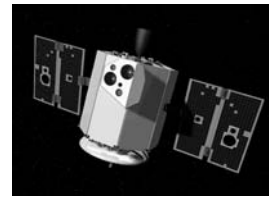


Figure 2.9b. Clementine (credit—NASA).

Tuesday, February 10

On this date in 1720, Edmund Halley was appointed second Astronomer Royal. Too bad he didn't live to see the 1842 birth of Agnes Mary Clerke, an Irish writer recognized internationally for her superb compilations of facts. In 1903, the Royal Astronomical Society awarded her an honorary membership, placing her with Caroline Herschel and Mary Somerville. You'll find some of her astronomical entries in the *Encyclopedia Britannica*!

One of Agnes' most fascinating books is *The Herschels and Modern Astronomy*. Her delightful insight showed us Sir William in a light we rarely see:

"The vision of the skies was never lost sight of, and the struggle to realize it in conjunction with his sympathetic helpers absorbed every remnant of time. At meals the only topics of conversation were mechanical devices for improving success and averting failure. William ate with a pencil in his hand and a project in his head. Between the acts at the theatre, he might be seen running from the harpsichord to his telescope. After a rehearsal or morning performance, he would dash off to the workshop in periwig and lace ruffles, and leave it but too often with those delicate adjuncts to his attire torn and pitch-bespattered."

Before moonrise, celebrate Clerke's birthday by studying a difficult open cluster discovered in 1784 by William Herschel on this very night—NGC 1663. Located about two finger-widths southeast of Aldebaran (RA 04 49 24 Dec +13 08 27), near a curving trio of brighter stars, a telescope sees it as a small compression of stars, requiring a larger aperture to resolve. At 700 light-years away, scientists are unsure of its classification, but believe NGC 1663 to be the remnants of a once-larger open cluster. Although its appearance is unprepossessing, NGC 1663 lent itself to science indirectly: while it was under study, three new galaxies were discovered. *That* would have brought Herschel running from the harpsichord!



Figure 2.10a. NGC 1663 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.10b. Agnes Mary Clerke (historical image).

Wednesday, February 11

Today marks the 1657 birth on this date of Bernard Le Bovier, French scientist and author who interpreted science in everyday terms. By an odd quirk of astronomical fate, he was born on the anniversary of Rene Descartes' death ("I think, therefore I am")—a philosopher whose theories he popularized—and wrote Sir Isaac Newton's obituary. Le Bovier's sense of humor used Descartes' atomistic philosophy to advantage, proclaiming that living beings existed elsewhere on their own planets. His satirical books were extremely popular, and *Conversations on the Plurality of Worlds* became a worldwide bestseller. The following is from that work:

"We alone can recognize that we, in a company of fourteen worlds, revolve round the Sun. . . We alone can establish truths about the motions and properties of the planets. If the Creator had not wished us to do this, He would not have given us such a convenient observatory."

While celebrating February 11, view an open cluster discovered by Herschel on this date. Find the area easily by aiming binoculars about halfway between Alpha Orionis and Gamma Geminorum (RA 06 13 42 Dec +12 48 06). Look for a faint pair of stars known as K Orionis, but don't confuse them with slightly brighter Xi and Nu. Concentrate on the northernmost of the K pair, and you'll pick up a slight condensation of faint stars—NGC 2194. While this Herschel "400" target is sufficiently bright to see in small optics, its true beauty shines in larger telescopes. This rich, young concentration of stars is over 3,700 light-years away and is less than 9,000 years old. Photometric studies of this neophyte cluster show it to be metal-poor for its age, but NGC 2194 is definitely a very pleasing sprinkling of stars to enjoy on a winter's night!



Figure 2.11a. NGC 2194 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.11b. Bernard Le Bovier (historical image).

Thursday, February 12

Today is unofficially Physicist's Day! We'll begin by celebrating three notable births on this date, starting in 1893 with Marcel Minnaert, solar physicist. Minnaert's innovative techniques in solar spectrophotometry aided the discovery of structure in the Sun's outer layers. Next is 1918 and Julian Schwinger, a physicist big on electromagnetic field theory, who shared the Nobel Prize for work in quantum electrodynamics. Last is the 1936 birth of Fang Lizhi, who published his work on the Big Bang theory in 1972. Even in exile from Communist China, he continues to express his belief in freedom of intellectual expression and continues his work in theoretical cosmology.

Tonight we'll time-travel back 5,000 years as we head for NGC 2392. Located about two finger-widths southeast of Delta Geminorum (RA 07 29 10 Dec +20 54 42), this beauty is a planetary nebula commonly known as the "Eskimo." Discovered in 1787 by Sir William Herschel, a small telescope will see it as a fuzzy green star, while aperture will reveal definite annulus around its central stellar point. A steady night helps to reveal details, and a nebula filter lights it up! NGC 2392 is so complex that it is not yet fully understood. As with Minnaert's solar work, we know the glowing gases are the outer layers of its central star, shed 10,000 years ago, while the inner ribbons of light (called filaments) are areas where particles are being pushed away by the strong stellar wind. Even now, we still can't quite explain the unusual outer filaments! It won't look like a Hubble image in your telescope, but you can still marvel at a unique mystery—seeing its light as it was when "physicists" began using the first "computer"—the newly invented abacus!



Figure 2.12a. NGC 2392 (credit—Palomar Observatory, courtesy of Caltech).

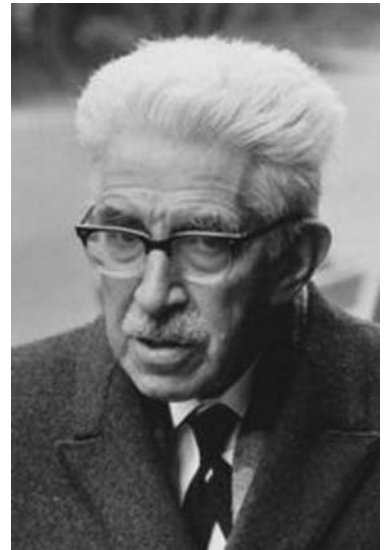


Figure 2.12b. Marcel Minnaert (historical image).

Friday, February 13

We salute Johan Ludvig Emil Dreyer, who was born on this date in 1852. At age 30, Danish astronomer Dreyer became director of the Armagh Observatory—not a grand honor, considering the observatory was so broke it couldn't afford to replace its equipment. Like all good directors, Dreyer somehow managed to get a new 10" refractor but no funds for an assistant to practice traditional astronomy. However, J.L.E. was dedicated and within 6 years had compiled all observations known to him into one unified work called the *New General Catalogue of Nebulae and Clusters of Stars* (NGC). Originally containing 7,840 objects, and supplemented in 1895 and 1908 with another 5,386 designations, the NGC remains the standard reference catalog. Although Dreyer's personal observations included such nebulous descriptions as "a vault of stars," modern astronomers continue to use his abbreviations as a kind of shorthand.

Honor Dreyer tonight by discovering one of his catalog objects suited for all optics—NGC 2287. Located about two finger-widths south of Alpha Canis Majoris (RA 06 46 00 Dec +20 46 00), only an open cluster this bright could stand up against brilliant Sirius. From a dark-sky location, your unaided eye can even spot this magnitude 4.5 star vault as a hazy patch. Aristotle saw it as early as 325 BC! Officially discovered by Hodierna, we know it best by the designation Messier Object 41. Even from 2,300 light-years away, the cluster's brightest star, an orange giant, stands out clearly from the stellar nest. With large aperture, you'll notice other K-type stars, all very similar to Sol. Although small scopes and binoculars won't reveal too much color, you might pick up on the blue signature of young, hot stars. NGC 2287 could be anywhere from 190 to 240 million years old, but its stars shine as brightly now as they did in Aristotle's day...and Dreyer's!



Figure 2.13a. NGC 2287: M41 (credit—Palomar Observatory, courtesy of Caltech).

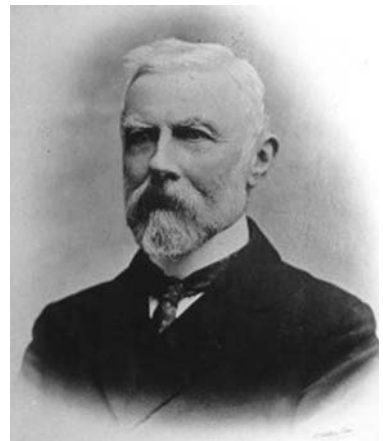


Figure 2.13b. J.L.E. Dreyer (historical image).

Saturday, February 14

On this date in 1747, astronomer James Bradley presented his evidence of Earth's wobble, called nutation. The study took 19 years, but won Bradley the Copley Medal! In 1827, George Clark was born. The name might not ring a bell, but it was indeed a bell—melted down—that he used to create his first brass telescope. George's family went on to produce the finest—and largest—telescopes of their time.

In 1898 Fritz Zwicky came along, his name synonymous with the theory of supernovae. The Swiss-born Caltech professor was also a salty character, often intimidating his colleague Walter Baade and referring to others as "spherical bastards." Although Zwicky was difficult to work with, he was also brilliant—predicting the phenomenon of gravitational lensing.

Tonight we'll look at a supernova remnant as we venture to the Crab Nebula. Finding M1 is easy: it can be seen with as little as $7\times$ magnification. Locate Zeta Tauri (about halfway between Orion's "head" and the southernmost bright star in Auriga) and aim about 1 degree northwest (RA 05 34 31 Dec +22 00 52). Viewing M1 with small optics helps to understand why Charles Messier decided to compile his famous catalog. Unaware of its earlier discovery, Messier located a fuzzy object near the ecliptic and assumed it was the return of Halley's Comet. Considering his primitive telescope, we can't fault his observation. But Chuck was a good astronomer. When he realized the object wasn't in motion, he began compiling a log of things not to be confused with comets—the famous Messier objects. Enjoy looking at this spectacular deep-sky jewel, and we'll study it in depth another time. Of course, Zwicky would have cursed me for saying that observing without science is an "empty brain exercise and therefore a waste of time." But on the date of his birth, I took his advice... "Give me a topic and I'll give you an idea!"



Figure 2.14a. Messier Object 1 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.14b. Fritz Zwicky (historical image).

Sunday, February 15

This date's astronomical births begin in 1564 with Galileo Galilei—pioneer of physics and astronomy—who didn't invent the telescope but certainly perfected it. Arrested for heresy, Galileo entreated fellow scientists to discover the universal truths for themselves. His cry was ignored. To his friend, Johannes, he wrote:

"I wish, my dear Kepler, that we could have a good laugh together at the extraordinary stupidity of the mob. What do you think of the foremost philosophers of this University? In spite of my oft-repeated efforts and invitations, they have refused, with the obstinacy of a glutted adder, to look at the planets or Moon or my telescope."

The birth of lunar and planetary observer William Pickering followed in 1858. During Pickering's professional years at Harvard, he noted that the entire constellation of Orion is encased in faint nebulosity. Later verified by E.E. Barnard, this nebula is now known as Barnard's Loop.

With a very dark sky and excellent transparency, you can trace the "Loop" with binoculars. The area is so large and it's pointless to provide coordinates, but the brightest portion extends eastward between Alpha and Kappa. Because the Orion complex contains so many rapidly evolving stars, it stands to reason a supernova has occurred there. Barnard's Loop is probably the ancient shell leftover from such a cataclysmic event. If taken as a whole, it would encompass 10 degrees of sky! More difficult for Northern Hemisphere viewers is IC 2118, a huge reflection nebula west of Rigel known as the "Witch Head." Once photographed by Pickering, IC 2118 is more sensitive to film than to the eye, but that doesn't mean you can't see it. Sky conditions are the decisive factor, so look closely around the eastern edge where the fueling stars are brightest. You just might surprise yourself!



Figure 2.15a. Eastern edge of IC 2118 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.15b. William Pickering (historical image).

Monday, February 16

Joachim Rheticus was born on this date in 1514. While still a teenager, Rheticus' father was beheaded just for teaching astronomy. Despite persecution, Joachim remained loyal to the teachings of Copernicus and published the first account of the heliocentric hypothesis in 1540. Nearly two centuries later on this date, Pierre Bouguer (1698) was born. A child prodigy and a professor by age 15 (a smart little Bouguer), Pierre was the first to fashion a workable photometer. His simple device used translucent paper, which enabled him to compare the intensity of light sources.

Tonight we appeal to the more advanced stargazer. Begin at the border of Orion and locate 8 Monoceros. We're hunting for an odd star cluster called Dolidze 22 (RA 06 23 06 Dec +04 40 55). Although there's no great scientific reason to observe this sparse open cluster, it's an exercise aimed at sharpening your skills. To date, no data exist on the cluster's true distance or age. Now, move about 2 degrees south and study Collinder 91 (RA 06 21 42 Dec +02 22 00). Again, a loose, star-poor collection, essentially unstudied except for association. Why choose these two objects instead of brighter ones? Learning to visually understand a group relationship among stars is a skill Sir William Herschel had naturally, but one that can only be developed by most of us with a lot of practice. As Herschel once said:

"The phenomena of nature, especially those that fall under the inspection of the astronomer, are to be viewed not only with the usual attention to facts as they occur, but with the eye of reason and experience."



Figure 2.16a. Dolidze 22 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.16b. Collinder 91 (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, February 17

Sky alert! At dawn, Mars and Jupiter will be about half a degree apart, but the real show is Antares and the Moon. A close brush for some—and an occultation for others! Be sure to check the Resources section for specific times and locations.

This morning there's a special reason to aim a telescope toward the Moon—Giordano Bruno. Philosopher, monk, and a mathematician, the 1548-born Bruno was most importantly an astronomer who believed in an infinite universe and multiple worlds. . .and spoke against both an Earth-centered universe and the idea of immutable stars. In 1592, he was imprisoned for 8 years but refused to change his stance. For his heresy, he was burned at the stake on this day in 1600. During his lifetime, Giordano Bruno became one of the very few people to witness a lunar impact, and the resulting crater bears his name. Although this crater is very small and requires favorable libration to observe, why not honor Bruno by looking the Moon's way? After all, he was willing to die for what we now know is true!

Tonight journey south of Orion to Lepus and its brightest star—Alpha. Named Arneb, this double star resides about 900 light-years away. Its wide separation of 35.5'' means it's probably not a true physical pair, but the 11th magnitude disparate companion is a nice challenge. For binoculars and small scopes, hop due east of Alpha about a finger-width for brilliant multiple-star system and open cluster NGC 2017. The gravitationally bound stars in this small open cluster are a well-studied source of radio and infrared emission. NGC 2017 produces a dense wind from a thin H II region hidden within it, which may come from a loose distribution of gas and dust. Power up, and the primary colorful members begin to split into disparate pairs as the combination of aperture and magnification increases resolution. It's a much underrated jewel box!



Figure 2.17a. NGC 2017 (credit—Palomar Observatory, courtesy of Caltech).

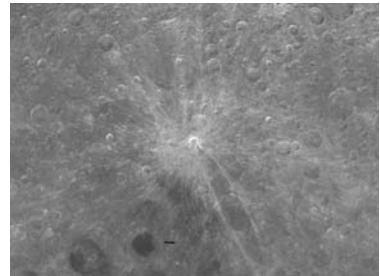


Figure 2.17b. Crater Giordano Bruno (credit—NASA).

Wednesday, February 18

Tonight let's honor Sir Patrick Moore and his catalog of sky greats—the Caldwell List. Begin with Sirius and the southern upside down Y formation of Canis Major, whose crux is Delta. Hop northeast to Tau for open cluster NGC 2362 (RA 07 18 36 Dec 24 59 00). In binoculars, Caldwell 64 appears as two stars—Tau and the variable UW. At minor magnification, Tau shows a slight nebulosity, the many unresolved stars surrounding it. Now power up with a telescope and behold the “ Mexican Jumping Star!”

This rich, 4,600 light-years distant gathering contains about 40 members and is one of the youngest of known star clusters. Many resolvable stars haven't yet reached the main sequence! Still pulling together, the cluster is estimated to be less than a million years old. The central star—Tau—is a true member and one of the most intrinsically luminous stars known. This group may last as long as the Pleiades but will pull apart long before reaching the Hyades' age. Tau's immense stellar winds will blow away any accretion around the smaller stars. Magnify as much as skies will allow. As individual stars begin to resolve in and out around its bright central member, you can see how it got its nickname!

Now head for the eastern star, Eta Canis Majoris. Aim your binoculars about one field further south. Difficult for northern observers, this collection is visible unaided in the Southern Hemisphere. Collinder 140 (RA 07 23 18 Dec -32 04 00) is around magnitude 3.5 and is a rich open cluster. Located around 1,000 light-years away, and estimated to be 22 million years old, even small optics will enjoy this large, jewel-like collection of stars, which includes the double Dunlop 47 among its many binary systems. Studied for its unusual patterns of stellar evolution, Collinder 140 is worth some of your study time as well!



Figure 2.18a. NGC 2362 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.18b. Area of Collinder 140 (credit—Palomar Observatory, courtesy of Caltech).

Thursday, February 19

On this date we celebrate the 1473 birth of Nicolaus Copernicus, creator of the modern Solar System model.

“Finally we shall place the Sun himself at the center of the Universe. All this is suggested by the systematic procession of events and the harmony of the whole Universe, if only we face the facts, as they say, ‘with both eyes open.’”

Take a look at Copernican theory just as the master did:

“For a traveler going from any place toward the north, that pole of the daily rotation gradually climbs higher, while the opposite pole drops down an equal amount.”

While we won't travel, pick a bright star and watch as the evening progresses.

“I shall now recall to mind that the motion of the heavenly bodies is circular, since the motion appropriate to a sphere is rotation in a circle.”

Now let's further honor Copernicus with a star cluster discovered by Herschel in 1784 on this date—NGC 1817. Located in Taurus about a fist-width northwest of Orion's "head," this small open cluster pairs with NGC 1807, also a Herschel discovery. In the finderscope, locate 15 Orionis and you'll see the hazy pair about a degree northeast. The northernmost cluster—NGC 1817 (RA 05 12 12 Dec +16 41 00)—is about the same age as the Hyades and contains several hundred members. Less populous is the more southerly open cluster. NGC 1807 (RA 05 10 42 Dec +16 32 00), which photometric measurements show may not be a true cluster at all. Even larger telescopes have difficulty resolving out this very rich galactic cluster, which recent studies show contains as many as a dozen Delta Scuti type stars. Mark your notes, for this pair is an urban observing challenge, a Herschel object, and a binocular deep-sky target! Enjoy your observations. As Copernicus would have said:

“Although all the good arts serve to draw man's mind away from vices and lead it toward better things, this function can be more fully performed by this art, which also provides extraordinary intellectual pleasure.”



Figure 2.19a. NGC 1817 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.19b. NGC 1807 (credit—Palomar Observatory, courtesy of Caltech).

Friday, February 20

On this date in 1962, John Glenn was rocketing around Earth on his first orbit as our friends “down under” made history. Residents of Perth, Australia, simultaneously switched on lights as Glenn flew over—the first city spotted from space! Today in 1996 also marks the discovery of Sakurai’s Object, a star in collapse. While studying Sagittarius and photographing what appeared to be a typical nova, Yukio Sakurai became only the third twentieth-century astronomer to witness a star in final helium flash. When this occurs, the star is switching its nuclear fuel from hydrogen to helium and then burning the helium to carbon in the final stage, burping forth an envelope from its interior.

Let’s examine an open cluster where stars have gone through this same evolutionary step. Begin by identifying Delta Geminorum and hop a fist-width east for open cluster NGC 2420 (RA 07 38 23 Dec +21 34 24). This magnitude 8.5 group is visible under dark-sky conditions to binoculars as a weak, round, hazy patch and requires a mid-sized telescope to begin resolution of its long, looping chains of stars. Some members are similar to Sakurai’s Object, while others have evolved to helium depletion. Studying clusters like NGC 2420 is important: they are areas where stars are all about the same age, yet their different masses mean they evolve at different rates. Average telescopes will only see the primary stars, while large aperture notices the distinct glow of hundreds of stars on the verge of resolution. If you get the impression of a weak globular cluster, you’d be correct. With a thousand members packed into a 30-light-year sphere, a lot has happened during its 1.7-billion-year lifetime. It may have started in our own galaxy’s cluster-forming region and been thrown clear by an encounter with a large mass. Or, it might have once been part of a smaller galaxy absorbed by our own. But one thing is clear: its unusual Sun-like elements—so far from where they belong—make NGC 2420 a prime playground for study. Some of its members could even be blue stragglers—unions of two stars into one!

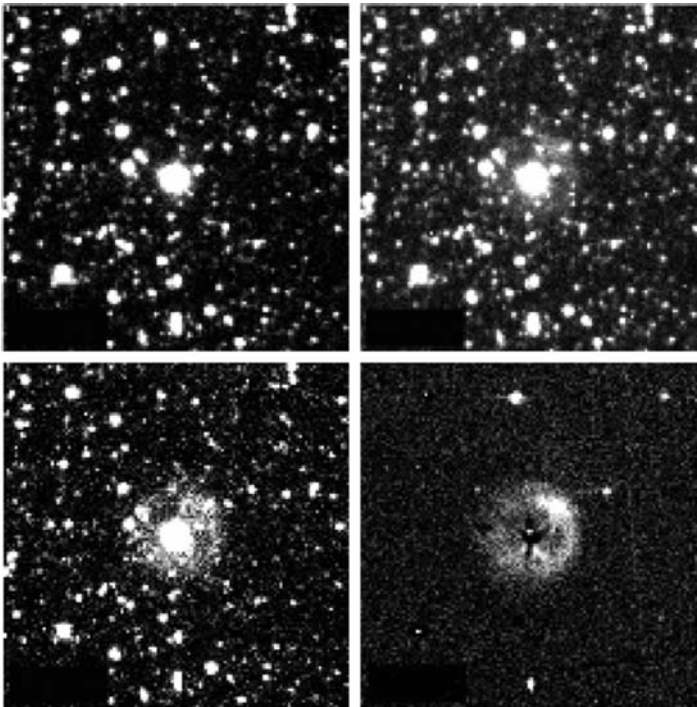


Figure 2.20a. Sakurai’s Object (press release photo).



Figure 2.20b. NGC 2420 (credit—Palomar Observatory, courtesy of Caltech).

Saturday, February 21

This day in 1972, Luna 20 made a safe touchdown in the Apollonius highlands, where it captured 30 grams of surface material to return to Earth. The Moon will make a very scenic appearance in the pre-dawn skies and be visible for several hours after the Sun rises. Take time to show others its position as you walk to work or school, and explain its movement toward the Sun from our viewpoint. How long does the Moon remain visible as the sky brightens?

Tonight we'll study an object of many names: Melotte 25, Collinder 50, and Caldwell 41, a star cluster so bright it doesn't require a telescope. At 150 light-years away, the Hyades is the nearest gathering of stars to our Solar System that can be seen as a cluster. So, where is it? First, look at Aldebaran. With the exception of this 60-light year-distant orange giant, almost all the stars around it are moving toward a point slightly east of Betelgeuse. The 790 million-year-old central mass spreads over a 10 light-year area, while outlying stars could stretch as far as 80 light-years. Aim binoculars its way and be blown away by a rich field of stars! Even with minimum magnification you'll split the brightest member of the Hyades, the twin Sigma pair. They'll appear close to the same magnitude and distance to the eye, but only the northernmost belongs to the Hyades moving cluster. Power up with a telescope. You'll discover a wealth of other doubles and delightful color combinations in this much under-visited treat!



Figure 2.21a. Illustration of the Hyades Cluster (generated image).



Figure 2.21b. Area of Sigma 1 and Sigma 2 Tauri (credit—Palomar Observatory, courtesy of Caltech).

Sunday, February 22

If you're up before dawn, look for the relatively close pairing of the waning Moon and Jupiter. Try using the Moon's position to see how long you can still spot the bright planet as the sky turns blue! When the Sun has risen, salute the 1824 birth of Pierre Janssen, the first to devise a method for observing solar prominences. With a spectroscope, he proved the solar chromosphere is gaseous in nature and reported a helium spectral line. Janssen was also the first to record surface granulation via photography and published his own illustrated solar atlas in the year 1904.

In 1966, Kosmos 110 launched its canine crew, Veterok and Ugolyok, into space history. Tonight let's look at a celestial dog as we turn to Canis Minor. A large portion of the constellation is only viewable from the Southern Hemisphere, and most of its brighter stars hide below the horizon for the north. Look for an arch of four fairly bright stars to the east of Canis Major. The second from the east is Xi Puppis. Aim telescopes or binoculars just north of Xi (RA 07 44 36 Dec -23 52 00) for M93.

This bright open cluster is a rich concentration of stars of various magnitudes, which explodes in sprays of stellar fireworks in the eyepiece of a large telescope. Spanning 18–22 light-years and residing 3,400 light-years away, M93 contains blue giants and lovely golds. Janssen would have been very proud to know it's been studied spectroscopically and contains many Sun-like stars! M93 is the last object personally discovered by Messier, who described it as "A cluster of small stars without nebulosity." Did he realize that the light left during the reign of Ramses III? Or that this celestial gathering was 100 million years old? Did Messier realize it was forming about the time Earth's landmasses were breaking up, dinosaurs ruled, and the first mammals and birds were evolving? Although H.G. Wells' *The Time Machine* is a work of fiction (published on this date in 1895), each time we view light through a telescope we take a journey back across time itself.



Figure 22a. M93 (credit—Palomar Observatory, courtesy of Caltech).

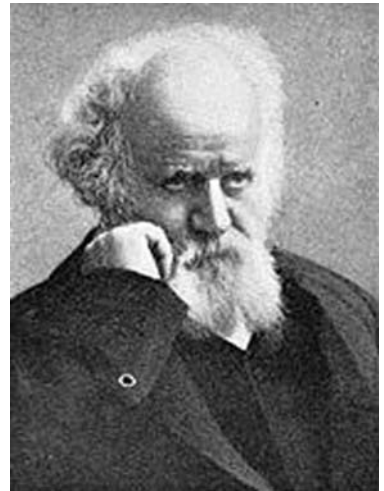


Figure 22b. Pierre Janssen (historical image).

Monday, February 23

On this date SN 1987A was first spotted in the Large Magellanic Cloud—the first bright supernova seen since 1604 and the brightest of the twentieth century. Almost exactly 20 years later, a supernova in Scorpius became the first unaided visible event of the twenty-first century! Supernova explosions are fairly common events in the universe. Once the initial burst is over, remnants—such as M1—may be visible for centuries in both X-ray and radio emission. But far more stars end their lives quietly, ejecting a shell of gas and forming planetary nebulae. Look to feet of Orion and the brightest star of Lepus, where the three make a triangle. Aim toward the center of the triangle (RA 05 19 45 Dec $-25\ 03\ 50$) for spectacular IC 418, the Spirograph Nebula. When its light left in 7 AD, the central star, much like Sol, was in its final stages. A few thousand years earlier it was a red giant, shedding its layers until only its superheated core remained. In several thousand years, the visible nebula will fade away, and in several billion, the central star will become a white dwarf. At magnitude 11, the central star is easily seen against a slightly elongated shell and larger scopes will see a delightful texture to this planetary object!

About a fist-width east-northeast of Sirius for NGC 2359 (RA 07 18 30 Dec $-13\ 13\ 48$) is a Herschel object known as “Thor’s Helmet.” Unlike the Spirograph, this unusual character is the product of the central Wolf–Rayet star, its stellar winds, and the surrounding interstellar matter. The powerful star emits a high velocity wind, pushing matter ahead of it—compressing and expanding its ring-like shell. As it grows, it collects more gas and dust from the interstellar medium. Although most planetary nebulae contain old stars, the central Wolf–Rayet star in NGC 2359 is very young. Its ultraviolet photons are the fueling source of this delightful 8th magnitude emission nebula!



Figure 2.23a. IC 418 (credit—NASA/Hubble Heritage).



Figure 2.23b. NGC 2359 (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, February 24

On this date in 1949, the first rocket to reach outer space was launched, and in 1968, *Nature* magazine announced a discovery made by Jocelyn Bell, a pulsar. Pulsars aren't visible, but let's look at a region containing one. Identify Procyon west of Orion, and then south for dimmer Alpha Monocerotis. Draw an imaginary line between them. If you use this distance as the base of a triangle, you'll find PSR 0820+02 (RA 08 23 09 Dec +01 59 12) at the apex pointed east.

Moonless nights are a good time to identify the faint constellation of Monoceros. Betelgeuse, Sirius, and Procyon form a triangle, and most of the Unicorn's stars fall inside it. Alpha Monocerotis is a handspan south of Procyon. Use Orion's belt and look a handspan east for Delta. A fist-width southeast is Gamma; and Beta is about two finger-widths further along. About a palm-width southeast of Betelgeuse is Epsilon. Knowing these stars will help you find many wonderful objects! Let's start our journey tonight two finger-widths northwest of Epsilon.

Binocular target NGC 2186 (RA 06 12 06 Dec +05 28 00) is a triangular open cluster set in a rich field, revealing 30 or more stars to a telescope. This Herschel "400" object can be spotted with simple equipment and has been searched intensively for circumstellar disks—the raw material for forming planetary systems. No luck? Then try using Sirius and Beta Monocerotis as guides to another cluster: hop about a fist-width east-southeast of Beta, or northeast of Sirius, for the magnificent M50 (RA 07 02 49 Dec -08 22 36). Containing as many as 200 members, this colorful old cluster resides almost 3000 light-years away. Its light left when people first smelted iron for use in tools, the Mayan culture was just beginning to develop, and the Hebrews and Phoenicians were creating alphabets. Binoculars see an almost heart-shaped collection of stars, while telescopes reveal color—including a very notable red star. Enjoy this worthy cluster and make a note. ...You've captured another Messier object!



Figure 2.24a. NGC 2186 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.24b. M50 (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, February 25

The New Moon is a time for obscure objects requiring dark skies. Locate Epsilon Monocerotis and head three finger-widths northeast for a vast complex of nebulae and star clusters. Variable binary S Monocerotis is easily visible, and small binoculars will find the beginnings of a rich cluster surrounding it: NGC 2264 (RA 06 41 00 Dec +09 53 00). Larger binoculars and small telescopes will detect a distinct wedge of stars—the 2-million-year-old Christmas Tree Cluster. Its nebulosity is beyond a small telescope, but the brightest portion is the Cone Nebula.

The northern region—the photographic-only Foxfur Nebula—is part of a vast complex extending from Gemini to Orion. Northwest are several regions of bright nebulae. Best suited to the average scope is large, faint NGC 2245, which accompanies an 11th magnitude star. Fog-like NGC 2247 is a circular patch of nebulosity around an 8th magnitude star. IC 446 is for larger aperture, appearing comet-like with nebulosity fanning away southwest. Even to a large scope, the “barely there” IC 2169 is most difficult of all!

Return to Epsilon Monocerotis, and move a finger-width east for another star field with an interesting companion. NGC 2244 (RA 06 31 54 Dec -04 56 00) is a galactic cluster embroiled in a reflection nebula commonly called the “Rosette.” The cluster stars heat the nebula’s gases to nearly 10,000 degrees Celsius, emitting light in a process similar to fluorescence. A huge percentage of this light is hydrogen-alpha; backscattered from its dusty shell and polarized. You won’t see any red hues, but with good seeing, small telescopes can detect a broken, patchy wreath of nebulosity around the well-resolved symmetrical concentration of stars crowned by the yellow jewel of 12 Monocerotis. Larger scopes, and filtered ones, will make out separate areas, which also bear their own distinctive NGC labels. The entire region is one of the best for winter skies!



Figure 2.25a. NGC 2264 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.25b. NGC 2244 (credit—Palomar Observatory, courtesy of Caltech).

Thursday, February 26

Today we celebrate the birth on this date of many astronomers, starting in 1786 with François Arago, who discovered the solar chromosphere and made astonishingly accurate estimates of planetary diameters. Arago's experiments proved the wave theory of light and contributed to the laws of polarization. Following in 1842 was astronomer and author Camille Flammarion, who studied multiple stars, the Moon, and Mars. Although erroneous in some observations ("May we attribute to the color of the herbage and plants which no doubt clothe the plains of Mars, the characteristic hue of that planet..."), Flammarion was entrusted with a personal copy of the Messier Catalog, including the author's notes, which he later revised. Last is the 1864 birth of John Evershed, who contributed mightily to solar physics when he photographically discovered that gases in sunspots flowed horizontally from the center toward their edges, an effect now named for him!

Let's celebrate them all by kicking up some stardust about 5 degrees south of Alpha Monocerotis and into Puppis for M46 (RA 07 41 42 Dec -14 49 00). Containing around 150 resolvable stars, and possibly involving as many as 500, this cluster appears faint and compressed to binoculars, but one star seems brighter than the rest. Through the eye of a telescope, you'll soon discover the reason! In its northern portion, the 300-million-year old M46 (Figure 2.26a) contains a planetary nebula known as NGC 2438, first noted by Sir William Herschel. While it would appear to be a member of the cluster, the planetary nebula is just a little closer to us than the stars. Be sure to mark your notes. There's a lot to find in just a little area! Afterwards, relax and enjoy the Delta Leonid meteor shower. Burning through our atmosphere at speeds of up to 24 kilometers per second, these slow travelers will seem to radiate from a point around the middle of Leo's "back." The fall rate is rather low at around 5 per hour, but they are still worth keeping a watch for!



Figure 2.26a. M46 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.26b. François Arago (historical image).

Friday, February 27

Today let's celebrate the 1897 birth on this date of Bernard Lyot, master of optics. He invented the polariscope, and produced the first solar coronagraph. He also made the first motion pictures of solar prominences. Lyot was an astute observer, and realized that the lunar surface had similar properties to volcanic dust. He didn't see canals on Mars but observed sandstorms there, as well as atmospheric conditions on other planets. The Lyot filter is well known, and so is his micrometer, a device used to make precise distance measurements, especially those between close double stars. By all accounts a wonderful and generous man, Lyot sadly died of a heart attack while returning from seeing an eclipse.

Honor Lyot's work by studying two open clusters, found about a fist-width north of Xi Puppis. The brighter of the two—M47 (RA 07 36 36 Dec -14 29 00)—is 1,600 light-years away and a glorious object for binoculars. Filled with mixed-magnitude stars that resolve fully to aperture, M47 features the matched-magnitude double star Struve 1211 near its center. For all its bright beauty, this stellar swarm has the most ironic of histories. Probably discovered first by Hodierna but kept secret, it was independently recovered by Charles Messier, but its position was logged incorrectly. Later, it was cataloged by both William and Caroline Herschel. . . and yet again by John Herschel, who said: "This cluster has not since been observed. It is probably very loose and poor one." Even Dreyer had a hard time nailing it down! Funny, considering it has only been there for 78 million years. . .

While M47 is a Herschel object, look just slightly north (about a field of view) to pick up another cluster that borders it, NGC 2423 (RA 07 40 45 Dec -19 09 00). This compressed cluster contains more than two dozen faint stars with a lovely golden binary at its center. By comparing the two clusters telescopically, you are also expanding your own studies by viewing two different types of stellar evolution: M47 is very similar to the Pleiades, while NGC 2423 more closely resembles the Hyades.



Figure 2.27a. M47 (credit—Palomar Observatory, courtesy of Caltech).



Figure 2.27b. Bernard Lyot (public image).

Saturday, February 28

If you didn't notice the beautiful visage of the tender young Moon and Venus last night at sunset, try again tonight. The pair will be even closer! For most observers, Venus will be only slightly more than a degree away from the Moon's limb. Have you checked Venus's phase in the telescope lately? Just like our own Moon, the inner planets (Mercury and Venus) have phases. Because they're inside Earth's orbital path, we only see a thin crescent when they first emerge from the Sun's glare, and they become gibbous as they are about to pass behind the Sun from our point of view. That's also the reason why we only see these two planets either after sunset or before sunrise!

Take a closer look at the slender crescent Moon. It, too, has only just emerged from the Sun's glare, and now is the time to get a great look at two craters—Langrenus and Vendelinus. If you remember Mare Fecunditatis, you won't have any trouble spotting Langrenus on its south shore about mid-way along the Moon's visible limb. It's a very old crater with an approximate diameter of 132 kilometers, and appears to binoculars as a shallow, bright ring; featuring a central peak. Further south is equally old Vendelinus. Slightly larger and spanning 147 kilometers, it will appear even more shallow—because it is. It lacks a central peak, but telescopes at high power can resolve its few minor interior craters.

Keep your binoculars or telescopes out for a while after the Moon sets, and let's head a little less than a fist-width east-southeast of Alpha Monocerotis (RA 08 00 01 Dec -10 46 12) to check out NGC 2506. On a dark night, this nearly 7th magnitude object is one of the most impressive of the Monoceros open clusters. Caught in a chain of stars, it displays a rich concentration, almost appearing like a globular cluster. NGC 2506 has been used to study old, metal-poor galactic clusters. Evolution has enriched its iron content, and—despite its extreme age—it is still a beauty. Be sure to mark your "400" notes!

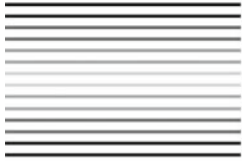


Figure 2.28a. Langrenus and Vendelinus (credit—Dave Nash).



Figure 2.28b. NGC 2506 (credit—Palomar Observatory, courtesy of Caltech).

CHAPTER THREE



Sunday, March 1

In 1966, Venera 3 became the first craft to touch another planet when it impacted Venus on this date. Although communications failed before it could transmit data, it was still a milestone achievement. If you're out at sunset, be sure to have a look at Venus and say *Spaseba!* In 2003, another *Deep-Sky Companion* See O'Meara, Stephen book by notable observer and author Stephen O'Meara premiered. Known for his high-quality sketches of Solar System objects and uncanny observing skills, O'Meara was the first to sight Comet Halley in 1985, and sketch the dark spokes in Saturn's rings (before Voyager had imaged them). Still part of the editorial staff at *Sky & Telescope*, and a treasured lecturer, let's take just a moment to congratulate Steve on a lifetime of achievement.

Let's practice Steve's powers of observation by identifying some prominent lunar craters around Mare Crisium. North you'll spy Cleomides and at the western edge, Proclus. Near the terminator northwest is Macrobius, and southwest is Tarantius. Power up and identify the small wells of Peirce, Picard, and Lick inside the smooth sands of Crisium.

Now let's talk about George Abell, who was born this day in 1927. Abell was responsible for cataloging 2,712 clusters of galaxies from the Palomar sky survey, a task he completed in 1958. Using these plates, Abell proposed that the grouping of such clusters delineated the arrangement of matter in the universe. He developed the luminosity function, which shows the relationship between brightness and the number of members in each cluster, allowing you to infer the cluster's distance. Abell also discovered planetary nebulae, and developed the theory (along with Peter Goldreich) of their evolution.

For seasoned observers, wait until the Moon has set and honor Abell by viewing one of his galaxy clusters—Abell 1367, located about a degree southwest of 93 Leonis (RA 11 44 44 Dec +19 41 59). It's an area of challenging intrigue for a large scope—spanning a degree of sky and containing as many as two dozen small galaxies—a gemstone for the galaxy collector.

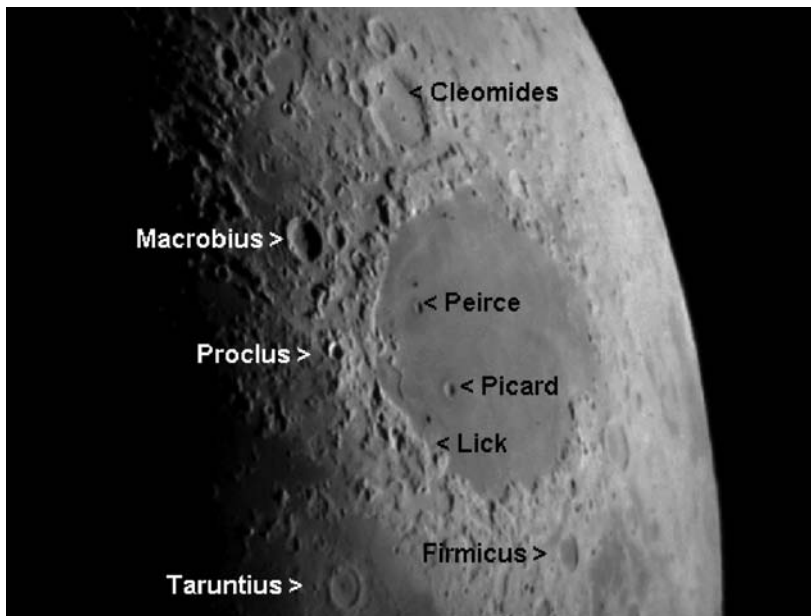


Figure 3.1a. Crisium area (credit—Greg Konkell).



Figure 3.1b. Abell 1367 (credit—Palomar Observatory, courtesy of Caltech).

Monday, March 2

About an hour before dawn, look for Mars on the horizon. Keep it in binocular view as dawn breaks and you'll see Mercury only half a degree away! In 2004, Rosetta, the first deep-space mission of the European Space Agency (ESA), was launched toward Comet 67/P Churyumov–Gerasimenko and will reach the comet sometime in 2014 to release a surface lander named *Philae* to explore.

Too bad Heinrich Wilhelm Olbers died today in 1840. He discovered comets and calculated their orbits. Tonight is about one of his discoveries—asteroid Vesta. Tonight Vesta will be easy to find around a fist-width south of the Moon. With a mean diameter of 530 kilometers, 4.5-billion-year-old Vesta is the second largest minor planet, and one of the brightest. At magnitude 6, it will outshine all but the major stars in its area.

Vesta is a well-studied asteroid. Like the nearby Moon, Vesta shows evidence of an impact crater near its south pole. It measures 460 kilometers in diameter, is 13 kilometers deep, and has a central peak rising 18 kilometers over the crater floor. This impact occurred roughly a billion years ago and may be the origin of Howardites, Eucrites and Diogenites (HED) meteors. Several other large craters up to 150 kilometers wide have also been discovered, along with a dark, maria-like basaltic flow stretching across 200 kilometers of surface—fittingly named for Olbers.

Look at the Moon for Theophilus, Cyrillus, and Catharina. None of these craters are as large as the one formed when 1% of Vesta's mass was blown away! Although Theophilus is no larger than the asteroid's minor craters, its details and central peak will give you a feel for Vesta's size. It's easy to get the impression that "minor planets" are small, but they are not: Vesta's huge crater is about the same diameter as the state of Ohio! Now take a good look at the stars around you before the Moon fades them away. Olbers once said:

"Why is the night sky dark if there are so many bright stars all around to light it?"

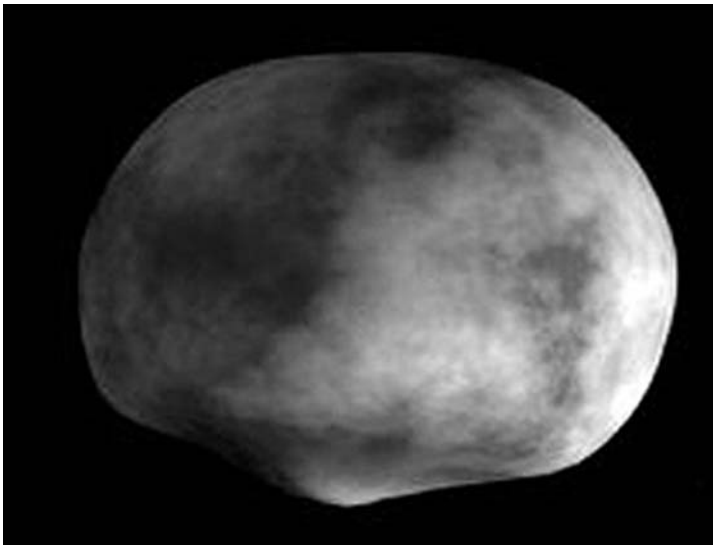


Figure 3.2a. Asteroid Vesta (credit—NASA)



Figure 3.2b. Theophilus, Cyrillus, and Catharina (credit—Greg Konkell).

Tuesday, March 3

Today, we honor the 1838 birth on this date of George Hill, a master of celestial mechanics. Watch Jupiter, and you'll see it rises earlier each day heading west—but not Saturn, which appears to be moving eastward, contrary to the sky. This is retrograde motion—a long word for a simple concept. As the planets orbit the Sun, there are times when an inner planet, such as our Earth, passes the slower-moving outer planets. Like passing a car on a circular track, the slower body seems to keep the same speed until the faster begins to catch up. There comes a point where we seem to overtake the slower body. As we pass, the slower car seems to stand still for a moment until it retreats behind us—first slowly, then faster. Neither body has changed direction, but the point of view has!

Now, look where the Moon's orbit has it positioned tonight. For most, the Pleiades will be less than 1 degree away, and many of its brighter stars remain easily visible. Practice your own brand of celestial mechanics and choose a notable nearby star, checking its relationship with the Moon periodically for several hours. Does the Moon seem to progress toward the star or away? What conclusion would you draw from observing this motion? While waiting, look at the northern lunar surface for two major craters along the terminator. Aristoteles and Eudoxus are visible in smaller binoculars and full of pleasing telescopic details.

Now head about 5 degrees west of Alpha Leonis (Regulus) for a very cool variable known as R Leonis (RA 09 47 33 Dec +11 25 43). When R is at maximum (its brightest point), this long-term variable will shine more brightly than others in the field. But watch it over the coming months. While at minimum (its faintest stage), R is a deep, ruby red, and no brighter than are its companions to the north and southeast. Changing about three full magnitudes over a period of 150 days, this 600-light-year-distant curiosity is worth returning to again and again!



Figure 3.3a. Aristoteles (credit—Alan Chu).



Figure 3.3b. R Leonis (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, March 4

Today we celebrate the birth on this date of Sir Patrick Moore. Author of 60 books and host of *The Sky at Night* See Moore, Sir Patrick TV show, this gentleman-scholar sparked the interest of several generations of sky-watchers. So excellent were his observations the Soviets used his lunar charts to correlate the first Lunik 3 pictures of the far side of the Moon, and he was also involved with NASA's lunar mapping prior to the Apollo missions. After more than four decades of tireless service, we salute you!

At first quarter, the Moon is offering more major landmark craters to learn. Begin with Eudoxus and look around! Southwest are Cassini and its interior crater, Cassini A. This concentric pair is on many observing lists. Try picking out Aristillus and Autolycus. Is the shallow ring of Archimedes in the sunlight or still in shadow? Look for Plato. This lunar crater can be spotted unaided.

With a small telescope or binoculars, you'll see a feature tonight that seems so straight and perfect that you can understand how Schiaparelli could have thought he saw canals on Mars! Although our Moon is far closer than is Mars, the appearance of Vallis Alpes, or the Alpine Valley See Vallis Alpes, shows that nature often provides curiosities that can be mistaken as artificial under certain lighting conditions. When Vallis Alpes has a shadow on its floor, this narrow slash on the lunar surface can be interpreted in many ways. Enjoy learning its position tonight, and watch over the coming nights as it changes. Sometimes you can see some of the strangest things when you observe. As Sir Patrick Moore once said:

"I thought 'The Martians have arrived!,' but then I realized that I was looking at pollen slightly out of focus."

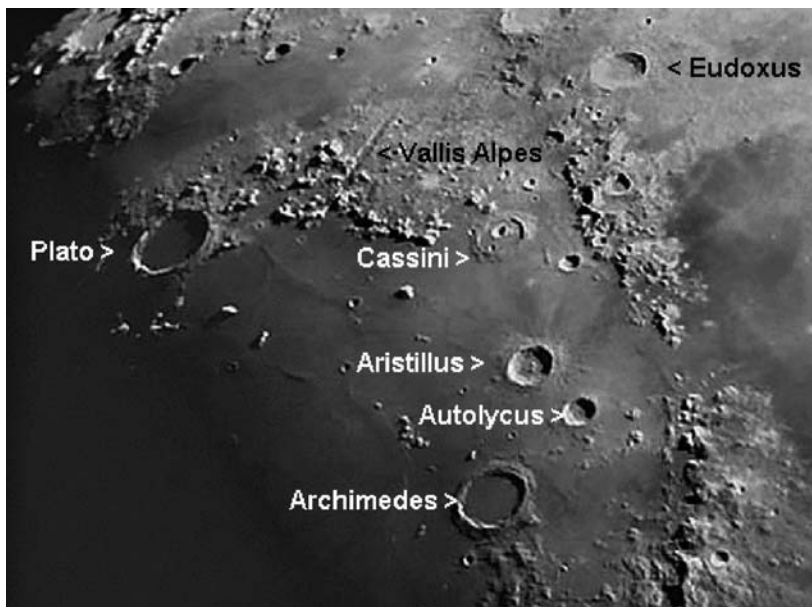


Figure 3.4a. Vallis Alpes region (credit—Roger Warner).



Figure 3.4b. Sir Patrick Moore (widely used public image).

Thursday, March 5

This date celebrates the 1512 birth of Gerardus Mercator. Mercator was the cartographer who created the Mercator map projection, the series of parallels and meridians drawn as straight lines to allow an accurate ratio of latitude to longitude. Mercator also designed the first celestial globe in 1551. Let's honor his work by studying lunar cartography tonight. The lunar globe is divided into northern and southern hemispheres, but far side and near side instead of east and west. Latitude and longitude, degrees, hours, minutes, and seconds are all part of the lunar equation. Without them, it would be impossible to correctly target an area on the Moon! Let's try to get a feel for these imaginary lines.

Tonight's terminator will be just slightly west of 0 degrees at the Moon's "equator." This should make things a bit easier for you. You'll find Plato at approximately 52 N and 10 W. Can you still spot Theophilus, Cyrillus, and Catharina? They are between 10 and 20S and roughly between 22 and 26E. Although it sounds simple, the closer to either pole, the steeper the curve, and the more difficult it can be to relate the numbers to what you see in the eyepiece. But like a star chart, it only takes practice to become proficient! Would you like to learn more major features? Handsome old Ptolemaeus is around 9S and 2 W. Arzachel? 18S and 2 W. Aliacensis? 30S and 2E. Have fun learning your way around and remember the craters you see. We'll be back to visit later...

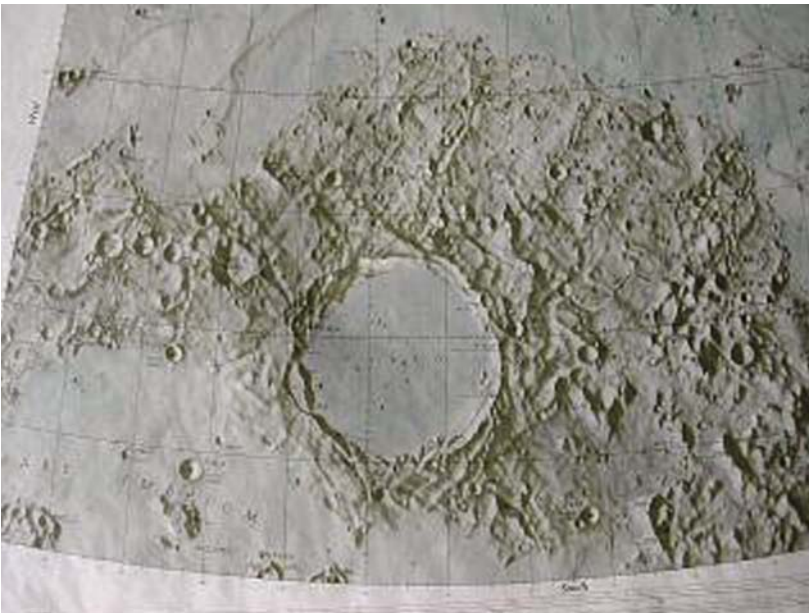


Figure 3.5a. Lunar reference chart (public image).



Figure 3.5b. Lunar image (credit—Greg Konkel).

Friday, March 6

If you see sunshine today, then celebrate the 1787 birth on this date of Joseph Fraunhofer—a trailblazer in modern astronomy. His field? Spectroscopy. Fraunhofer developed scientific instruments and specialized in the area of applied optics. While designing the achromatic objective lens for a telescope, he saw the spectrum of sunlight as it passed through a thin slit and the dark emission lines. Fraunhofer recognized that they could be used as wavelength standards, so he began measuring, labeling the most prominent with the letters still used today. His skill in optics, mathematics, and physics led Fraunhofer to design and build the very first diffraction grating. You've probably seen these little rainbows hundreds of times in your life without even realizing what they are. Would you like to create your own grating? Take a piece of ordinary clear cellophane (a bit of clean food wrapping is fine) and scratch it lightly a few times in one direction only with a piece of sandpaper. Hold it adjacent to a bright light source and tilt it until you see hundreds of hair-fine lines of color. Yes, it's crude... but it works! Did Fraunhofer's telescope designs also succeed? Of course! His achromatic objective lens is still used in modern telescopes.

Tonight the lunar crater for named for Fraunhofer is visible, but so overlighted it will be difficult to see. Honor the man of lines by looking for another "line" on the Moon (return to last night's area and head west). If conditions are right, you'll notice a thin black line cutting across the scenery not too far from Arzachel. Crater Thebit and bright Thebit A will guide you. The line is the shadow of an impressive lunar fault called Rupes Recta, or the "Straight Wall." During lunar sunrise, we can only see the shadow on the floor of Mare Nubium, but during third quarter, the escarpment is lit in brilliant white!

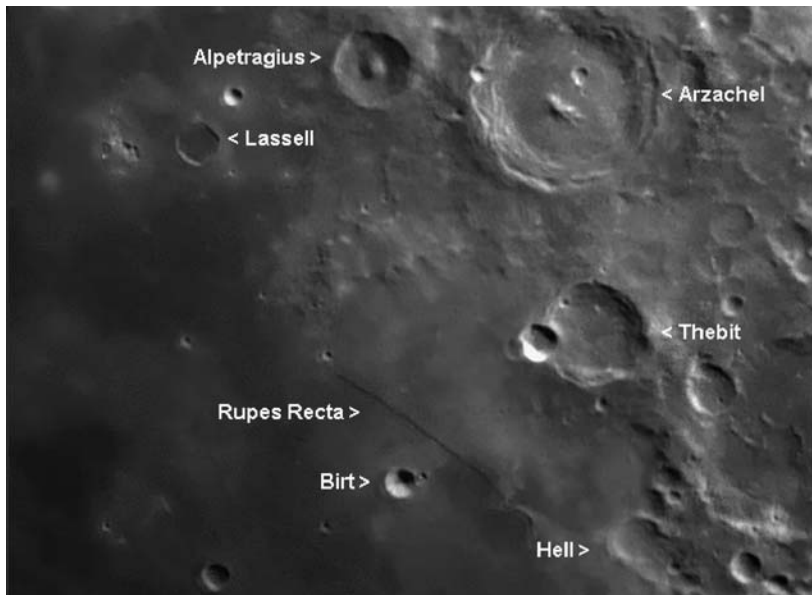


Figure 3.6a. Area of Rupes Recta (credit—Roger Warner).



Figure 3.6b. Joseph Fraunhofer (historical image).

Saturday, March 7

Today we celebrate two notable births. The year 1837 is Henry Draper's, first to photograph the stellar spectrum; and 1792 is the year Sir William Herschel's only child—John—was born. John Herschel began his astronomical career in 1816 when he built his first telescope. His path led him to eventual British knighthood for furthering his father's work, and to South Africa to complete his father's survey by cataloging the stars, nebulae, and other objects of the southern skies. In his own words, "He that on such quest would go must know not fear or failing." John returned to England in 1838, published his work, fathered 12 children, named the moons of Saturn and Uranus, and expanded the field of photography. He was a prodigious author, and you'll even find examples of his handiwork in the *Encyclopedia Britannica!*

Tonight honor the great J. Herschel by identifying the lunar crater named for him in the lunar northern hemisphere. Once you have located J. Herschel, power up. Caught on this oblique crater's edge is the deep pit of Horrebow—and a nice double strike. Compare the 156-kilometer diameter interior of J. Herschel to the smoothness of bordering Mare Frigoris. The difference in textures is astonishing! If the view holds steady, look for the larger C crater inside the walls, and a very distinct, drifted look to the crater rims. If John Herschel were alive tonight to share the eyepiece with you on his birthday, he would have said:

"In circumstances where the uninformed and unenquiring eye perceives neither novelty nor beauty, the scientist and natural philosopher walks in the midst of wonder."

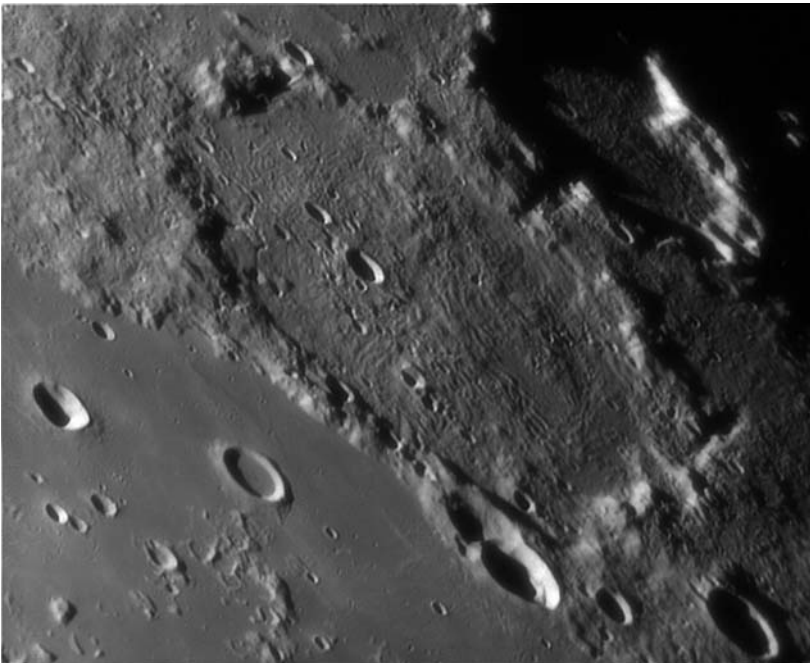


Figure 3.7a. Crater J. Herschel (Credit—Wes Higgins).

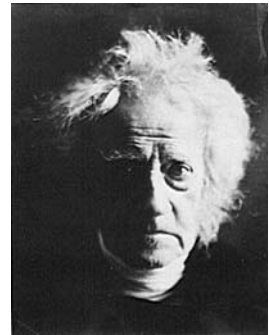


Figure 3.7b. John Herschel (historical image).

Sunday, March 8

On this date in 1618, Johann Kepler formulated his *Third Law of Planetary Motion*. Too bad he couldn't stick around until 1804 to meet Alvan Clark, the "father" of the refractor. Clark refracting telescopes and optics graced the great observatories of the world. Tonight we'll turn our own telescopes toward Saturn.

For a small telescope at low power, a first glimpse of Saturn is far from the grand image often portrayed of the ringed planet. Instead of beautiful, Hubble-like images, the viewer is greeted with something that looks more like a sesame seed on a black saucer than a fascinating distant world. But don't give up! No matter what telescope size you use, the image is more dependent on seeing conditions (such as the steadiness of the atmosphere and transparency) rather than aperture. Even at low power, watching Saturn's moons orbit over a period of days is very rewarding.

And even a very small telescope will reveal Saturn's ring structure. As optic size increases, so do details on successive nights. Look for such wonders as the wide dark band known as the Cassini division and the dark shadow of the planet's orb against the rings. Sharp-eyed observers often spy the "Encke gap"—the thin, minor ring around the outside. Subtle shadings and the ring shadows on Saturn's yellowish globe await! Try sketching while observing, even if you throw it away later. When sketching, the eye and the mind coordinate to pick up on finer details than seen by just observing alone. Be sure to take plenty of time! When the one pure moment of seeing and stability combine, even the smallest of telescopes will reward you with a view you'll never forget.

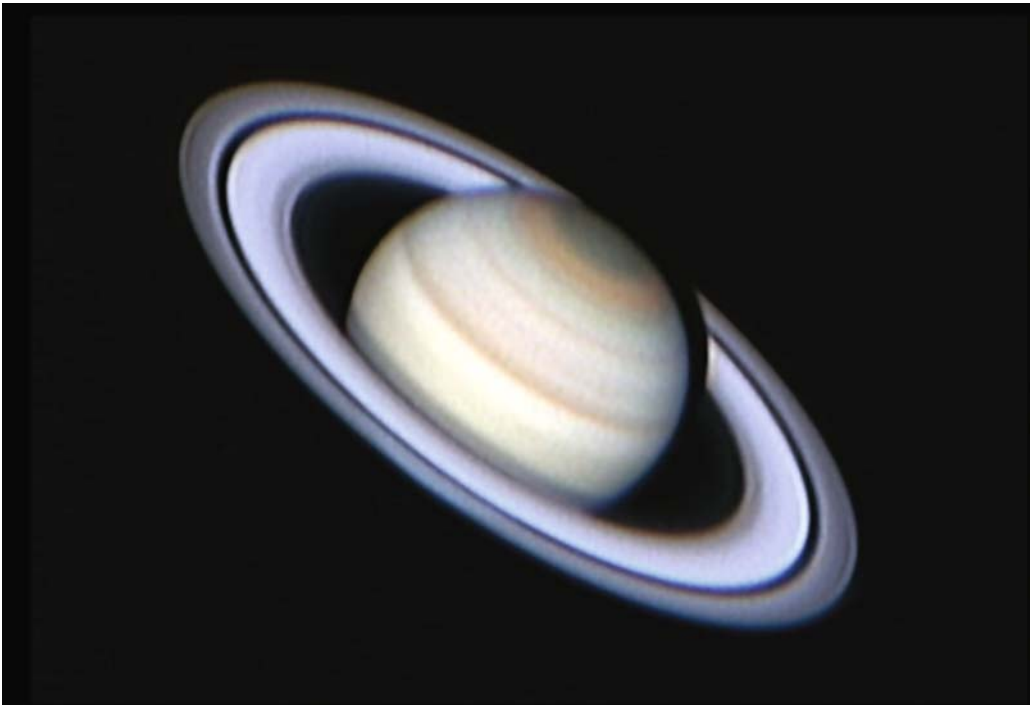


Figure 3.8. Saturn (credit—Wes Higgins).

Monday, March 9

Today note the 1934 birth on this date of Yuri Alekseyevich Gagarin, the first man in space. His 89-minute ride onboard Vostok 1 went into history, but Gagarin never went into space again. He spent the rest of his life training new cosmonauts, and died during a routine training flight when his two-seater jet crashed. Tonight we'll salute his achievements by turning binoculars toward the Moon to identify two bright spots on the surface, Aristarchus and Kepler, which are craters with high albedo, or surface reflectivity. Comrade Gagarin? *Atdahchachyestee...*

Look about a finger-width from the limb of the Moon for Alpha Leonis (RA 10 08 22 Dec +11 58 01), one of the closest bright stars to the ecliptic and known as far back as medieval times. Some cultures referred to it as the "fallen angel," "the heart of the lion," and the "yellow emperor." We know it more commonly by its Latin name—Regulus. It's not terribly massive, only about 3.5 times larger than our own Sun and just a few hundred million years old. But unlike Sol, 77.5-light-year-distant Regulus rotates to the extreme, revolving on its axis in less than 16 hours. Because of this rapid spin, its photosphere stretches, giving the star an oblate profile. As a victim of gravity darkening, Regulus' poles are far hotter than its equator and 500% brighter. If it rotated any faster, centripetal force would pull it apart! But the "Little King" isn't alone in space; it has two other members in its local court—a gravitationally bound 0.006-light-year-distant binary system. The brighter of the binary companions can be spotted in binoculars, but it will require a telescope to see the fainter third star another 15 billion kilometers away. The pair happily live out their lives orbiting each other about every 2 millennia, and around Regulus itself every 130,000 years.

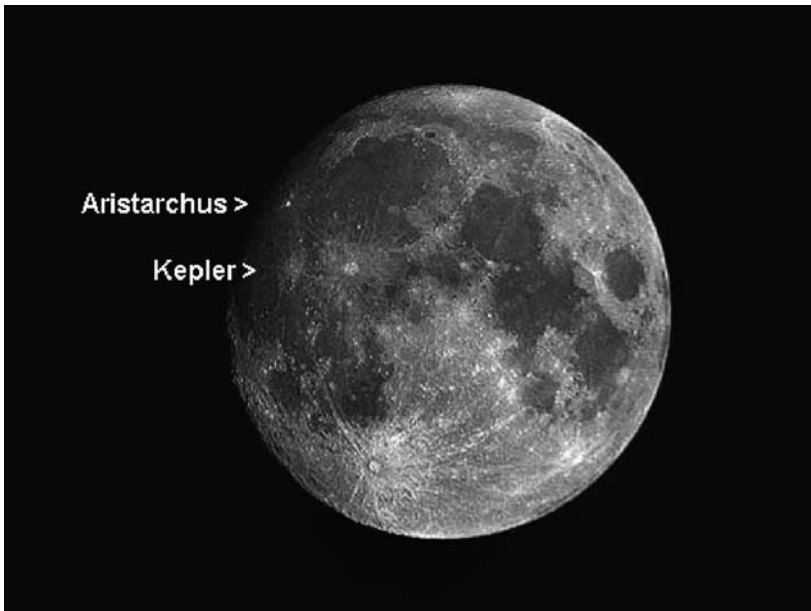


Figure 3.9a. (credit—Yuri Gagarin (historical image)).



Figure 3.9b. Aristarchus and Kepler (credit—Roger Warner).

Tuesday, March 10

On this date in 1982, the world didn't end when all nine planets aligned on the same side of the Sun. This perfectly natural occurrence is called syzygy. Tonight the Moon isn't in the seventh house, and Jupiter isn't aligning with Mars. However, you can spot Saturn just a few degrees away from the near-full Moon's limb!

With such bright sky, it's going to be difficult to practice much astronomy—or is it? There are always some very cool things to do if you just know where to look! Let's head for the eighth brightest star in the sky—Procyon.

Often called "the one who proceeds the Dog," Procyon also represents a dog, the beloved pet of Helen of Troy. If you haven't noticed, Alpha Canis Minoris *See* Procyon is also the eastern member of what is sometimes called the "Winter Triangle," appearing above the horizon before the Dog Star, Alpha Canis Majoris. At 0 magnitude, it's in fair competition with the other trio members: dazzling Sirius and mighty Betelgeuse. At a little more than 11 light-years away, it is also one of the closest stars to our Solar System.

Now just stop and look at this beautiful star. Arabic tales describe Procyon and Sirius as two sisters, who along with their brother—Canopus—tried to cross the sky when they came to the Great Sky River. When they both entered the Milky Way and tried to swim across, only Sirius was strong enough to make it and now stands on the southern bank of that river of stars. Left alone to the north as her siblings moved on, Procyon is often referred to in mythology as "she who weeps." Not surprisingly, astrology also associates Procyon with watery catastrophes!

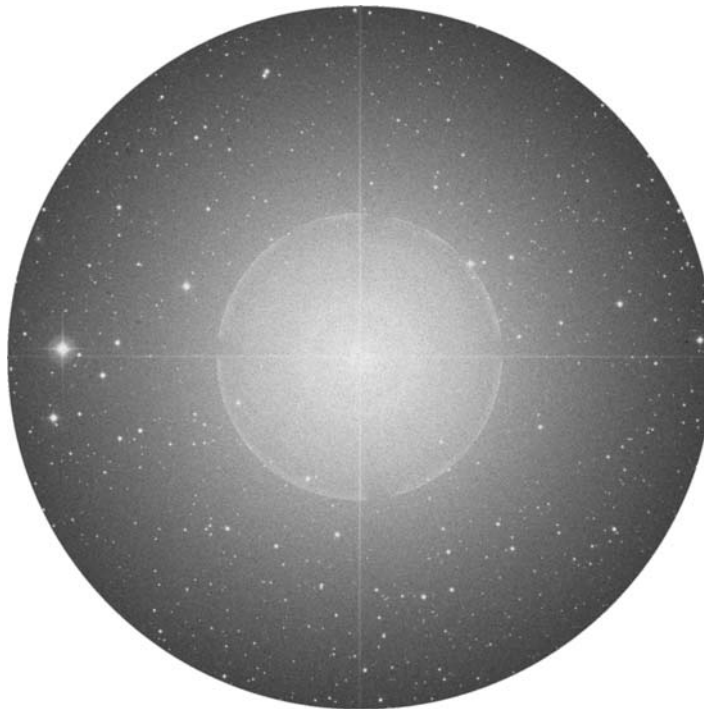


Figure 3.10. Alpha Canis Minoris: Procyon (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, March 11

Today marks the 1811 birth of Urbain-Jean-Joseph Le Verrier. His fascination with celestial mechanics led to his numerical prediction of the existence of Neptune. How? Thanks to Herschel's discovery of Uranus, he calculated Neptune's position through irregularities in Uranus' orbit, a feat of which Herschel said: "He discovered a star with the tip of his pen, without any instruments other than the strength of his calculations alone."

Unfortunately, he wasn't correct about predicting Vulcan, a planet within the orbit of Mercury. Had Le Verrier celebrated his 149th birthday, he would have witnessed the 1960 launch of Pioneer V, a first attempt to really study our own Solar System. Slightly larger than a child's play ball, Pioneer V spread its solar panel wings and orbited the Sun between Earth and Venus, giving us new information on micrometeorites, cosmic radiation, interplanetary space, and magnetic fields. It operated successfully at a distance of over 36 million kilometers from home for over 3 months!

Tonight we'll begin by looking 90 times closer as we watch the rise of the Full Worm or Sap Moon. There's a special reason to look! Within 9 days, Earth will once again reach Equinox, and the Moon will subtly shift its track across the night sky. Choose your position to observe carefully and remember it. As the Moon appears, mark its rise point against a landmark such as a distant building or tree. Return to the same observing position in the months ahead and look for the same landmark. You'll see why Le Verrier was so fascinated with celestial mechanics. They work!

Now check out a very pleasing little group of stars about a fist-width southeast of Procyon (RA 08 25 39 Dec 02 54 23). The primary star's name is C Hydrae, and although the group isn't truly gravitationally bound, they're a real delight to binoculars and telescopes of all sizes with their mixed-magnitude similar spectral types!



Figure 3.11a. C Hydrae (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.11b. Urbain Le Verrier (historical image).

Thursday, March 12

Today let's celebrate three births! First comes Simon Newcomb. Born on this date in 1835, Newcomb was a Canadian-American astronomer who was really good with numbers. We have him to thank for ephemerides, those great tables of computed places of celestial bodies over long periods of time. Next is 1824 and Gustav Robert Kirchhoff, a physicist who established the theory of spectral analysis. Kirchhoff's rule states: "When light passes through a gas, the gas absorbs the wavelengths it would emit if heated." Kirchhoff was very knowledgeable in the field of electricity as well. In 1845, he proved current would flow at the speed of light in a zero resistance conductor. Last is Dorrit Hoffleit (b. 1906), the author of the Yale Bright Star Catalog. Dorrit enjoyed an 80-year career in astronomy and was one of the last living links to Annie Jump Cannon and the senior women's astrophysics team at Harvard. In her 100-year life, Hoffleit certainly saw a lot of advances in astronomy!

Before the Moon rises, locate 6 Canis Minoris about three finger-widths northwest of Procyon. This normal K-type orange giant is around 560 light-years away from Earth, but aim a telescope its way for an opportunity to study an overlooked open cluster—Dolidze 26 (RA 07 30 06 Dec +11 54 00). In the eyepiece, you'll find a faint collection of stars that aren't related to 6 Canis Minoris. Clusters of this type aren't highly studied yet, but they belong to a group near in age and population and sharing similar star formation processes. Unlike other open clusters, these odd collections contain peculiar stars that produce very high velocity stellar winds and steady X-ray emission. Although it might not be as splashy as a Messier object, Dolidze 26 may very well accelerate cosmic ray particles!



Figure 3.12a. Dolidze 26 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.12b. Gustav Kirchhoff (historical image).

Friday, March 13

Today note the 1886 birth of Albert William Stevens, a daring balloonist who took the Explorer II to an altitude of 72,395 feet. He took the first photo showing Earth's curvature and the first solar eclipse photo of the Moon's shadow on Earth. Also, salute the 1855 birth on this date of Percival Lowell, who predicted the existence of Pluto (but Clyde Tombaugh was the one who actually discovered it, on Lowell's 75th birthday!). Sir Percival was a determined soul who spent his life trying to find proof of life on Mars. He founded Lowell Observatory in 1894, where he studied Mars intensively, drawing the Red Planet covered with canals and oases. As Lowell once said: "Imagination is as vital to any advance in science as learning and precision are essential for starting points."

Tonight we'll look at a bright collection of stars located less than a handspan west of Procyon. Its name is Collinder 106 (RA 06 37 19 Dec +05 57 55). At a combined magnitude of 4.5, this expansive open cluster can be spotted as a hazy patch with the unaided eye and comes to full resolution with binoculars. It contains only around 14 members, but this widely scattered galactic collection has helped scientists determine size scales and dispersion among groups of its type. Viewed telescopically at low power, the observer will find it rich in background stars and a true delight in a low power, wide-field eyepiece. If you'd like a challenge, hop a half degree to the northeast to spot Collinder 111 (RA 06 38 42 Dec +06 54 00). While visually only about one-tenth the apparent size of its larger southwestern neighbor, spare little Collinder 111 also belongs to the same class of open clusters. Who knows what may lurk around these understudied clusters?



Figure 3.13a. Collinder 106 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.13b. Sir Percival Lowell (historical image).

Saturday, March 14

Before dawn, look for the close appearance of Spica and the Moon to celebrate today's famous astro births, starting with astronaut Frank Borman (b. 1928), a crewmember of Apollo 8, the first manned flight around the Moon. Next, astronaut Eugene Cernan (b. 1934), who floated in space for more than 2 hours during the Gemini 9 mission and piloted Apollo 10. How about Giovanni Schiaparelli (1835), the Italian astronomer who described Mars's "canali" and named its "seas" and "continents." Schiaparelli's comet studies demonstrated that meteoroid swarms existed in the path of cometary orbits, and thus predicted annual meteor showers. He was first to suggest that Mercury and Venus rotate and discovered the asteroid Hesperia. Still not enough? Then wish a happy birthday to Albert Einstein (b. 1879), the German-American physicist considered the most brilliant intellect in human history!

For a moment let's reflect on Einstein's Cross, proof of his genius. We can't observe this Pegasus-based gravitational lens right now, but we can try to understand Einstein's theory of gravity as an effect of the curvature in space-time. For example, if you draw a line around the center of a ball, the line would be straight, eventually coming back to its point of origin. We don't see the point until we reach it, but we know it's there. Einstein knew this dimension existed and predicted any object with mass will bend space and time around it, just like our line around the ball. He predicted light would also follow a curved path around an object. . .such as a distant quasar located behind a closer galaxy!

Tonight's object is a "cross" of stars that will be our anchor for starhopping over the next few days. Begin at Procyon and shift about 10 degrees southwest (or 2 degrees south of 18 Monocerotis) to locate this pretty grouping of stars. Yes it's true. It's just an unknown, undocumented, and unnamed asterism, but how fitting to honor all these famous astro figures and a brilliant man who once said: "The fairest thing in life we can experience is the mysterious. It. . .stands at the cradle of true art and true science."

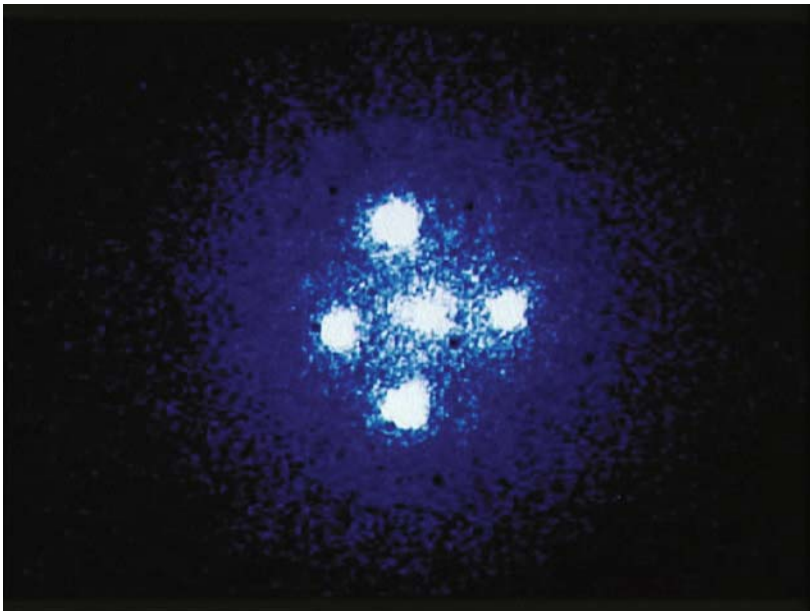


Figure 3.14a. Einstein's Cross (credit—HST/NASA).



Figure 3.14b. "Einstein's Asterism" (redit—Palomar Observatory, courtesy of Caltech).

Sunday, March 15

Today marks the 1713 birth of Abbé Nicolas Louis de Lacaille, the French astronomer who named 15 of the 88 constellations. Using only a half-inch refractor, Lacaille made 26 new discoveries and charted 9,776 stars, creating the first southern star catalog. Sharing the date is William Rutter Dawes (b. 1799). “Eagle-eyed” Dawes made exhaustive measurements of binary stars, discovered Saturn’s inner Crepe Ring, and accurately mapped Mars. Dawes also devised the elegantly simple formula (Dawe’s Limit) of dividing the number 11 by the aperture in centimeters to give the arcseconds of resolution required to split a binary star. Thankfully, somebody was watching the sky at 5:30 p.m. on this date in 1806, because the observed fall of a pristine 6-kilogram chondrite meteor made an indisputable case that chondrites carried carbon-based organic chemicals. Perhaps it was from one of the Corona Australid meteors whose shower peak is tonight after midnight? The fall rate is about 5–7 per hour, and best for our friends in the southern hemisphere!

Return to our Monoceros marker for a challenging study. Larger telescopes should look for diminutive Bochum 2 less than half a degree northeast of “Einstein’s Asterism” (RA 06 48 50 Dec –00 22 35). At low power, it’s just a tight configuration of stars, but test the Dawe’s Limit of your telescope and increase magnification. This young open cluster has been studied for internal kinematics, spectroscopic binaries, and its motion in the galaxy, but its most interesting feature is a trapezium system at its heart. After a 4-year study, two of the members were documented as close binary stars with highly eccentric orbits, and one of the members is leaving as a runaway! For smaller optics, continue another half degree east for NGC 2301 (RA 06 51 48 Dec +00 28 00). Even telescopes as small as Lacaille’s can see this bright, 2,500 light-year-distant open cluster. Studied for its variable stars, NGC 2301 is also on many binocular deep-sky observing lists!



Figure 3.15a. Bochum 2 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.15b. NGC 2301 (credit—Palomar Observatory, courtesy of Caltech).

Monday, March 16

Tonight, let's walk back through time, starting in 1966 with the first U.S.-manned docking of the Gemini VIII, piloted by Neil Armstrong. Now let's go to 1932 for the birth on this date of Ronnie Walter Cunningham, an American astronaut aboard the first manned Apollo mission (Apollo 7). In 1927, Vladimir Mikhailovich Komarov, Soviet cosmonaut, became the first man to die during a space mission when the chutes tangled on Soyuz-1 and it fell to Earth. Although all are notable events, none is more fitting to celebrate tonight than the 1750 birth of Caroline Lucretia Herschel.

Through her telescope, Caroline Herschel created a world of her own, as the first woman to discover a comet. Then she found 8 more and went on to find 3 nebulae and 20 deep-sky objects. Fourteen objects in the Herschel catalog bear her signature and William's own note: "Lina found it." To preserve her brother's night vision, Caroline noted William's directions and descriptions, but was just as avid at the eyepiece. In her memoirs, she states: "I knew my brother to be at no great distance making observations with his various instruments on double stars, planets, etc., and I could have his assistance immediately when I found a nebula, or cluster of stars..."

Tonight let's honor Caroline by returning to the Einstein's Asterism and dropping 15 degrees due southeast to study the initial open cluster our first lady of astronomy discovered—NGC 2360 (RA 07 17 42 Dec -15 38 00). At a distance of 4,600 light-years, magnificent NGC 2360 contains around 40 members, 7 of which are red giants. It took many years for Caroline Herschel to be recognized for her astronomical achievements, and she never overcame what she thought were her own shortcomings. Her last recorded words were, "Tell them that I am good for nothing." Well, Caroline, don't you believe that! Over a quarter of a millennium later, we still remember a brave woman who didn't stand in her brother's shadow. She stood beside it.



Figure 3.16a. NGC 2360 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.16b. Caroline Herschel (historical image).

Tuesday, March 17

Celestial scenery alert! A few hours before dawn, the Moon and mighty Antares will be nearly touching, separated by only a fraction (0.2) of a degree. For some, this could be a wonderful occultation event, so be sure to check maps and resources! Although the occultation path is limited, even moreso is the graze path, just a few kilometers wide. For these lucky viewers, brilliant red Antares may flash in and out of view several times as it moves slowly along behind the lunar mountains.

On this date in 1958, the United States launched its first satellite. Tiny, coconut-sized Vanguard 1 carried a radio transmitter and completed a circumnavigation every 107.9 minutes. Vanguard 1 is the oldest satellite still in orbit, and should remain there until the twenty-third century!

Return to our Einstein's Asterism tonight and head slightly more than half a degree west to study scattered open cluster—Dolidze 25 (RA 06 45 06 Dec +00 18 00). This low power, telescopic only, galactic cluster is a worthy study for those who seek the unusual. Located at the outer edges of our own galaxy, Dolidze 25 may very well be the product of the merger of the Milky Way and the Canis Major Dwarf galaxy. Extremely rich in oxygen and significantly deficient in metals, this huge star-forming region contains young stars, pre-main sequence stars, and Delta Scuti types. With its thin veil of nebula, Do25 should prove to be challenging and quite to your liking! Hop another half degree west, and then slightly south for Dolidze 23 (RA 06 43 12 Dec -00 00 00). This telescope-only cluster reveals around a dozen easily resolvable stars at low power. Dolidze 23's two brighter members are finder-scope visible. Locate the cluster at low power, and place it at the south edge of the field of view. Turn off your drive units and allow the field to cruise by naturally as you observe. This allows Dolidze 25 to drift across your line of sight, a technique that often improves your ability to spot fine detail in fainter objects.



Figure 3.17a. Dolidze 25 (credit—Palomar Observatory, courtesy of Caltech).

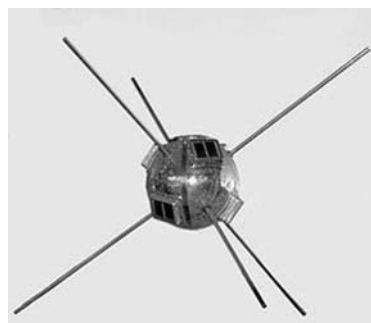


Figure 3.17b. Vanguard 1 (credit—NASA).

Wednesday, March 18

On this date in 1965, the first 20-minute spacewalk was performed by Alexei Leonov outside the Soviet Voskhod spacecraft. Alexei had problems in re-entering the spacecraft. Imagine his fear as he had to let air leak out of his space suit in order to squeeze back inside! When they landed off-target in the heavily forested Ural Mountains, the crew of two had to spend the night in the woods surrounded by wolves. It took over 24 hours before they were located, and rescuers had to chop their way through the forest on skis to recover them. Brave men!

Before we move onto new challenges, return to Monoceros tonight for three more objects that will increase your knowledge of the sky and sharpen your observing skills. Locate Einstein's Asterism and head north about 1 degree, then a bit east to capture NGC 2282 (RA 06 46 51 Dec +01 18 54). Listed on star charts as a bright nebula, this elusive telescopic area is actually quite a bit more; it's a young star cluster containing over 100 members. Although the nebulosity is vague and requires a dark sky, the small concentration of stars does not. Sitting on the edge of a molecular cloud, our very young group is nearly impossible to fully resolve and with good reason—many of its stars are still pre-main sequence.

Continue your north-northeast track another half degree to spot the small open cluster Collinder 115 (RA 06 46 30 Dec +01 46 00). Few studies have been made of this old, arrow-shaped galactic cluster, and it's an observing challenge to find in the surrounding starfield. Skip east-southeast a half degree for Dolidze 24 (RA 06 44 45 Dec +01 45 00). It may be larger and brighter, but it ranks high on the GITRAC (Gee, Is That Really A Cluster) list. By studying stellar associations such as Dolidze 24, scientists gather more information about the rotation of our galaxy. What an awesome constellation it would make 100,000 light-years closer!



Figure 3.18a. NGC 2282 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.18b. Dolidze 24 (credit—Palomar Observatory, courtesy of Caltech).

Thursday, March 19

Let's start by taking a look at Baron Wilhelm von Biela, born on this date in 1782. The Austrian astronomer calculated the 6.6-year orbital period of a known comet. By 1846, Biela's Comet had broken into two pieces and, true to the Baron's calculations, returned a little over 6 years later in 1852 as widely separated twin comets. Tonight let's discover a comet-like nebula in Monoceros, which deserves your time and attention. Start at Betelgeuse and look for far fainter 13 Monocerotis about a fist-width east. In binoculars or your finderscope, star 13 will show a widely spaced, bright, optical companion northeast. Follow the same trajectory 2 degrees northeast for NGC 2261.

Edwin Hubble's Variable Nebula is a 10th magnitude object, which appears very blue through larger apertures and is a true enigma to space science buffs. The fueling star, variable R Monocerotis, doesn't display a normal stellar spectrum and may include a proto-planetary system. R itself is usually lost in the high surface brightness of the "comet-like" structure, yet the nebula itself varies with no predictable timetable, perhaps due to dark masses shadowing the star. We don't even know how far away it is, because there's no detectable parallax! NGC 2261 has baffled and challenged all astronomers who have studied it. As Edwin Hubble said, "A striking instance of actual change in form has been found in the case of the nebula NGC 2261, one of the few real examples of cometary form in the sky and definitely one of the finest."

Even fairly modest telescopes can pick up the dramatic differences, which can occur in just a matter of weeks, or sometimes even from one night to the next. According to Hubble:

"These changes, though striking, seemed improbable on account of the short interval and raised a suspicion as to whether the changes could be real and were in the nebula itself or whether they might not be due to some peculiar photographic action. But repeated plates taken under different conditions of seeing, exposure time, aperture, etc., verified the changes beyond question."

Enjoy it for its color—or enjoy it for its mystery!



Figure 3.19a. NGC 2261: Hubble's Variable Nebula (credit—Hubble Space Telescope/StSci/NASA).



Figure 3.19b. Baron Wilhelm von Biela (historical image).

Friday, March 20

Since the beginning of 2009, the Sun has been traveling low in the sky, moving higher each day until reaching northern hemisphere vernal equinox. Today the Sun will rise exactly in the east and set exactly in the west—precisely 12 hours later—making it possible for most observers to see all 110 Messier objects in a single night. The Messier Marathon isn't easy. This year, why not try your own style of marathoning, as we take a less frenzied pace over the next 11 days, enjoying these splendid objects "ten at a time."

Note: To reduce clutter during the Marathon, Messier object coordinates are not included with the text. Instead, readers with driven telescopes will find them listed at the end of the Resources section, in the order discussed here.

When the sky darkens enough to find guidestar Delta Ceti, the M77 spiral galaxy will be your first; the M74 spiral galaxy east of Eta Pisces will be your second mark. Both are telescopic only, and an extreme challenge due to low position. Next is M33, west of Alpha Triangulum. With ideal skies, the Pinwheel Galaxy can be seen in binoculars, but sky glow makes this huge, low-surface brightness spiral difficult for even telescopes at low power. M31, the Andromeda Galaxy, is a delightful capture for both binoculars and scopes just west of Nu Andromedae. For the telescope, two more on the list are companions to M31: elliptical M32 on its southeastern edge, and M110, to the northwest.

Head northwest for two open clusters visible to both telescopes and binoculars. You'll find M52 easiest by identifying Alpha and Beta Cassiopeiae, drawing a mental line between them, and extending it the same distance northwest of Beta. Next, hop north of Delta Cassiopeiae to pick up our eighth object—open cluster M103. Head south toward Perseus to telescopically locate the M76 planetary nebula just north of Phi. Binoculars are all that's needed to see M34, an open cluster located roughly halfway between Algol and the lovely double Almach. As you can see, such a quick journey takes away some of the beauty of learning the history and science behind the objects. . . But the race is on!



Figure 3.20a. M74 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.20b. M34 (credit—Palomar Observatory, courtesy of Caltech)

Saturday, March 21

Today, note the 1927 birth on this date of Halton Christian Arp, one of the most noted minds of our time regarding the origin and evolution of galaxies. Through his incredible study of peculiar galaxies and quasars, we are no longer able to assume that redshift is a uniform indicator of distance, or that the two are unrelated.

Tonight our marathon will be more relaxed because the fastest-setting objects are already completed. Take a moment to enjoy M45, the Pleiades. The “Seven Sisters” are easily visible high in the west, and their cool, blue beauty is incomparable in binoculars or telescopes. Head for Lepus and identify Beta and Epsilon. Triangulating south with this pair is 5th-magnitude star ADS3954, and the small globular M79 to its northeast. M42, the Orion Nebula, is next. M43 is part of M42 to the north northeast. The next two objects are M78, northeast of Zeta Orionis and M1, the Crab Nebula, northwest of Zeta Tauri.

Now take a few minutes to relax. The remaining objects on tonight’s list are all very easy, well positioned, and observable with binoculars. Are you ready? Then let’s go! Open cluster M35 is northwest of the toe of Gemini—Eta. The next stop is Auriga, directly between Theta and southern Beta. Slightly to the east you’ll find open cluster M37. Now use Theta and western Iota. Roughly halfway between them and in the center of Auriga you will find open cluster M38. Hop southeast to capture M36. Although this pace may seem rather scandalous, take stock of what you’ve accomplished! You’ve visited 20 Messier objects in just two nights...with time to spare. Return to your favorite objects and enjoy them. As Halton Arp once said:

“Sometimes I think that Astronomy is not so much a science as a series of scandals.”



Figure 3.21a. M38 (credit—Palomar Observatory, courtesy of Caltech).

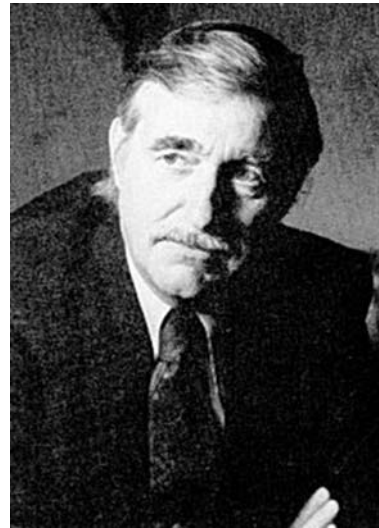


Figure 3.21b. Halton Arp (historical image).

Sunday, March 22

Born on this date in 1394 was Ulugh Beg, builder of the first observatory. Beg's chart listed 994 stars and was the first produced since Hipparchus! In 1799, Friedrich Wilhelm August Argelander, who cataloged the positions and magnitudes of 324,188 variable stars, was born! Now get Sirius, go south, and start our list for tonight with open cluster M41. Return to Sirius and head a fist-width east-northeast for M47. Dimmer, more compressed M46 is east. Drop slowly south about three finger-widths and encounter lively M93! Incredibly colorful open cluster M50 is roughly one-third the distance between Sirius and Procyon. Drop south-southeast of Zeta Monocerotis for dim open cluster M48. The "Beehive"—M44—is just north-northwest of Delta Cancri. Continue south to Alpha, and then west for M67. It will appear as a fine haze to binoculars, but telescopes see a spectacular cloud of similar magnitude resolvable stars.

Telescopes, head a fist-width east Regulus for finderscope stars 52 and 53, and head between them. Just about 1.5 degrees south of 52 is elliptical galaxy M105. Larger scopes see two additional faint galaxies, NGC 3384 and NGC 3389, to M105's west. Continue another degree south toward star 53 for the silver-gray beauty of M96. Enjoy its bright nucleus and wispy arms!

Now relax and enjoy a spring evening with two meteor showers. The northern hemisphere Camelopardalids have no definite peak, and a fall rate of only 1 per hour. They're the slowest recorded meteors, entering our atmosphere at speeds of only 7 kilometers per second! Far more interesting for both hemispheres is tonight's peak of the March Geminids. These slower than normal meteors will be fun to watch! When you see a bright streak, trace it back to its point of origin: which did you see, a Camelopardalid, or a March Geminid?



Figure 3.22a. M96 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.22b. Friedrich Argelander (historical image).

Monday, March 23

In 2001 on this date the Mir space station ended 15 years in orbit with a fiery return. This date is also the 1837 birth of Richard Anthony Proctor who showed the stars' motion, distribution, and relation to nebulae. In 1829, Norman Pogson, creator of the magnitude scale still used today, was born. The year 1749 saw the birth of Pierre-Simon Laplace, who theorized that the Solar System formed from a nebula, formulated mathematical probability, and helped create the metric system!

Return to Leo tonight. Identify 52 Leonis and drop south past M105 for M95, which isn't as bright or large as neighboring M96. Small scopes see central brightening, and large ones begin resolution of this awesome barred spiral. Look to the southwestern star of the three marking Leo's "hips"—Theta Leonis. South is faint star 73, and a degree east-southeast is the pairing of M65 and M66. Western M65 and eastern M66 are both beautiful spirals worthy of far more time and attention.

Head north for another same-field pair—M81 and M82—in Ursa Major. Draw a mental line between Gamma and Alpha. Extend the line beyond Alpha the same distance. Begin an eyepiece sweep to locate them. The southernmost is stunning, bright-cored M81. North is the broken, spindle-shaped peculiar galaxy M82. Southeast of Beta Ursae Majoris (UM) is the edge-on galaxy M108. Continue another half degree southeast for the Jupiter-sized planetary M97. Continue south to Gamma UM for same-field M109. The last in Ursa Major is an error on Messier's part. M40 is actually double star WNC4, located northeast of 70 Ursae Majoris. Now to Canes Venatici and our last object tonight: Alpha and northern Beta are easily recognizable to the east of the last star in the "handle" of the Big Dipper (Eta). You'll find the soft-spoken spiral galaxy M106 almost directly midway between Beta CVn and Gamma UM less than 2 degrees south of star 3. Add as much aperture as you can to this gorgeous study!



Figure 3.23a. M106 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.23b. Pierre Laplace (historical image).

Tuesday, March 24

On this date in 1835 Josef Stefan was born, a physicist whose word was “law” to radiation! In 1941 on this date, Joseph Taylor, Jr, the radio astronomer who jointly discovered the first binary pulsar, was born. Last, let’s celebrate the 1893 birth of Walter Baade, who studied the Andromeda Galaxy’s core with the 100” Hooker telescope, resolving it (and two different Cepheids) for the first time.

Tonight, identify Canes Venatici’s two brightest stars, Alpha and Beta. Galaxy M94 forms a triangle with Alpha and Beta CnV, the apex toward Eta Ursae Majoris (UM). M63 is one-third the distance between Beta CnV and Eta UM. M51 resides near visual star 24 CnV. You’ll find M101 to the other side of Alkaid. The accepted designation for M102 is lenticular galaxy NGC 5866, located southeast of Iota Draconis. You’ll find small globular cluster M53 northeast of Alpha Comae. M64 is about one-third the distance from Alpha Comae to Eta UM. M3 is one-third the distance between Arcturus and Cor Caroli.

Now for the incredibly rich galaxy fields near Coma Berenices and Virgo. Identify the eastern-most star in Leo—Denebola—and head a fist-width due east. M98 is west of star 6 Comae. Return to 6 Comae and drop 1 degree southeast for M99. Congratulations! In just 5 days you have logged 50 of the brightest and most beautiful members of the deep sky!



Figure 3.24a. M99 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.24b. Walter Baade (historical image).

Wednesday, March 25

Today celebrates the 1786 birth of Giovanni Amici, inventor of the achromatic lens, and in 1923, the birth of Kenneth Linn Franklin, radio astronomer. Tonight continue our marathon around midnight. It's time to dance. . .

Leo's easternmost bright star Denebola points to 6 Comae, about three finger-widths east. Two degrees northeast of 6 you'll pass two 5th-magnitude stars leading to M100, the largest-appearing galaxy in the Coma–Virgo cluster. Continue 2 degrees north for bright yellow 11 Comae. One degree northeast is 9th magnitude, round M85. Try a “trick of the trade” to locate two more. Return to 6 Comae, relocate M99, turn off your drive, and take a break for 14 minutes. When you return, the elongated form and near-stellar nucleus of M88 will have “drifted” into view. Wait another 2–3 minutes, and the faint, barred spiral M91 will join the show in a 1-degree field of view.

Now locate bright Vindemiatrix (Epsilon Virginis), a handspan due east of Denebola. Hop 4.5 degrees west and a shade north to locate the largest elliptical galaxy presently known, M60. This magnitude 9 galaxy can be spotted with binoculars, but a telescope will reveal faint NGC 4647, which only appears to be interacting with M60. In the field west is our next Messier: bright-cored elliptical M59. (Yes, there's more, but not tonight. Let's keep our studies to only the Messiers!) Move a degree west for fainter M58. About a degree north will locate face-on spiral M89. One half degree northeast is delightful 9.5 magnitude M90, whose dark dust lanes show in larger scopes. Continue 1.5 degrees southwest for M87, the first radio source galaxy discovered. M87 contains a black hole, and more than 4,000 globular clusters surround its elliptical form. Now take a break. . . Things are about to get a lot hotter!



Figure 3.25a. M87 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.25b. Giovanni Amici (historical image).

Thursday, March 26

Midnight now. Dawn is only a few hours away and the beginning of a new day. It is also a New Moon and the perfect time to try all 110 Messier objects in just one night! What's that? You want to keep on going ten at a time? Then let's do just that. . . . Slightly more than a degree northwest of M87 is the same-field pair, western M84 and eastern M86. Head to 31 Virginis and identify splendid variable R a degree west. Two degrees northwest is galaxy M49. Shift 3 degrees southwest for the handsome yellow double 17 Virginis. A half degree south is large face-on spiral M61. Now go for Spica, and 11 degrees due west. M104, the Sombrero Galaxy, will be your reward for a job well done. Congratulations! You've just seen 15 of the finest galaxies in the Coma–Virgo region in just hours, and our "Marathon" continues.

Five degrees south-southeast of Beta Corvi is your marker star, the double A8612, for the same-field globular M68, the Southern Pinwheel. M83 is 10 degrees southeast of Gamma Hydrae. Now make a wide move and head southeast of Arcturus for Alpha Serpentis. Eight degrees southwest is outstanding globular cluster M5 sharing the field with 5 Serpens. Now locate the "keystone" shape of Hercules, and identify Eta in its northwest corner. One-third the way between it and southern Zeta is the fantastic M13, the "Great Hercules Globular Cluster." More difficult is M92, because there are no stars to guide you. Try this trick: using the two northernmost stars in the "keystone," form an equilateral triangle in your mind, with its apex to the north. Point your scope there. Way to go, astronomer! You have now passed the most difficult part of the "mini-thon," and just think of the rewards! In less than a week, you have conquered over half of the Messier catalog.

While you spend a sleepy day, think about a French amateur astronomer who was watching a round black spot transit the Sun today in 1859. His name was Lescazbault, and he was sure he'd witnessed a new planet, which he christened "Vulcan." Nathaniel Bowditch was also born this date in 1773. He also devised the "Bowditch Curve," which applies in both physics and astronomy.

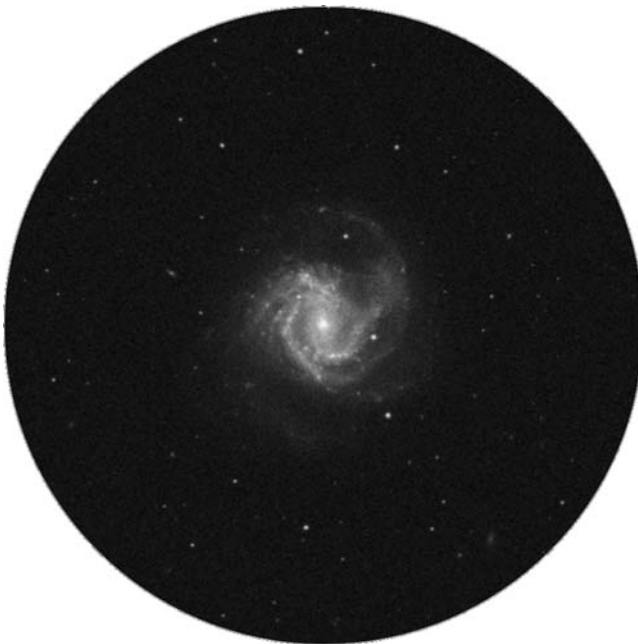


Figure 3.26a. M61 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.26b. Nathaniel Bowditch (historical image).

Friday, March 27

Are you tired of running the Messier Marathon yet? Don't be. Up before dawn isn't everyone's idea of a good time, but those who enjoy astronomy will enjoy seeing the promise of summer in the stars. For the next several days, we'll enjoy the finest and most easily located objects as we continue. Start with Lyra and its southernmost two bright stars Beta and Gamma. M57, the Ring Nebula, is about halfway between—the donut with your morning coffee! M56 resides about midway between Gamma Lyrae and Beta Cygni. Two degrees south of Gamma Cygni is open cluster M29, and M39 is less than a fist-width northeast of Deneb. Hop north of Gamma Sagittae to find M27, and the loose globular M71 is southwest of Gamma.

Now to early morning skies, and into our galactic halo, as we track down globular clusters. Ophiuchus' many stars can be hard to identify, so start with Beta Scorpii (Graffias) and head about 10 degrees northeast. That's Zeta: it's the marker you'll need for M107. About one quarter the way back toward Graffias, you will see a line of three stars in the finder. Aim at the center one, and you'll see globular M10 in the same field, and M12 is 3 degrees northeast. M14 is approximately 16 degrees south and due east of M10.

Enjoy your day and think about the importance of the birth of John Pierce in 1910. Pierce undertook the visionary work of communications satellites. Although people scoffed at his ideas, in 1960 he convinced a U.S. agency called NASA to convert a balloon-borne experiment called "Echo" into a radio wave reflector. Thanks to his brilliant work, the next step was the development of Telstar, a satellite that ushered in the modern age of television! Of course, you could always just skip TV tonight and do the marathon all at once. . .

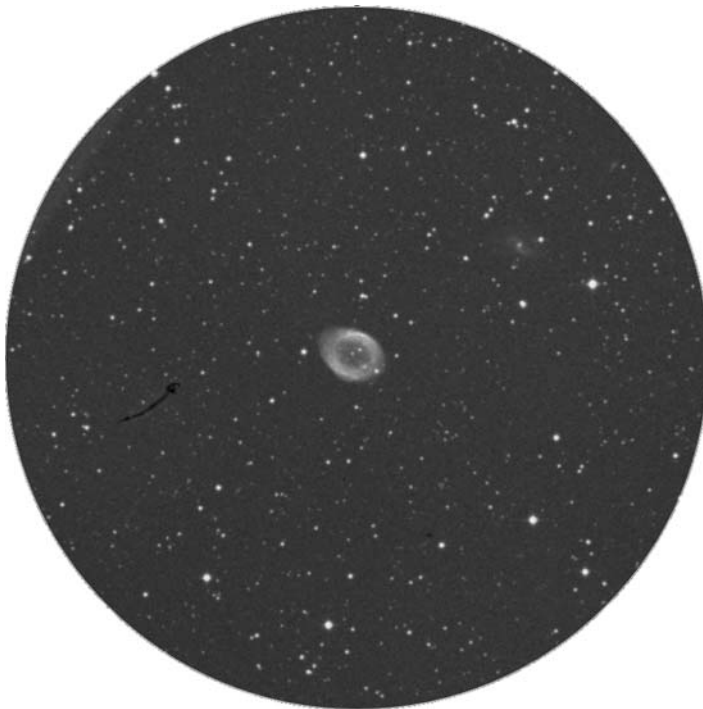


Figure 3.27a. M57 (credit—Palomar Observatory, courtesy of Caltech).

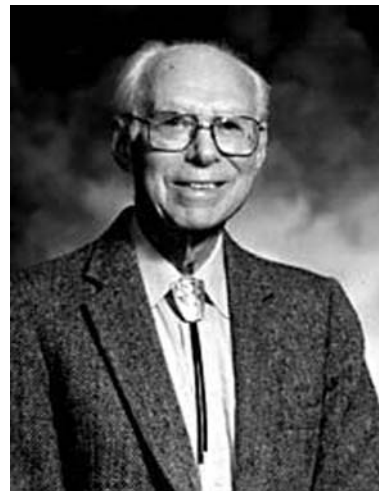


Figure 3.27b. John Pierce (historical image).

Saturday, March 28

In just a few short days, you've conquered 80 objects from a prestigious observing list! The time before dawn is a very quiet and beautiful part of the day. Now head for bright Eta Ophiuchi directly between Scorpius and Sagittarius. Globular M9 is 3.5 degrees southeast. Now head for Antares. The diffuse, giant globular cluster M4 is about a degree west. Four degrees northwest of Antares is compact, bright globular M80. Seven degrees due east of Antares is globular M19! The last globular cluster this morning is M62, located another 5 degrees south of M19. Hey, you're doing terrific! Some of these are tough to find unless you've had practice. But now we're up to a total of 85, and about to add a few more...

The lower curve of Scorpius is quite distinctive and the unaided eye pair you see at the "stinger" is beautiful double Lambda and its slightly less bright neighbor Upsilon. Just northeast is beautiful M6, the Butterfly Cluster. Slightly southeast is an unaided hazy patch. Aim there, and you'll find spectacular open cluster M7, or Ptolemy's Cluster. Identify Lambda Aquilae, look west, and you'll find M11, the Wild Duck open cluster. About the same distance to the south/southwest is open cluster M26. These are all great binocular targets, but it will take an exceptionally dark, clear sky to see the Eagle Nebula associated with M16—an easy open cluster about a fist-width southwest of M26.

If you're lost, try counting the stars down the Eagle's back from bright Altair until you reach Gamma Scuti and look about 2 degrees northwest. What you seek is worth the time it takes, because cluster M16 is a star-forming region located on the edge of one of the Milky Way's own spiral arms about 7,000 light-years away. Perhaps Messier was the first to notice the Eagle Nebula (IC 4703), because his notes include the description: "enmeshed in a faint glow." Large telescopes can see the dark dust lanes containing the Pillars of Creation, but it isn't always easy. The entire nebula eluded the Herschels!



Figure 3.28a. M16 and the Eagle Nebula (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.28b. The "Pillars of Creation" in the Eagle Nebula (credit—Hubble Heritage Team).

Sunday, March 29

Get up before dawn, and let's take a less frenzied look at the beauty around us. Begin by identifying Lambda, the northernmost star in the teapot asterism of Sagittarius. Its name is Kaus Borealis—the “northern” star—so grab your binoculars, for north is the direction we're heading. . . The bright “Nike Swoosh” of M17 is located a fist-width north of Lambda. Many of you know this as the Omega or Swan Nebula. Slide south for a very small collection of stars known as M18. Move further south to call up a huge cloud of stars labeled M24. This patch of Milky Way “stuff” will also show a wonderful open cluster—NGC 6603—to average telescopes, and some great Barnard darks to larger ones. Shift southeast for open cluster M25, and head due west a fist-width for open cluster M23. From there, drop south again, and M21 will be your reward. M20—the Trifid Nebula—is southwest. M8—the Lagoon Nebula—is further south again, and very easy to see. This particular star hop is great fun. If you have children, point out the primary stars, and show them how they look like a dot-to-dot “tea kettle.” From the kettle's “spout” pours the “steam” of the Milky Way. If you start there, all you will need to do is follow the “steam” trail up the sky and you will see the majority of these with ease. Our Messier temperature has now risen to 98. . .

On this date in 1974, NASA's Mariner 10 went into history by returning the first close-up pictures of the planet Mercury. Mariner also became the first craft to use solar wind to navigate when its panels were reconfigured into makeshift solar sails! Take time to honor the 1890 birth of Spencer Jones on this date, the first to prove Earth had a slightly irregular rotation, and to triangulate the Sun's position using an asteroid. Oddly enough, Vesta was also discovered on this date! If you'd like to take a look at this Arizona-sized world for yourself, be sure to look tomorrow night, as it appears less than a fist-width (8 degrees) south of the crescent Moon!



Figure 3.29a. M18 (credit—Palomar Observatory, courtesy of Caltech).

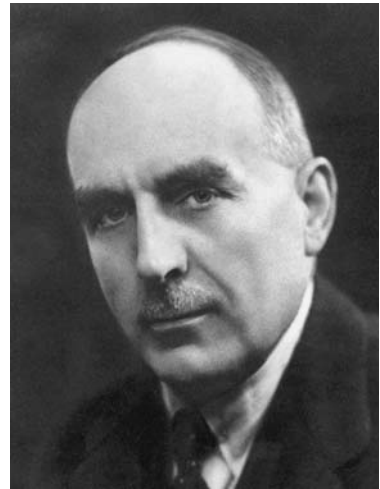


Figure 3.29b. Spencer Jones (historical image).

Monday, March 30

Wake up, sleepyhead. . . You must get up before dawn to finish our Messier studies! While the coffee is brewing, think about the year 239 BC, when the Chinese first recorded a perihelion passage of Halley's Comet. Now, step outside and look at the starry skies as you pay a moment's silent tribute to the English astronomer Stephen Groombridge, who passed away on this day in 1832. At age 51, he began cataloging 4,243 circumpolar stars within 50 degrees of Polaris. Although the catalog wasn't published until 6 years after his death, Groombridge never stopped working on it, even after he founded the Astronomical Society!

OK, now it's crunch time, and the first few on this list will be fairly easy to see around 5.00 am, but you won't have long before the dawn steals them from the sky. Remember Kaus Borealis? Good. We're starting at the top of the tea kettle with Lambda, our marker for the small M28 globular cluster. It is just a breath north-northwest. Larger, brighter, and quite wonderful globular cluster M22 is to Lambda's northeast. The southeastern corner of the tea kettle is Zeta. Slide southwest to capture globular cluster M54. Head another 3 degrees southwest for the faint, fuzzy ball of M70. Two degrees further west is another globular: say good morning to M69!

You've done a fantastic job over the last 10 days, and you can certainly understand by now that even with this slower pace, the Messier Marathon is a challenge not everyone can appreciate. Now, try to get some rest because the last objects on the list are coming up. . .



Figure 3.30a. M69 (credit—Palomar Observatory, courtesy of Caltech).



Figure 3.30b. Stephen Groombridge (historical image).

Tuesday, March 31

Be warned! It's really going to get tough to finish our Messier list, but you can do it! Start an hour before sunrise, but don't procrastinate. Small globular M55 is about a fist-width east-southeast of Zeta Sagittarii, and the dawn is coming. Even more difficult is equally small globular M75. Look for a "V" pattern of stars in the finder a fist-width south of Beta Capricorni, and aim at the northeastern star of this trio. Without the "square" of Pegasus to guide us, look low to the east and identify Enif by its reddish color. The power-punch globular M15 is northwest, and you should be able to see the star on its border in the finderscope. Be thankful M2 is such a fine—and large—globular cluster just a little less than a fist-width due west of Alpha Aquarii. Head a fist-width southwest of Beta Aquarii to snag what will now be two extremely dim ones—globular M72 and open cluster M73 open just west of Nu. We will be just ahead of the light of dawn for our last object. Hang on, Delta Capricorni, and show us the way south-southwest to star 41! If you can find that? Hey—you've found the dim globular cluster M30 in the same field northwest.

Congratulations!

You've done the entire Messier catalog in less than 2 weeks!

Is this a perfect list with perfect instructions? No way. Just like the weather, things aren't always perfect. These are just general guidelines to help you find the Messiers for yourself. Unless you're using a computer-guided scope, it takes a lot of practice to find them all, so don't be discouraged if they don't just fall from the sky. You might find all of them in 1 year—or you just might find all of them in one good night. Regardless of how long it takes you, or how long it takes the skies to cooperate, the beauty, joy, and reward is the peace and pleasure it brings.

Now, stop and salute the 1966 launch of Luna 10, the first spacecraft to orbit the Moon!



Figure 3.31a. M75 (credit—Palomar Observatory, courtesy of Caltech).

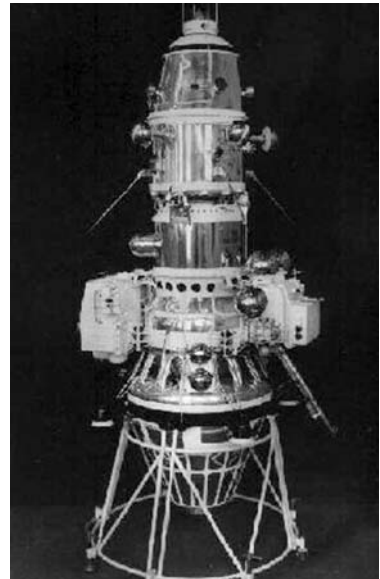
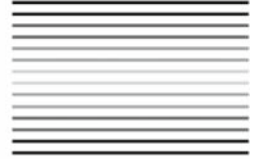
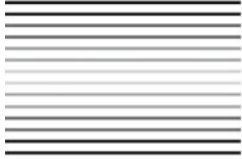


Figure 3.31b. Luna 10 (credit—NASA archives).

CHAPTER FOUR



April, 2009



Wednesday, April 1

On this date in 1960, the first weather satellite— Television InfraRed Observation Satellite 1 (TIROS 1)—was launched. Although today these satellites are commonplace, the TIROS was an achievement. It only operated successfully for 78 days, but for the first time we were able to see the face of Earth's changing weather.

There's plenty of moons to explore tonight, so why not try locating an area where many lunar missions have left their mark! Binoculars easily reveal the fully disclosed mares of Serenitatis and Tranquillitatis. Set your sights where these two vast lava plains converge. Telescopically you will see a bright "peninsula" where they meet in the west. Look for bright and small crater Pliny to the east of this point. It is near this inconspicuous feature that the remains of Ranger 6 lie forever preserved after "crash-landing" on February 2, 1964. Unfortunately, technical errors prevented Ranger 6 from transmitting lunar pictures, but not Ranger 8! On a successful mission to the same area, NASA received 7,137 "postcards from the near side of the Moon" for 23 minutes before a very hard landing. On the "softer side," Surveyor 5 touched down safely nearby after 2 days of malfunctions on September 10, 1967. Incredibly, the tiny Surveyor 5 endured temperatures of up to 139°C, but still spectrographically analyzed the area's soil and also managed to televise over 18,000 frames of "home movies" from its distant lunar location.

Tonight let's "see double." At magnitude 2.5, Gamma Leonis—or Algieba—is the second brightest member of the Leo "question mark." Now, a question for you. Did you know that Algieba is among the loveliest pairs in the night sky? See for yourself! Separated by less than 5", the primary appears ivory, while the secondary is golden. Those with smaller scopes will enjoy the beauty of the airy disks displayed by this pair.

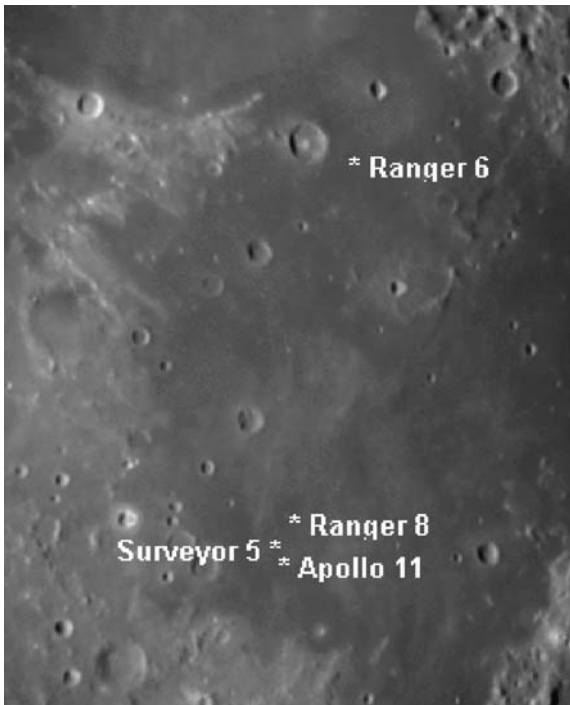


Figure 4.1a. "Moon Shot" (credit—Greg Konkell).

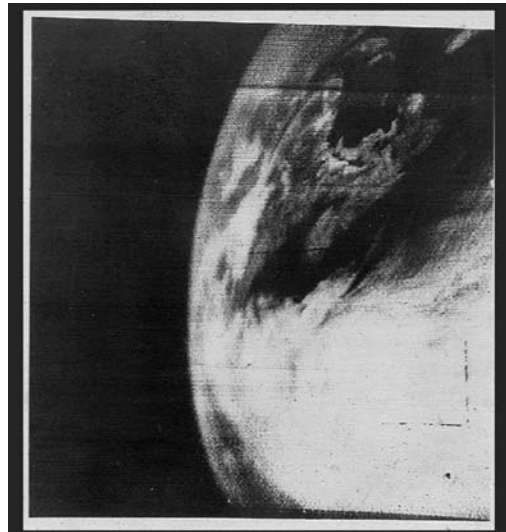


Figure 4.1b. TIROS (credit—NASA).

Thursday, April 2

On this date in 1889, the Harvard Observatory's 13" refractor arrived at Mt. Wilson. Just one month later, it went into astronomical service at Lick Observatory, located at Mt. Hamilton. It was here that the largest telescopes in the world resided from 1908 to 1948—the 60" for the first decade, then the 100". This latter mirror is still the largest solid piece ever cast in plate glass, and weighed 4.5 tons. Would you believe it's just 13" thick?

This date in 1845, the first photograph of the Sun was taken. Although solar photography and observing is the domain of properly filtered telescopes, no special equipment is necessary to see some effects of the Sun, only the correct conditions. Right now Earth's magnetosphere and magnetopause (the point of contact) are positioned correctly to interact with the Sun's influencing interplanetary magnetic field (IMF), and the plasma stream that flows past us as the solar wind. During the time around equinox, this leaves the door wide open for one of the most awesome signs of spring—aurora! Visit the Geophysical Institute to sign up for aurora alerts, and use their tools to help locate the position of Earth's auroral oval.

Tonight's featured lunar crater is located on the south shore of Mare Imbrium right where the Apennine mountain range meets the terminator. At 58 kilometers in diameter and 12,300 feet deep, Eratosthenes is an unmistakable crater. Named after the ancient Greek mathematician, geographer, and astronomer Eratosthenes, this splendid crater will display a bright west wall and a black interior hiding its massive crater-capped central mountain, 3,570 meters high! Extending like a tail, an 80-kilometer-long mountain ridge angles away to its southwest. As beautiful as Eratosthenes appears tonight, it will fade away to almost total obscurity as the Moon becomes full. See if you can spot it again in 5 days!

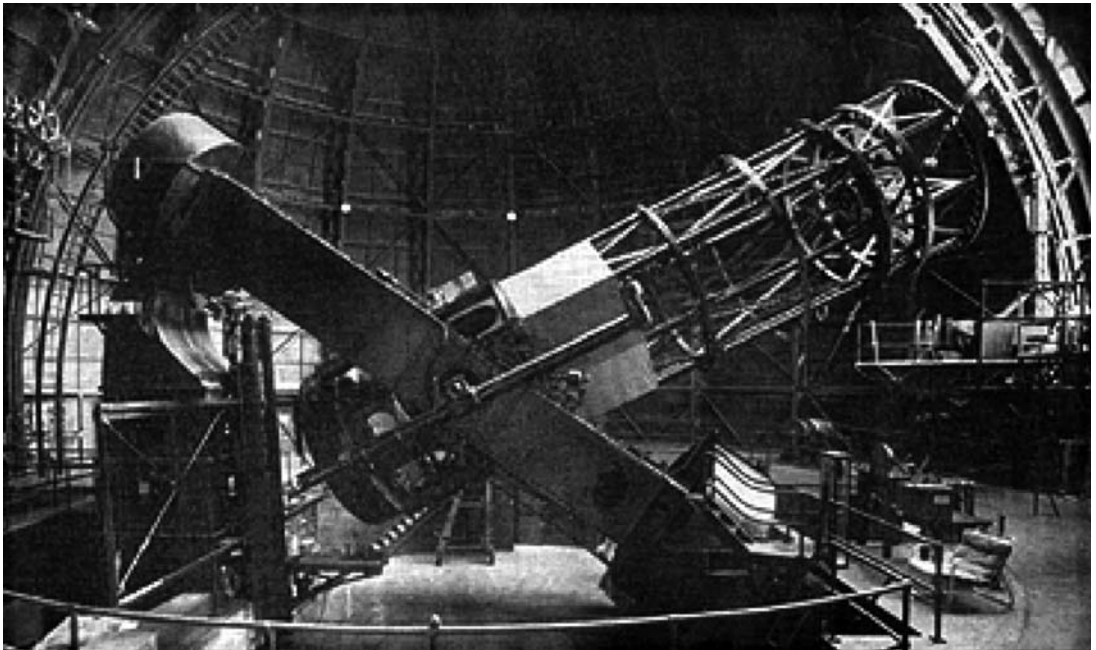


Figure 4.2a. The Hooker Telescope (credit—NASA).

Friday, April 3

This date marks the 40th anniversary of the launch of the first lunar orbiter, Luna 10. That makes another good reason to view the Moon tonight! Follow the southward descent of large crater rings Ptolemaeus, Alphonsus, and Arzachel to a smaller, bright one southwest named Thebit. We're going to have a look at Hell. Just west of Thebit and its prominent A crater to the northwest, you will see the Rupes Recta appearing as a thin, white line. Continue south until you see large, eroded crater Deslandres. On its western shore is a bright ring that marks the boundary of Hell. Although this might seem like an unusual name for a crater, it was named for an astronomer—and clergyman!

While you're out tonight, be on watch for the Kappa Serpentid meteor shower. Its radiant will be near the "Northern Crown"—the constellation known as Corona Borealis. The fall rate is small with an average of 4 or 5 per hour.

Deslandres, etc., credit: Greg Konkel



Figure 4.3. Deslandres, Hell and Walter (credit—Alan Chu).

Saturday, April 4

Today we celebrate the 1809 birth on this date of astronomer Benjamin Peirce. Peirce was a professor of astronomy and mathematics for nearly 40 years and contributed greatly to the discovery of Neptune.

On the lunar surface, crater Copernicus becomes visible to even the most modest of optical aids. Small binoculars will see Copernicus as a bright ring about mid-way along the lunar dividing line of light and dark called the terminator. Telescopes will reveal its 97-kilometer (60-mile) expanse and 120-meter (395-foot) central peak to perfection. Copernicus holds a special appeal; it's the aftermath of a huge meteoric impact! At 3,800 meters deep, its walls are 22 kilometers thick. Over the next few days, the impact ray system extending from this tremendous crater will become wonderfully apparent.

Tonight use Copernicus as a guide and look north-northwest to survey the Carpathian Mountains. The Carpathians ring the southern edge of Mare Imbrium, beginning well east of the terminator. But let's look on the dark side. Extending some 40 kilometers beyond into the Moon's own shadow, you can continue to see bright peaks, some reaching 2,000 meters high! Tomorrow, when this area is fully revealed, you will see the Carpathians begin to disappear into the lava flow forming them. Continuing onward to Plato—on the northern shore of Mare Imbrium—and look for the singular peak of Pico. Between Plato and Mons Pico, you will find the many scattered peaks of the Teneriffe Mountains. It is possible that these are the remnants of much taller summits of a once precipitous range. Now the peaks rise less than 2,000 meters above the surface. Time to power up! West of the Teneriffes, and very near the terminator, you will see a narrow line of mountains, very similar in size to the Alpine Valley. Known as the Straight Range, some of its peaks reach as high as 2,000 meters. Although this doesn't sound particularly impressive, that's over twice as tall as the Vosges Mountains in west-central Europe and comparable to the Appalachian Mountains of the eastern United States.



Figure 4.4a. Crater Copernicus (credit—Greg Konkell).

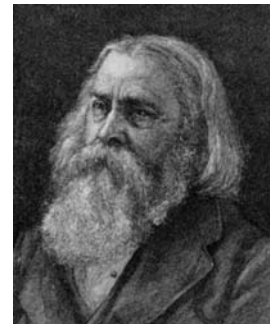


Figure 4.4b. Benjamin Peirce (historical image).

Sunday, April 5

Today let's take a look at Vincenzo Viviani. Born on this date in 1622, Viviani was a mathematician. At age 17, he became the student, secretary, and assistant to Galileo, serving him until the Master died in 1642. Viviani published his own books on mathematical and scientific subjects and edited the first edition of Galileo's collected works. He was an ardent supporter of Galileo and worked tirelessly to reinstate his mentor's good name.

Tonight let's continue our lunar mountain-climbing expedition and revisit the "big picture" on the lunar surface. All of Mare Imbrium is bathed in sunlight tonight, and we can see its complete shape. Appearing as a featureless ellipse bordered by mountain ranges, let's identify them all again. Starting at Plato and moving east to south to west you will find the Alps, the Caucasus, the Apennine, and the Carpathian Mountains. Look at the form closely. Doesn't it look like it's possible that an enormous impact created the entire area? Compare it to the younger Sinus Iridum, which is ringed by the Juras Mountains. The latter region may have also been formed by a much later and very similar massive impact event.

Are you in the mood for a double star? Then let's head west and away from the Moon. Begin your search right after skydark with El Nath. From Beta Aurigae, shift about two finger-widths east-northeast to identify very dim 26 Aurigae. At low power, look for an 8th magnitude companion due west of the 5.5 magnitude primary. The brighter star should give a warm yellow appearance, while the fainter will appear slightly bluer. This pair shares space with a third member (magnitude 11.5), some three times further out than the closer, brighter secondary. Thanks to lunacy, small instruments will have difficulty distinguishing the C star in such bright skies.



Figure 4.5a. Lunar image (credit—Greg Konkel).



Figure 4.5b. Vincenzo Viviani (historical image).

Monday, April 6

Today we begin by honoring the 1890 birth on this date of André-Louis Danjon. This French astronomer created the five-point scale for rating the darkness and color of a total lunar eclipse, a scale that still bears his name. Danjon also studied Earth's rotation and developed astronomical instruments, including a photometer to measure Earthshine.

On the Moon tonight, we'll start by identifying the large mare just south of central on the lunar disk called Oceanus Procellarum. Look almost centrally within its gray expanse for a large crater that has mostly melted down. This "ghost crater" has no name, but look along its edge for Class I Flamsted. Note that it is very near here that Surveyor 1 still stands. It made its landing on June 2, 1966, and sent back more than 11,000 pictures of the rock strewn, desert-like floor. This area was one of the first chosen for an Apollo mission landing, but it was later scratched for a more central location.

Now let's move onto 3.2-magnitude Mebsuta—Epsilon Geminorum. Mebsuta is the brightest star (other than Castor) in northwestern Gemini. It has a very distant 9th magnitude companion. As you observe Epsilon, keep in mind that its spectral class (G8) is very similar to that of our Sun. Despite this, Mebsuta glows with an intensity of light 7,600 times brighter. It's one of a rare class of stars called "yellow supergiants," stars whose nuclear cores are vastly swollen due to advanced age and that have taken on "planetary" proportions. Why planetary? Because the planet Venus would find itself orbiting inside Mebsuta's 4,600°C temperature photosphere!



Figure 4.6a. Crater Flamsted (credit—Alan Chu).

Tuesday, April 7

If you're up before dawn this morning, look for the Red Planet: Mars. This date in 2000 NASA launched the 2001 Mars Odyssey spacecraft on a Delta 2 rocket. Odyssey would travel 460 million kilometers and enter Martian orbit over a year later. Its primary mission was to look for water ice under the Martian surface and create a thermal map.

While you're out tonight, be sure to look for Saturn just a couple of finger-widths north of the Moon. For something less obvious, head to the lunar surface and Oceanus Procellarum. On the terminator to its southwest (and almost due west geographically), you will see two craters nearly identical in size and depth. The southern crater is Billy, one of the darkest-floored areas on the Moon. Inside Billy's bright rim, you will notice an interior as featureless as a mare. North of Billy is Hansteen, whose interior is much brighter and shows complex details. Comparing the two will show that Billy was once filled with smooth lava, while Hansteen avoided this fate and shows its native scarred interior.

Although skies will be bright this evening, we can still have a look at brilliant Arcturus, a star whose distance from Earth (10 parsecs) and radial velocity (less than 200 meters per second) can almost be considered benchmarks. By skydark, you will see 0.2 magnitude Arcturus, the brightest star in Boötes and fourth brightest star in the night sky. Look for Arcturus's orange color! Because a star's intrinsic luminosity relates to its apparent brightness and distance, Arcturus's absolute magnitude is almost precisely the same as its apparent magnitude. Just because Arcturus's radial velocity is nearly zero doesn't mean it isn't on the move. Every 100 years Arcturus shifts almost 1 degree across the sky!

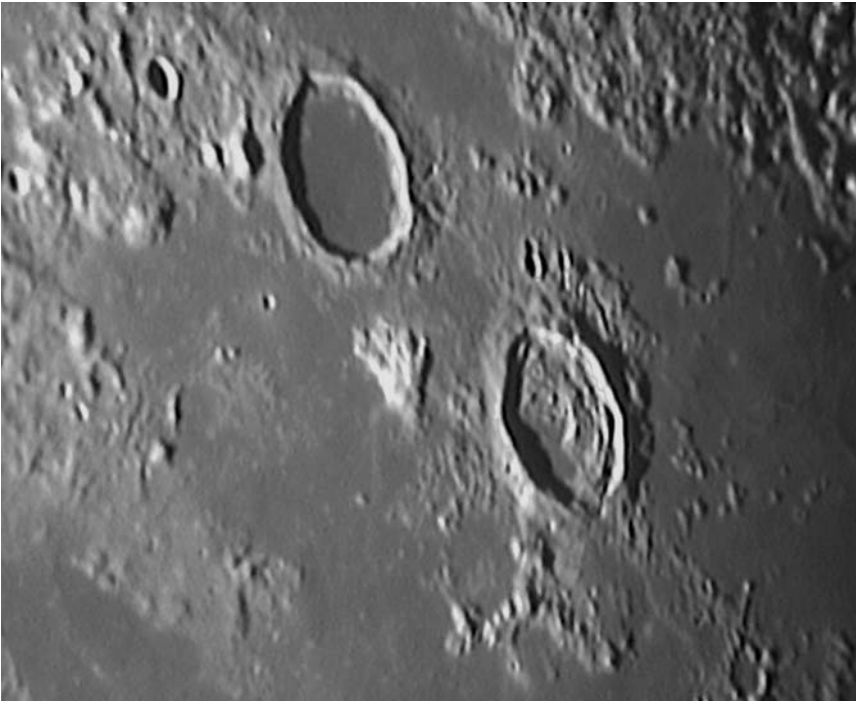


Figure 4.7a. Mars Odyssey mission (credit—NASA).

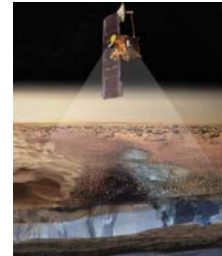


Figure 4.7b. Hansteen and Billy (credit—Alan Chu).

Wednesday, April 8

Today let's salute the 1732 birth on this date of David Rittenhouse. Although Rittenhouse's name might not stand out in a crowd, his contributions should! Rittenhouse was professor at the University of Pennsylvania and a friend of Benjamin Franklin. He was one of the first to observe the atmosphere of Venus, and true to Franklin's style, placed a spider web on his telescope's finder—creating the first crosshairs!

Tonight let's launch our lunar explorations as we head for the far north for an "on the edge" feature, Pythagoras. Named for the Greek philosopher and mathematician, you will see this smooth, walled plain as a thin, bright ellipse standing out clearly against the background of northern Sinus Iridum. Pythagoras is one of the deepest craters in the northern quadrant and would be even more spectacular if visible from overhead, rather than at an angle. Look for its tall and prominent central peak.

Although the Moon will interfere with most studies, we can still check out Iota Cancri, a fine wide disparate double of magnitudes 4.0 and 6.6 separated by some 30". The members of this true binary are so distant from one another that they take over 60,000 years to complete a single orbit around their common center of gravity! Located slightly less than a fist-width due north of M44, the pair is about 300 light-years distant. Both stars shine with a light considerably brighter than our Sun's, and observers may note the subtle gold and pale blue color contrast between them.



Figure 4.8a. Pythagoras (credit—Alan Chu).

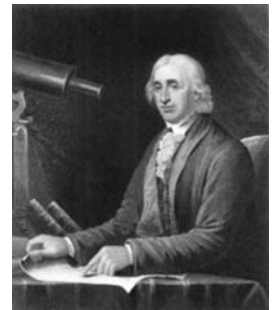


Figure 4.8b. David Rittenhouse (historical image).

Thursday, April 9

Today we begin by noting the 1816 birth on this date of Charles-Eugène Delaunay. This French astronomer worked for 20 years on lunar motion and advanced planetary-motion theories. Delaunay expressed the longitude, latitude, and parallax of the Moon as infinite series. In 1870 he succeeded Le Verrier as director of the Paris Observatory.

How fitting that we should be talking about a man of the Moon! Tonight's Full Moon is often referred to as the "Pink Moon" of April. As strange as the name may sound, it actually comes from the herb moss called ground phlox. April is the time of blossoming, and the "pink" is one of the earliest widespread flowers of the spring season. As you might expect, we know this Full Moon by other names as well. How about the "Full Sprouting Grass Moon"; the "Egg Moon"; the "coastal tribes Moon"; or the "Full Fish Moon," as we've entered the season when fish swim upstream to spawn.

Now let's take a journey toward the 25th brightest star in the night sky, 1.3 magnitude Regulus. Known as the "Little King," Regulus is the brightest star in Leo. At 77 light-years away, this star is considered a "dwarf" despite shining with a visible light almost 150 times that of Sol. The reddish-orange giant Arcturus and the blue-white dwarf Regulus both share a common absolute magnitude very close to 0. The two stars shine with a similar intrinsic brightness—despite widely different physical sizes—because Regulus's photosphere is more than twice as hot (12,000 K) as that of Arcturus. While observing Regulus, look for a distant companion of magnitude 8.5. Normally low powers would best concentrate the companion's light, but try a variety of magnifications to help improve contrast. For those with large aperture scopes, look for a 13.1-magnitude "companion's companion" a little more than 2" away!



Figure 4.9a. Regulus (credit—John Chumack).



Figure 4.9b. Charles-Eugène Delaunay (historical image).

Friday, April 10

Although the Moon will hamper the view, be up before dawn to enjoy the Virginid meteor shower. The radiant point will be near Gamma in the bowl of Virgo. The fall rate of 20 per hour is above average for meteor showers, and just one “shooting star” can make your day!

Even with tonight’s fast-rising Moon, let’s try for a scattered open cluster, NGC 2281 (RA 06 48 18 Dec +41 05 00) toward the west in Auriga. At magnitude 5.4, NGC 2281 should be visible as a nebulous mist in binoculars on a dark night, but you’ll need a scope and high power to darken the sky enough to see the bright members found near its core. NGC 2281 is around 1,500 light-years distant and 50 million years old. It can best be found by extending a line from Capella to Beta Aurigae an equal distance east to a pair of 5th magnitude stars separated by a finger-width. NGC 2281 lies less than a degree southeast of the eastern member of this pair (58 Aurigae).

When studied photometrically, NGC 2281’s binary stars were found to congregate more toward the center of the cluster, and with more intensity than for single stars alone. With a population of no more than 60 stars, the binaries far outnumber their counterparts!



Figure 4.10. NGC 2281 (credit—Palomar Observatory, courtesy of Caltech).

Saturday, April 11

This morning would be a great time to get up early, because Jupiter is going to have a “guest!” Sometimes it’s difficult to distinguish the planet Mercury with just the unaided eye, but if you can spot Jupiter you’ll find the elusive inner planet less than 7 degrees north of Jupiter!

Today we honor the 1862 birth of William Wallace Campbell, pioneer observer of stellar motions and radial velocities. Campbell was the director of Lick Observatory from 1901 to 1930 and he also served as president of the University of California and the National Academy of Sciences. Sharing his birthdate in 1901 was Donald H. Menzel, assistant astronomer at Lick Observatory, Director of Harvard Observatory, expert on the Sun’s coronosphere, and genuine unidentified flying object (UFO) buff. This date in 1960, the first radio search for extraterrestrial civilizations—Project Ozma—was started by Frank Drake; and in 1986, Halley’s Comet was also closest to Earth for this apparition at a distance of 65 million kilometers.

After such a grand day in history, it seems only fitting that we celebrate it with a grand object! Our mark is due west of Alpha Crateris and easily found by hopping northeast to Nu Hydrae and west past Phi 1 and 2. Now, center on Mu and drop south less than 2 degrees. Suitable for even small telescopes and larger binoculars, this handsome planetary nebula—NGC 3242—is often referred to as the “Ghost of Jupiter.” For aperture at high power, this nebula comes alive with an inner star revealed and an eye-like ring structure. With high surface brightness, it will take all the magnification that sky conditions allow and return structure. Be sure to use averted vision to pick up many faint details in this incredible planetary nebula, also known as Herschel H IV.27 and Caldwell 59!



Figure 4.11a. NGC 3242: the Ghost of Jupiter (credit—Adam Block/NOAO/AURA/NSF).

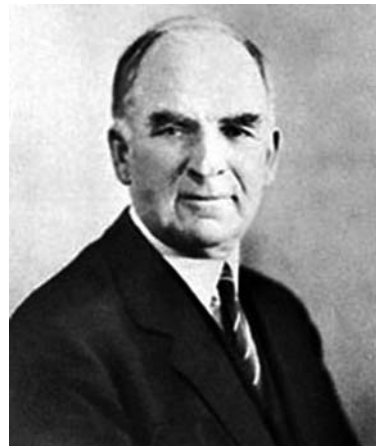


Figure 4.11b. William Campbell (widely used public image).

Sunday, April 12

On this date in 1961, Yuri Gagarin became the first person in space as he made one full orbit of Earth aboard Vostok 1, just 20 years before Columbia became the first space shuttle to be launched! Today also celebrates the 1851 birth of Edward Maunder, a bank teller turned assistant Royal Astronomer. Assigned to photographing and cataloging sunspots, Maunder was the first to discover solar minimum times and equate these with climate change. Maunder was also the first to propose that Mars had no "canals," only delicate changes in surface features. Smart man! If you're up before dawn this morning, you can spot the Red Planet for yourself about an hour before dawn.

If you like challenging planetary nebulae studies, here's a good one to try tonight—NGC 2610 (RA 08 33 23 Dec -16 08 58) near the Hydra/Puppis/Pyxis border. At 13th magnitude, it's not for the beginner, but a worthy study for seasoned veterans. Its position near two 7th magnitude stars will help reveal its location at low power. Magnify to catch a slightly elliptical shell, a stellar point on its northeast edge, and a wink of a central star. Note NGC 2610 is also cataloged as Herschel IV 65...another to add to your "Herschel Hit List!"



Figure 4.12a. NGC 2610 (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.12b. Edward Maunder (widely used public image).

Monday, April 13

If you have a hankering to see something very beautiful, be sure to look for the ultra-close pairing of Antares and the Moon in the predawn skies. Too bad the Sun will rise before they occult each other! Now begin the day with the 1738 birth of Paolo Frisi, who interpreted the works of Galileo Galilei and Sir Isaac Newton. He studied the motions, shape, and size of Earth and Moon per Newton's theories. Joining him in 1905 was Bruno Rossi, who studied cosmic rays and began the field of high-energy particle physics. Rossi was also one of the first to practice X-ray astronomy. NASA's Rossi X-ray Timing Explorer *See* Rossi, Bruno satellite honors his name. Tonight let's honor Rossi's achievements with a challenging study located 2 degrees west of Upsilon Hydrae. At magnitude 13, the unique galactic pairing of NGC 2992/93 will show the core regions of both galaxies cleanly to mid-aperture telescopes, but come to life in larger ones. NGC 2992 is a Seyfert type 2 galaxy, having a wisp extending from its galactic plane and divided by a dust lane. An incredibly powerful stellar wind that may drive from the core of this galaxy has perhaps produced massive bursts of star formation.

NGC 2992 is interacting with starburst galaxy NGC 2993, and they share mutual tidal forces. When they began to approach each other a "bridge" was created between the galactic nuclei in the form of ejected stars and gas, triggering violent star formation. Eventually this action will destroy their disk structures, and they will merge to create a single elliptical galaxy.

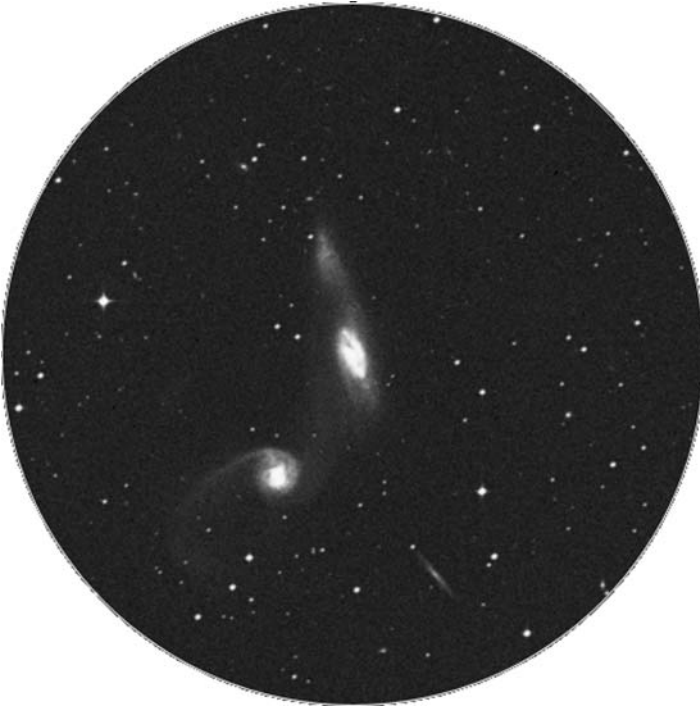


Figure 4.13a. NGC 2992/93 (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.13b. Bruno Rossi (widely used public image).

Tuesday, April 14

Today is the birthday of Christian Huygens (Figure 4.14b). Born in 1629 on this date, the Dutch scientist went on to become one of the leaders in his field during the seventeenth century. Among his achievements were developing a theory of light and patenting the pendulum clock. In addition, Huygens was discoverer of Saturn's rings and the planet's largest satellite, Titan. As you begin your observing evening, be sure to at least take a glance at Saturn and pay your respects to a man who was chasing photons some 380 years before us—and with equipment far more primitive. As you look at Titan, remind yourself of just much we've achieved since Chris's time!

This is also a wonderful chance to catch up on studies that you many have been clouded out on, as well as seasonal favorites from past years. If you're in the mood, turn an eye toward Lambda Hydrae. Not only is this a beautiful collection of stars in binoculars, but it holds a surprise for the telescope as well. Power up to help darken the field, and look for NGC 3145 to the primary star's southwest. Although it will take a mid-aperture telescope to make out the smooth, faint form of this spiral galaxy, it presents a wonderful challenge to larger scopes.

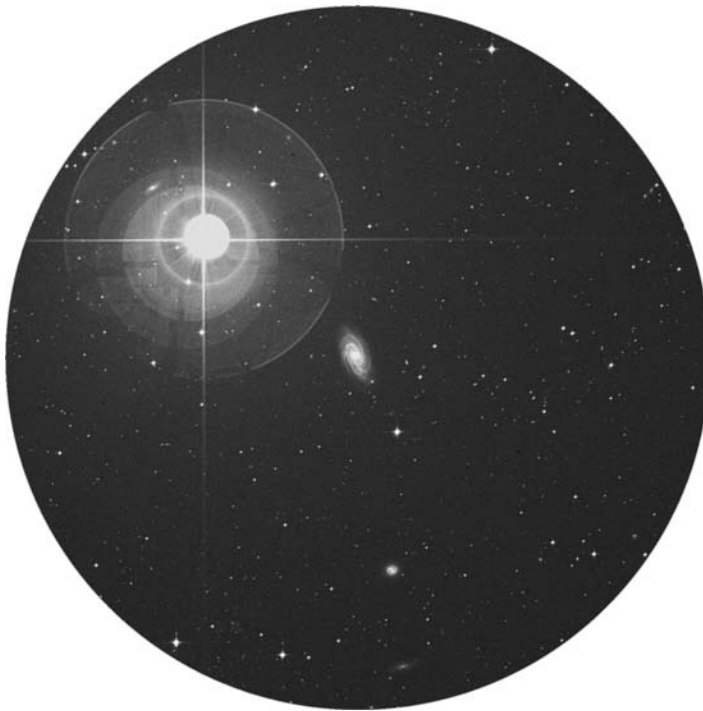


Figure 4.14a. NGC 3145 (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.14b. Christian Huygens (widely used public image).

Wednesday, April 15

What a wonderful morning to be up before dawn! Even if you only have a pair of binoculars, be sure to take a look at Mars, because Uranus is only about half a degree to its north! For astrophotographers, what a great opportunity to catch two planets in the same field of view! While outside, keep a watch for the “April Fireballs.” This unusual name has been given to what may be a branch of the complex Virginid stream, which began earlier in the week. The absolute radiant is unclear, but keep your eyes on the ecliptic near Virgo. These bright bolides can possibly arrive in a flurry depending on how much Jupiter’s gravity has perturbed the meteoroid stream. Even if you only see one tonight, keep watching in the days ahead. The April Fireballs will last for two more weeks!

Today we take note of the 1793 birth of Friedrich Georg Wilhelm von Struve, the first in a line of four generations of noted Struve astronomers! If you recognize his name as being connected to double stars, you’re right. He founded the modern study of binary stars. The first Struve measured 3,112 binaries, and discovered well over 2,000 of them on his own! Honor his work by viewing 27 Hydrae around 2 degrees southwest of Alpha (RA 09 20 29 Dec -09 33 20). This is a 5th and 7th magnitude well-separated pair!

Now we’re off to study another Herschel object (H II 506) in Hydra that’s a 7 degree drop south of Alpha—NGC 2907 (RA 09 31 42.1 Dec -16 44). Requiring at least a mid-aperture telescope to reveal, this edge-on galaxy is quite worth the trouble. It’s highly prized because of research on its dust extinction properties, which in some ways greatly resemble those of our own Milky Way Galaxy. For larger telescopes, averted vision will call up a hint of a dark dust lane across a bright core. Although it is neither particularly huge nor particularly bright, NGC 2907 will present an interesting challenge for those with larger scopes looking for something a bit out of the ordinary.



Figure 4.15a. NGC 2907 (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.15b. Friedrich Georg Wilhelm von Struve (historical image).

Thursday, April 16

Today let's begin with the 1682 birth on this date of John Hadley. Although you might not recognize his name, you're most certainly acquainted with his achievement! Hadley perfected methods for grinding and polishing telescope lenses and significantly improved the reflecting telescope. His 6" reflector was the first to be useful enough for astronomy!

Tonight let's take a look at a galaxy that could have been spotted using Hadley's equipment. By today's standards, even binoculars or a very small telescope can spot this galaxy, residing roughly a handspan below Spica—M83 (RA 13 37 00 Dec -29 51 58). Starhop instructions are not easy for this one, but look for a pair of twin stars just west of the easily recognized "box" of Corvus—Gamma and R Hydrae. You'll find it about four finger-widths further south of R.

One of the brightest galaxies around, Lacaille discovered the "Southern Pinwheel" with a half-inch aperture spyglass in 1752. Roughly 10 million light-years distant, M83 has been home to a large number of supernova events, one of which was even detected by an amateur observer. To binoculars, it will appear as a fairly large, soft, round glow with a bright core, all set in a delightful stellar field. As aperture increases, so do details, revealing three well-defined spiral arms, a dense nucleus, and a knots of stars. It is truly a beauty and should become an observing favorite!



Figure 4.16a. M83 (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.16b. John Hadley (historical image).

Friday, April 17

On this date in 1976, the joint German and NASA probe Helios 2 came closer to the Sun than any other spacecraft so far. One of its most important contributions helped us to understand the nature of gamma ray bursts. Let's begin our evening with a burst of galaxies in Hydra about 5 degrees due west of the Xi pairing (RA 10 36 35 Dec -27 31 03). Centermost are two fairly easy to spot ellipticals, NGC 3309 and NGC 3311, accompanied by spiral NGC 3322. Far fainter are other group members, such as NGC 3316 and NGC 3314 to the east of the 7th magnitude star; and NGC 3305 north of the 5th magnitude star. Although such galaxy clusters as the NGC 3308 region are not for everyone, studying those very faint fuzzies is a rewarding experience for those with large aperture telescopes.

Now let's kick back and watch the peak of the Sigma Leonid meteor shower. The radiant is traditionally located on the Leo-Virgo border but has migrated to Virgo in recent years. Thanks to Jupiter's gravity, this shower may eventually become part of the Virginid Complex as well. The fall rate is very low at around 1-2 per hour.

While we're watching, let's talk about Giovanni Riccioli, who was born on this date in 1598. Italian astronomer Riccioli was the first to observe a double star in the year 1650. . .and it was one you've probably observed, too—Mizar! He also watched shadow transits on Jupiter and did many lunar studies, including mapping. If you've ever wondered who gave such fanciful names to the lunar maria, or tagged the major craters with names of famous scientists and philosophers, now you know that it was Riccioli!



Figure 4.17a. NGC 3308 region (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.17b. Map showing Riccioli features (historical image).

Saturday, April 18

Today let's take a look at the 1838 birth of Paul-Émile Lecoq de Boisbaudran on this date, who improved the field of spectroscopic identification and spent many years scanning minerals for undiscovered spectral lines. His persistence finally netted him the discovery of three new elements!

Tonight let's start out "elemental" as we use binoculars to identify R Corvi, located almost dead center in the Corvus "rectangle" and to the southwest of its companion field stars. Although variable stars are not every one's cup of tea, R (RA 12 19 37 Dec -19 15 21) has changed greatly in a little less than a year—from magnitude 8 to as faint as magnitude 14! This Mira-type star should be nearing its maximum, so be sure to try it before it fades away. . .

Now let's head out in search of an object that is one royal navigation pain for the Northern Hemisphere but makes up for it in beauty. Start with the southernmost star in Crater, Beta. If you have difficulty identifying it, it's the brightest star east of the Corvus rectangle. Now hop a little more than a fist-width southeast to reddish Alpha Antilae. Less than a fist-width below, you will see a dim 6th magnitude star, which may require binoculars in the high north. Another binocular field further southwest and about 4 degrees northwest of Q Velorum is our object, NGC 3132 (RA 10 07 01 Dec -40 26 11). If you still have no luck, try waiting until Regulus has reached your meridian and head fully 52 degrees south. More commonly known as the "Southern Ring" or the "Eight Burst Planetary," this gem is brighter than the northern "Ring" (M57) and definitely shows more details. Able to be captured in even small instruments, larger ones will reveal a series of overlapping shells, giving this unusual nebula its name.



Figure 4.18a. R Corvi (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.18b. NGC 3132 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, April 19

Don't sleep in this morning! It's worth getting up early to see Jupiter and the Moon only about a finger-width apart in the morning sky. If you check out the pair in binoculars, you'll notice faint little Neptune is also a part of this early morning trio!

On this date in 1971, the world's first space station was launched, the Soviet research vessel Salyut 1. Six weeks later, Soyuz 11 and its crew of three docked with the station, but a mechanism failed, denying them entry. The crew conducted their experiments, but were sadly lost when their re-entry module separated from the return spacecraft and depressurized. Although the initial phase of Salyut 1 seemed doomed, the mission continued to enjoy success through the early 1980s and paved the way for Mir.

Now, let's try picking up a globular cluster in Hydra that is located about three finger-widths southeast of Beta Corvi and just a breath northeast of the double star A8612—namely, M68. This class X globular cluster was discovered in 1780 by Charles Messier, and first resolved into individual stars by William Herschel in 1786. At a distance of approximately 33,000 light-years, it contains at least 2,000 stars, including 250 giants and 42 variables. It will show as a faint, round glow in binoculars, and small telescopes will perceive individual members. Large telescopes will fully resolve this small globular to the core!



Figure 4.19a. M68 (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.19b. Salyut 1 (credit—NASA).

Monday, April 20

Today let's start with the 1928 birth on this date of Gerald S. Hawkins, who postulated that Stonehenge was a prehistoric astronomical observatory. Although you might think there's a touch of fantasy there, Hawkins did his homework and found a pattern of alignments with 12 major lunar and solar events). His findings "Stonehenge Decoded" appeared as an article in the prestigious *Nature* magazine and in a book of the same name. He went on to explore many other astro-archaeological structures as well.

Tonight let's take our own adventure as we move into the constellation of Cancer. This will be an ideal time to familiarize yourself with its dim stars and one very bright open cluster. Try using both Pollux and Procyon to form the base of an imaginary triangle. Now aim your binoculars or finderscope near the point of the apex to discover M44, the Beehive. According to ancient lore, this group of stars (often called the Praesepe) foretold a coming storm if it was not visible in otherwise clear skies. Of course, this came from a time when combating light pollution meant asking your neighbors to dim their candles. But once you learn where it's at, it can be spotted unaided even from suburban settings. Hipparchus called it the "Little Cloud," but not until the early 1600s was its stellar nature revealed.

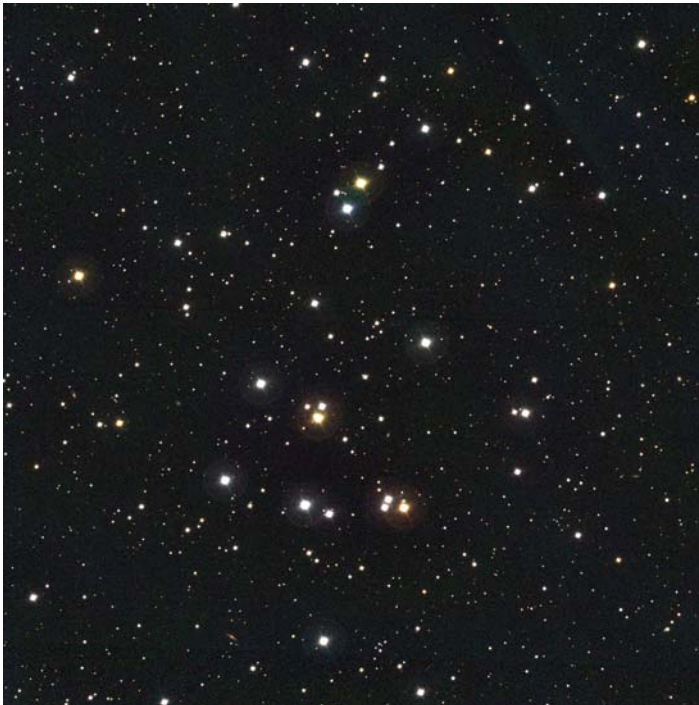


Figure 4.20a. M44: the Beehive Cluster (credit—NOAO/AURA/NSF).



Figure 4.20b. From *Stonehenge Decoded* (credit—Gerald Hawkins).

Tuesday, April 21

Let's start our day by taking note of the 1774 birth of Jean-Baptiste Biot on this date. This French mathematics wizard knew several popular astronomers of the day, including Arago and Laplace. Although he helped to measure the arc of the meridian, he's probably best known for making advances in astronomy in the fields of magnetism, heat, and optics.

Tonight let's use our optics to return to the upside down "Y" of the constellation of Cancer. If you can spot M44, the star just south of it is Delta. About three finger-widths southeast of Delta is Alpha, and we'll begin by exploring this star. The 130 light-year-distant Alpha Cancri—Acubens—is around 4th magnitude and is also a great double star for a small telescope. Its name translates as the "claw," and you will find it clutching a disparate 11.8 magnitude companion star nearby.

Now hop just one finger-width west for a stunning sight—the galactic cluster M67 (RA 08 51 18 Dec +11 48 00). Hanging out in space some 2,500 light-years away and containing more than 500 members, this grand cluster is a rule breaker in age. Believed to be about 10 billion years old, M67 is one of the oldest star clusters in our galaxy. Its stars have literally "switched off" from the main sequence, have passed through the red giant stage, and are returning to their blue youth! In binoculars, you will see it as almost galaxy-like in structure, while even small telescopes resolve individual stars. Large telescopes will reveal stars beyond stars, like a globular cluster smeared across the night. It is truly one of the most beautiful and mysterious of all open clusters.



Figure 4.21a. M67 (credit—Nigel Sharp and Mark Hanna/NOAO/AURA/NSF).

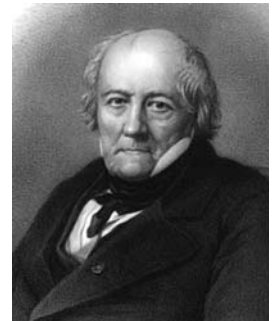


Figure 4.21b. Jean Biot (historical image).

Wednesday, April 22

Today a rather rare event will occur. Venus has just resumed prograde but is still moving slowly enough for Mars to catch it, and the pair will pass again on June 19! While you're out this morning, do look for Venus and the Moon making a very close conjunction. This could be a daylight occultation event, so be sure to check resources such as IOTA for specific information. However, be up well before dawn on this Moon- and planet-filled morning for a chance to view the peak of the Lyrid meteor shower. Since the radiant is near Vega, you will improve your chances of spotting them when the constellation of Lyra is as high as possible. This stream's parent is Comet Thatcher, and it produces around 15 bright, long-lasting meteors per hour.

Today celebrates the birthday of Sir Harold Jeffreys, who was born in 1891 on this date. Jeffreys was an astrophysicist, and the first person to envision Earth's fluid core. He also helped in our understanding of tidal friction, general planetary structure, and the origins of our Solar System.

We'll return tonight to Cancer to have a look at some curiosities. The first is about four finger-widths away from Delta, Zeta Cancri. Its name is Tegmeni, and it is a handsome double star for the small telescope. Both components are at nearly the same magnitude and are neatly split for mid-magnification ranges. About a finger-width due east is V Cancri, a Mira-type variable star. Although many such variables are difficult to follow with amateur equipment, V Cancri breaks the rules. It changes from magnitude 7.9 to magnitude 12.8 in a period of 125 days. When it swells to its maximum, it reaches a size about that of the orbit of Mars. For those of you who use only your eyes to observe, look again at the Beehive and concentrate on Delta to the southeast. Known as Asellus Australis, this is a yellow optical double star often called the "Southern Donkey."



Figure 4.22a. Zeta Cancri (credit—Palomar Observatory, courtesy of Caltech).

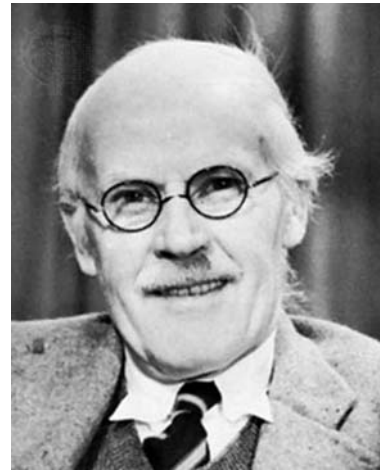


Figure 4.22b. Sir Harold Jeffreys (historical image).

Thursday, April 23

Pioneer quantum physicist Max Planck was born on this date in 1858. In 1900, Max derived the Planck equation to explain the shape of blackbody spectra (a function of temperature and wavelength of emission). A blackbody is any object that absorbs all incident radiation, regardless of wavelength. For example, heated metal has blackbody properties because the energy it radiates is thermal. The blackbody spectrum's shape remains constant, and the peak and height of an emitter can be measured against it, be it cosmic background radiation or our own bodies.

Now, let's put this knowledge into action. Stars themselves approximate blackbody radiators, because their temperatures directly control the color we see. A prime example of a "hot" star is Alpha Virginis, better known as Spica. Compare its color to the cooler Arcturus. . . What colors do you see? There are other astronomical delights that radiate like blackbodies over some or all parts of the spectrum. You can observe another example in a nebula such as M42, in Orion. By examining the radio portion of the spectrum, we find its temperature properly matches that of electrons fluorescing. Much like in a common household fixture, this process is what produces the visible light we see.

Ready for galaxy hunting in Cancer? You'll find NGC 2672 just about a degree northeast of Delta (RA 08 49 21 Dec +19 04 29). In larger scopes this small (magnitude 12.3) elliptical galaxy will show a companion—NGC 2673—on its eastern edge. For very large telescopes, look slightly southwest for challenging (magnitude 15) NGC 2677. If you're enjoying this small cluster of galaxies, move a third degree west, or let the field drift. Your reward is another galactic pair in the same field at high power, NGCs 2667A and B. Be aware that these difficult studies require very averted vision! Look for two almost stellar nuclei.



Figure 4.23a. NGC 2672/73 (credit—Palomar Observatory, courtesy of Caltech).

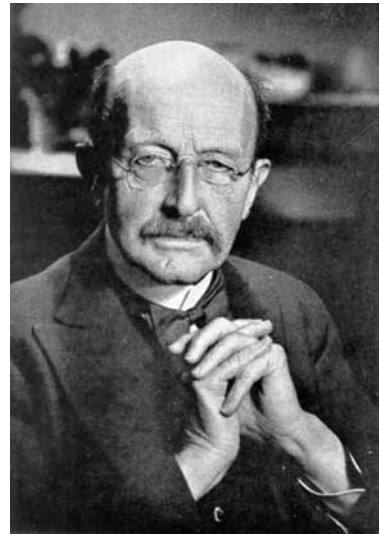


Figure 4.23b. Max Planck (widely used public image).

Friday, April 24

On this date in 1970, China launched its first satellite. Named Shi Jian 1, it was a successful technological and research craft. This achievement made China the fifth country to have sent a vessel into space. Observe a moment of silence for Vladimir Mikhailovich Komarov, the first man known to have died during a space mission. He was Command Pilot of Voskhod 1 and Soyuz 1. Komarov died during the landing of the Soyuz, when the spacecraft became entangled in its main parachute and fell several miles to Earth.

Tonight let's do a galaxy hop that's relatively easy for larger binoculars and small telescopes. You'll find a pair of galaxies almost perfectly mid-way between Theta and Iota, and their names are M65 (RA 11 18 55 Dec +13 05 32) and M66 (RA 11 20 15 Dec +12 59 21). Discovered by Méchain in March 1780, apparently Messier didn't notice the bright pair when a comet passed between them in 1773. At around 35 million light-years away, you will find M66 to be slightly brighter than its 200,000-light-year-distant western neighbor, M65. Although both are Sb-class spirals, the two couldn't appear more different. M65 has a bright nucleus and a smooth spiral structure, with a dark dust lane at its eastern edge. M66 has a more stellar-like core region with thick, bright arms that show knots to larger scopes, as well as a wonderful extension from the southern edge.

If you are viewing with a larger scope, you may notice to the north of this famous pair yet another galaxy. NGC 3628 (RA 11 20 16 Dec +13 35 13) is a similar magnitude edge-on beauty with a great dissecting dark dust lane. This pencil-slim, low surface brightness galaxy is a bit of a challenge for smaller scopes, but larger ones will find its warped central disk well worth high-power study. You may also be able to spot the "Leo Trio See M65" and members of Arp's Peculiar Galaxy Catalog!

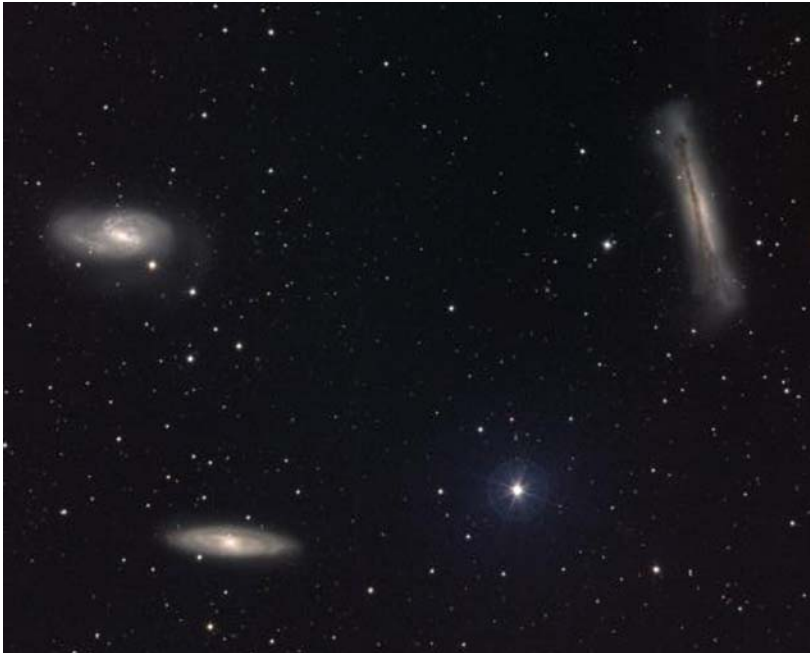


Figure 4.24a. M65, M66 and NGC 3628: the Leo Trio (credit—REU Program/NOAO/AURA/NSF).



Figure 4.24b. Vladimir Mikhailovich Komarov (historical image).

Saturday, April 25

Today marks the 19th anniversary of the deployment of the Hubble Space Telescope (HST). Although everyone in the astronomical community is well aware of what this magnificent telescope “sees,” did you know you could see it with just your eyes? The HST is a satellite that can be tracked and observed. Visit www.heavens-above.com and enter your location. This page will provide you with a list of visible passes for your area. Although you can’t see details of the scope itself, it’s great fun to track it with binoculars or see the Sun glinting off its surface in your scope.

Tonight is the New Moon. You’ve got dark skies ahead and hopefully an itch to see something out of the ordinary with your telescope. If so, let’s go south and locate a fine reflecting nebula—NGC 2467—in northern Puppis (RA 07 52 19 Dec $-26\ 26\ 30$). Sometimes referred to as the “Skull and Crossbones Nebula,” this billowing cloud of gas and dust is easily found less than a finger-width south-southeast of 3.5 magnitude Xi Puppis. Even small telescopes will find this expansive, star-studded emission nebula, a real beauty! Large aperture telescopes should look for neighboring splotches of nebulosity illuminated by small groupings of stars, some of which are part of a newly forming open cluster. Keep in mind while observing NGC 2467 that we are seeing it from a great distance. At 17,000 light-years away, this region of star formation is some 10 times farther away than the Great Nebula in Orion. If it were the same distance away, NGC 2467 would dwarf M42!

While you’re out, keep an eye turned toward the sky as the Mu Virginid meteor shower reaches its peak at 7–10 per hour. With dark skies early tonight, you might catch one of these medium-speed meteors radiating from a point near the constellation of Libra.



Figure 4.25a. NGC 2467 (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.25b. Hubble Space Telescope (credit—NASA).

Sunday, April 26

On this date in 1920, the Shapely–Curtis debate raged in Washington on the nature of (and distance to) spiral nebulae. Shapely claimed they were part of one huge galaxy to which we all belonged, while Curtis maintained they were distant galaxies of their own. Thirteen years later on the same date, Arno Penzias was born. He went on to become a Nobel Prize winner for his part in the discovery of the cosmic microwave background radiation while he was searching for the source of the “noise” coming from a simple horn antenna. His discovery helped further our understanding of cosmology in ways Shapely and Curtis could never have dreamed of.

Tonight we’re off to study another Herschel object (H II.506) in Hydra that’s a 7 degree drop south of Alpha—NGC 2907 (RA 09 31 42.1 Dec -16 44 04). Although it will require at least a mid-aperture telescope to reveal, this edge-on galaxy is quite worth the trouble. NGC 2907 is highly prized because of research done on its dust extinction properties, which greatly resemble those of our own Milky Way Galaxy. For larger telescopes, averted vision will call up a hint of a dark dust lane across a bright core. Although it is neither particularly huge nor particularly bright, this object will present an interesting challenge for those with larger scopes looking for something a bit out of the ordinary.



Figure 4.26a. NGC 2907 (credit—Palomar Observatory, courtesy of Caltech).

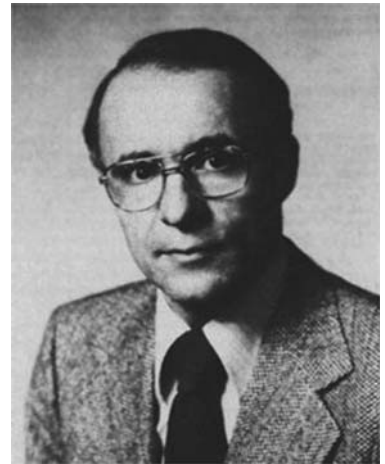


Figure 4.26b. Arno Penzias (widely used public image).

Monday, April 27

Did you spot the tender crescent of the Moon tonight just after sunset? Be sure to mark your notes as the “Old Moon in the New Moon’s Arms,” and then take a look in binoculars for asteroid Vesta just 6.6 degrees to the south!

Now let’s introduce Maurice de Broglie who was born on this date in 1875. French physicist de Broglie made many contributions to the study of X-ray spectroscopy, did pioneering work in nuclear physics, and studied cosmic radiation. He would have been fascinated with tonight’s object!

For those who like curiosities, our target for tonight will be 1.4 degrees northwest of 59 Leonis, which is itself about a degree southwest of Xi. Although this type of observation may not be for everyone, what we are looking for is a very special star, a red dwarf named Wolf 359 (RA 10 56 28 Dec +07 00 52). Although it is very faint at approximately magnitude 13, you will find it precisely at the center of the highly accurate half-degree field photo below.

Although this star was discovered photographically by Max Wolf in 1959, charts from that time will no longer be accurate because of the star’s large proper motion. This is one of the least luminous stars known, and we probably wouldn’t even know it was there except for the fact that it is the third closest star to our Solar System. Located only 7.5 light-years away, this miniature star is about 8% the size of our Sun, making it roughly the size of Jupiter. Oddly enough, it is also a “flare star,” capable of jumping about another magnitude brighter at random intervals. It might be faint and difficult to spot in mid-sized scopes, but Wolf 359 is definitely one of the most unusual objects you will ever observe.



Figure 4.27a. Wolf 359 (credit—Palomar Observatory, courtesy of Caltech).



Figure 4.27b. Maurice de Broglie (historical image).

Tuesday, April 28

Today we fondly remember Eugene Shoemaker on the date of his birth in 1928. The famous astronomer and geologist devoted much of his life to the U.S. Geological Survey, which enabled him to study features on the Moon and examine meteorite impacts on Earth. This keen interest led to the study of the asteroids that may have formed these features, which in turn led to his discovery of several asteroids. Added to this list are 32 comets, which now bear the Shoemaker name. Gene will live forever as “the father of the science of near-Earth objects.”

Also on this date in 1774, Francis Baily was born. Baily went on to revise several star catalogs and explain the phenomenon seen at the beginning and ending of a total solar eclipse, which we now know as “Baily’s Beads.” The year 1900 saw the birth of Jan Hendrick Oort, who quantified the Milky Way’s rotational characteristics and envisioned the vast, spherical area of comets at the edge of our Solar System that we now call the Oort Cloud. Last, but not least, was the birth of Bart Jan Bok (1906), who studied the structure and dynamics of the Milky Way.

For sky-watchers, no equipment is necessary to enjoy the “leftovers” of a traveler from the Oort Cloud. Tonight the Alpha Boötis meteor shower will reach its maximum. Pull up a comfortable seat and face orange Arcturus as it climbs the sky in the east. These slow meteors have a fall rate of 6–10 per hour and leave very fine trails, making for an enjoyable evening of quiet contemplation.



Figure 4.28a. Eugene Shoemaker (credit—NASA).

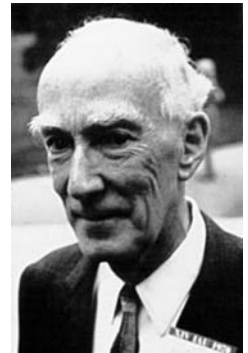


Figure 4.28b. Jan Oort (widely used public image).

Wednesday, April 29

Tonight our first voyage is to the Moon's surface. Look along the terminator in the southern quadrant for ancient old crater Furnerius . Named for French Jesuit mathematician George Furner, this crater spans approximately 125 kilometers and is a Lunar Club challenge. Power up and look for two interior craters. The smaller is crater A, and it spans a little less than 15 kilometers and drops to a depth of over 1,000 meters. The larger crater C is about 20 kilometers in diameter, but goes deeper, to more than 1,400 meters. That's about as deep as a coral will grow under Earth's oceans!

Now check out a changeable, sometimes transient, and eventually bright feature on the lunar surface—crater Proclus . At around 28 kilometers in diameter and 2,400 meters deep, Proclus will appear on the terminator on the western, mountainous border of Mare Crisium. For many viewers tonight, it will seem to be about two-thirds black, but one-third of the exposed crater will be exceptionally brilliant, and with good reason: Proclus has an albedo, or surface reflectivity, of about 16%, which is an unusually high value for a lunar feature. Watch this area over the next few nights as two rays from the crater will widen and lengthen, extending approximately 322 kilometers to both the north and south.

To help teach your eye to spot details, why not take a moment tonight to sketch what you see? It doesn't require artistic talent, just some patience. The act of sketching allows the mind to see details differently from when you are just observing. Even if you never share your drawings, you'll find you catch shadows and dimensions you've never noticed before!

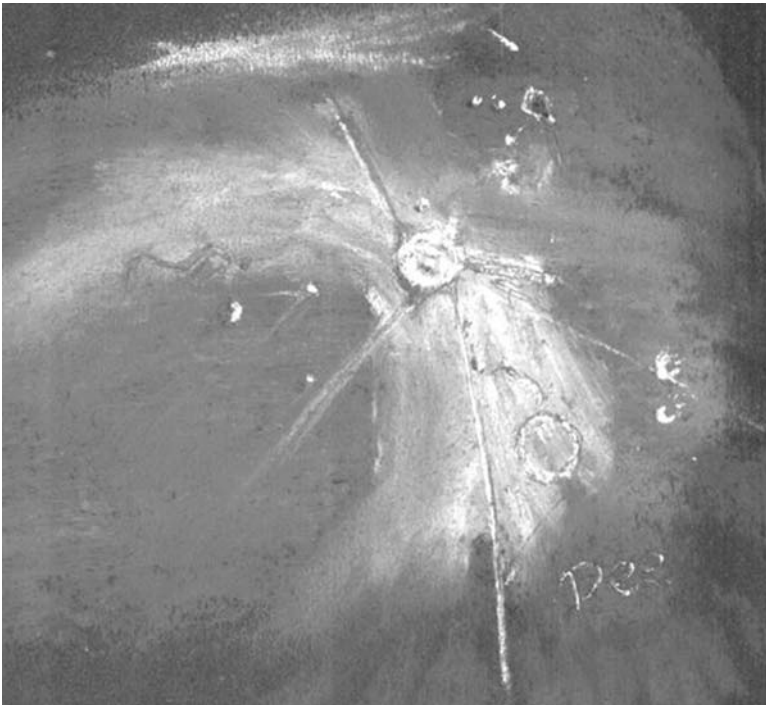


Figure 4.29. Proclus crater (credit—sketch by Deirdre Kellegan).

Thursday, April 30

Let's talk about Karl Frederich Gauss, who was born on this date in 1777. Known as the "Prince of Mathematics," Gauss contributed to the field of astronomy in many ways, from computing asteroid orbits to envisioning the heliotrope. Among Gauss' many endeavors, he is recognized most for his work on magnetism. We understand the term "gauss" as a magnetic unit. A refrigerator magnet carries about 100 gauss, while an average sunspot might go up to 4,000. On the more extreme ends of the magnetic scale, Earth produces about 0.5 gauss at its poles, while a magnetar can produce as much as 10^{15} gauss!

Although we cannot directly observe a magnetar, those living in the Southern Hemisphere can view a region of the sky where magnetars are known to lurk—the Large Magellanic Cloud. Or, you can use the projection method to view a sunspot! If you have a proper solar filter to avoid eye damage, you may be able to see how magnetism distorts sunspots as they near the limb—this is called the "Wilson Effect."

Tonight let's spend our evening with lunar studies, and a very fine old crater on the northwest shore of Mare Nectaris—Theophilus. Slightly south of mid-point on the terminator, this crater contains an unusually large multiple-peaked central mountain, which can be spotted in binoculars. Theophilus is an odd crater, one whose floor is a parabola—with no area on the surface being flat. It stretches across a distance of 100 kilometers and dives down as much as 440 meters below the surface. Tonight it will appear dark, shadowed by its massive west wall, but look for sunrise on its 1,400-meter summit!

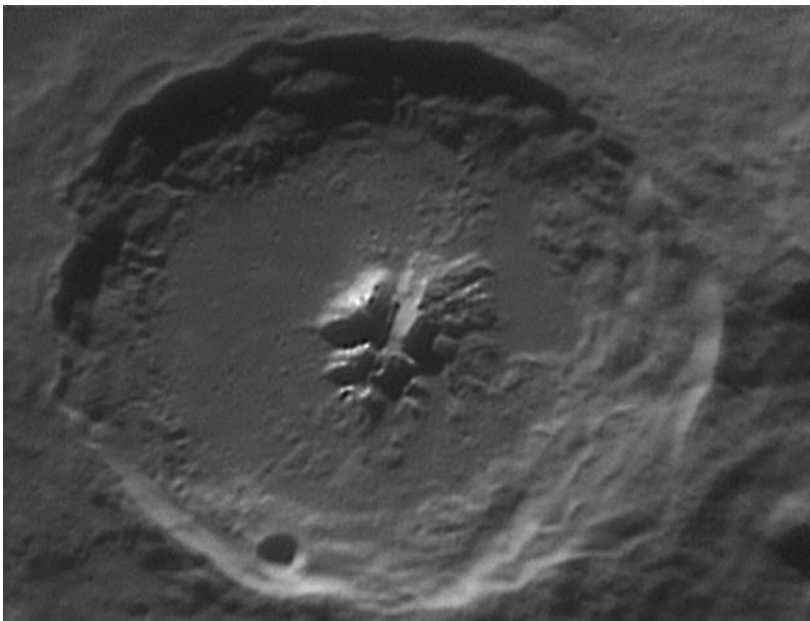



Figure 4.30a. Theophilus (credit—Wes Higgins).



Figure 4.30b. Karl Frederich Gauss (historical image).

CHAPTER FIVE



May, 2009

Friday, May 1

This date is a rather special one in history. In 1543 on this date, Copernicus published and distributed the “The Little Commentary,” which described his heliocentric beliefs. In 1949, Gerard Kuiper discovered Nereid, a 150-kilometer-wide satellite of Neptune. It’s so distant from the planet that it requires almost one Earth year (360 days) to complete an orbit! At magnitude 18.7, Nereid is beyond the detection point of most average telescopes but can be “seen” using long exposure Charge Couple Device (CCD) image stacking devices. Other sights that can’t be seen are the Van Allen Radiation Belts of our Earth, the discovery of which was announced in 1958 in this day’s copy of the *Washington Evening Star*. Thanks to James A. Van Allen’s use of the data from the Explorer I and Pioneer III space probes, we know that Earth’s magnetosphere contains concentrations of electrically charged particles. Say Happy Birthday to American astronaut M. Scott Carpenter, who was born on this date in 1925 and was one of the original seven Mercury astronauts to reach space in 1962.

Tonight’s outstanding lunar feature will be crater Maurolycus, just southwest of the three rings of Theophilus, Cyrillus, and Catharina. This Lunar Club Challenge spans 114 kilometers and goes below the lunar surface by 4,730 meters. Be sure to look for Gemma Frisius just to its north! Now, relax and enjoy the peak of the Phi Boötid meteor shower, whose radiant is near the constellation Hercules. The best time to view most meteor showers is around 2:00 a.m. local time, but you may have good success watching for these meteors as soon as the Moon waxes. The average fall rate is only about 6 per hour, but it’s a great way to spend a spring evening out under the stars!

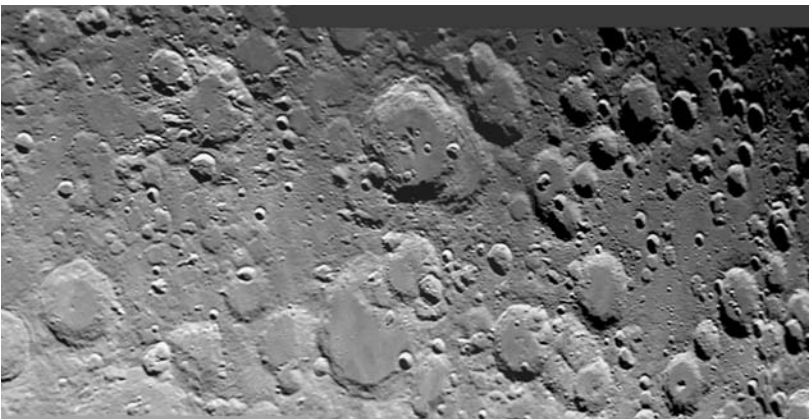


Figure 5.1a. Maurolycus (credit—Alan Chu).



Figure 5.1b. M. Scott Carpenter (credit—NASA).

Saturday, May 2

Today, let's start with the 1868 birth on this date of Robert Williams Wood. Although Wood's primary research was on sound waves, he devised a "zone plate" that could replace the objective lens of a telescope! He also improved the diffraction grating, did research in spectroscopy, and made photographs showing both infrared and ultraviolet radiations. Also, take a moment to note the 1925 passing of the star cataloger, Johann Palisa. Palisa remains the most successful visual discoverer in the history of minor planet research, discovering 122 asteroids with a 6" telescope and no photographic plates! Why not salute his achievements by looking for the asteroid Hebe, which reaches opposition tonight? Hebe is the 13th largest asteroid by mass and the 5th brightest to observe. If you collect meteorites and have an H chondrite, chances are good you have a physical piece of Hebe, since it is thought to have contributed up to 40% of all recovered chondrites! Be sure to check the Resources section of this book for information on how to find this cool asteroid. . .

Now, let's have a look at the Moon! Tonight's challenges are craters Cassini and Cassini A, which come into view just south of the black slash of the Alpine Valley. The major crater spans 57 kilometers and reaches a floor depth of 1,240 meters. Your assignment, should you decide to accept it, is to spot the central crater A. It only spans 17 kilometers, yet drops down another 2,830 meters below the primary crater's floor!



Figure 5.2a. Cassini (credit—Wes Higgins).



Figure 5.2b. Johann Palisa (historical image).

Sunday, May 3

How about starting the day with the bizarre and unusual? In 1375 BC, the oldest recorded total solar eclipse occurred—if we can believe eighth century Babylonian records! If you have a green laser pointer, or a telrad, you might want to wish Alfred Kastler a happy birthday. Born on this date in 1902, the physicist was very interested in what happened to atoms when excited by light or radio waves. Kastler developed a method called “optical pumping,” where atoms enter a higher energy state. Optical pumping is what makes your laser work!

Tonight notice just how close bright Regulus is to the Moon! If you’d like to try your hand at asteroid Ceres, you’ll find it approximately another 15 degrees north of the “Little King.”

Tonight let’s take a long Moonwalk together and do some major crater exploration. Try using mid-range magnification in your telescope and see how many of the objects in Figure 5.3a you can identify!.

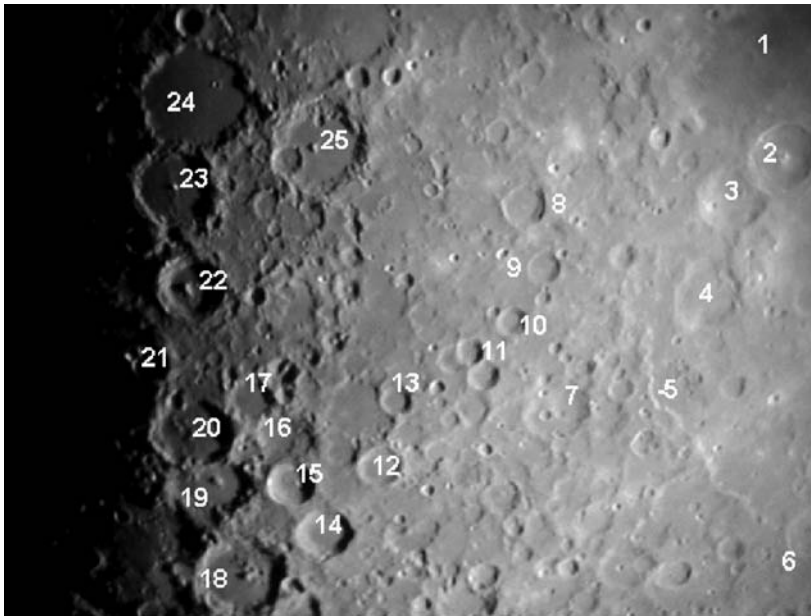


Figure 5.3a. Ptolemaeus area (credit—Greg Konkel). (1) Sinus Asperitatis, (2) Theophilus, (3) Cyrillus, (4) Catharina, (5) Rupes Altai, (6) Piccolomini, (7) Sacrobosco, (8) Abulfeda, (9) Almanon, (10) Taylor, (11) Abenezra, (12) Apianus, (13) Playfair, (14) Aliacensis, (15) Werner, (16) Blanchinus, (17) Lacaille, (18) Walter, (19) Regiomontanus, (20) Purbach, (21) Thebit, (22) Arzachel, (23) Alphonsus, (24) Ptolemaeus, and (25) Albategnius.

Figure 5.3b. Alfred Kastler (historical image).

Monday, May 4

On this date in 1933, Karl Jansky announced his findings to the International Radio Union. He had heard the sounds of the Milky Way! Just 56 years later, the space probe Magellan was on its way to Venus. Think of the advancement of radio in just half a century! Our real scoop of the day is the 1845 birth of William Kingdon Clifford, who managed to survive an 1870 shipwreck while traveling to view a total solar eclipse. Why is this important? At the time, a total solar eclipse was the only way to learn more about the effects of gravity, and Clifford's observations were published later that same year. His article "On the Space Theory of Matter" presented for the first time the idea that energy and matter are simply different types of curvature of space—the forerunner of Einstein's general theory of relativity!

Be sure to step outside tonight and take a look at the Moon! Even without special equipment, it's not hard to identify Saturn just a couple of finger-widths to the north. If you like to venture to the lunar surface, we can enjoy a strange, thin feature that's a nice challenge! Look toward the lunar south, where you will note the prominent rings of craters Ptolemaeus, Alphonsus, Arzachel, Purbach, and Walter descending from north to south. Just west of them, you'll see the emerging Mare Nubium. Between Purbach and Walter, you will see the small, bright ring of Thebit, with a crater caught on its edge. Look further west to spot a long, thin, dark feature cutting across the mare. Its name? Rupes Recta, better known as the "Straight Wall," or sometimes Rima Birt *See* Rupes Recta. The Straight Wall is one of the steepest known lunar slopes, rising around 366 meters from the surface at a 41-degree angle. Be sure to mark your lunar challenge notes and visit this feature again!

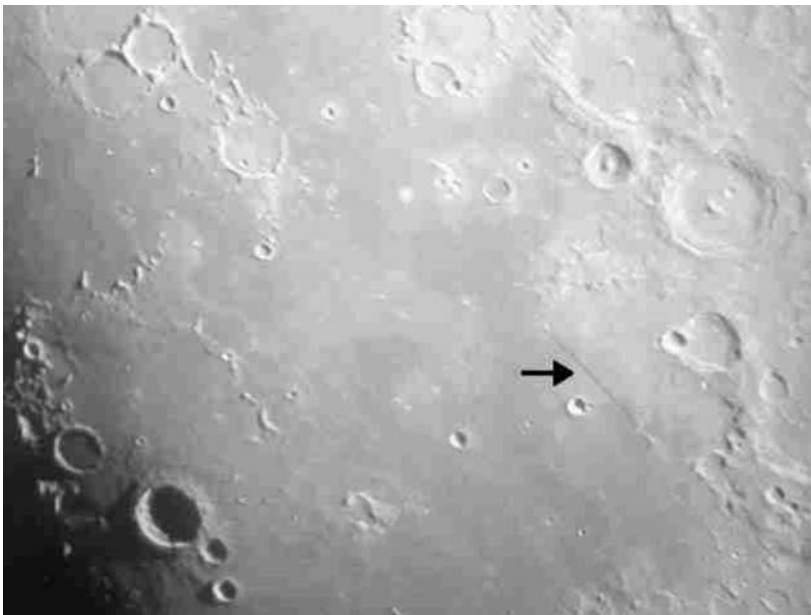


Figure 5.4a. Rupes Recta: the Straight Wall (credit—Greg Konkel).



Figure 5.4b. William Kingdon Clifford (historical image).

Tuesday, May 5

On this date in 1961 Alan Shepard became the first American in “space” (the region above the sky), taking a 15-minute suborbital ride aboard the Mercury craft Freedom 7. Only 150 years before this milestone, John William Draper was born. His interest in spectroscopy and photography led to the first astronomical photograph. . . of the Moon!

Now let’s look toward that same Moon and locate another unusual feature, Montes Recti , or the “ Straight Range .” You’ll find this curiosity tucked between Plato and Sinus Iridum, on the north shore of Mare Imbrium. To binoculars or small scopes at low power, this isolated strip of mountains will appear as a white line drawn across the gray mare. It is believed this feature may be all that is left of a crater wall from the Imbrium impact. It runs for a distance of around 90 kilometers and is approximately 15 kilometers wide. Some of its peaks reach up to 2,072 meters high! Although this doesn’t sound particularly impressive, that’s over twice as tall as the Vosges Mountains in west-central Europe, and on the average very comparable to the Appalachian Mountains in the eastern United States.

If you’d like to try your hand at another asteroid tonight, let’s head for bright Vesta. Using binoculars, locate the red primary star of Taurus—Aldebaran. For most small binoculars, the average field of view is around 4 degrees, so if you place Aldebaran at the bottom of the field, Vesta will appear near the top! Tonight Vesta is located around 3 degrees north of Alpha Tauri. Draw a quick sketch of the field stars and check over the next few days to see which one “moves.” Congratulations on learning to be an asteroid hunter!

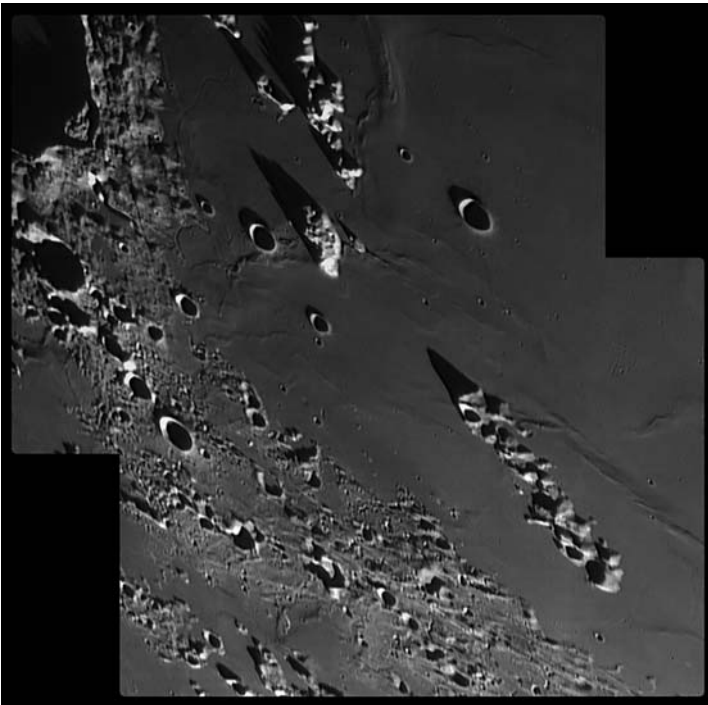


Figure 5.5a. Montes Recti: the Straight Range (credit—Wes Higgins).



Figure 5.5b. John William Draper (historical image).

Wednesday, May 6

Today let's start with a look at the 1872 birth on this date of Willem de Sitter, who developed theoretical models of the universe based on Albert Einstein's general theory of relativity. He set the fundamental constants for astronomy and determined the variations in Earth's rotation. Through his studies of the motion and distribution of the stars, he postulated the first theory of an expanding universe and worked with Einstein on those principles. In spite of all de Sitter's contributions to cosmology, his passion was Jupiter. He devoted his whole life to the study of Jovian satellites, determining their masses and orbits. To honor his birth, why not take a moment to look at Jupiter this morning before dawn? You may catch a shadow transit!

Tonight let's turn binoculars or telescopes toward the southern lunar surface, as we set out to view one of the most unusually formed craters, Schiller. Located near the lunar limb, Schiller appears as a strange gash bordered in white on the southwest and black on the northeast. This oblong depression might be the fusion of two or three craters, yet it shows no evidence of crater walls on its smooth floor. The manner of Schiller's formation remains a mystery. Be sure to look for a slight ridge running along the spine of the crater to the north through the telescope. Larger scopes should resolve this feature into a series of tiny dots.

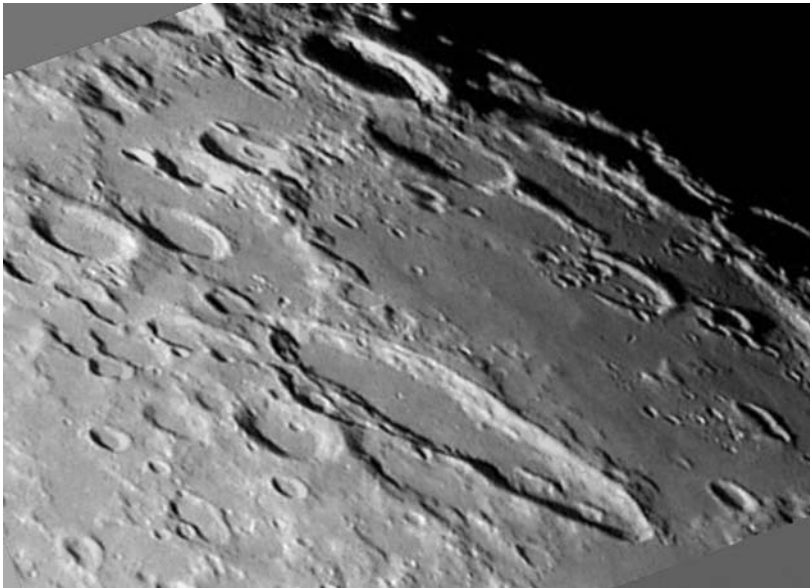


Figure 5.6a. Schiller (credit—Alan Chu).



Figure 5.6b. Willem de Sitter (historical image).

Thursday, May 7

Today we celebrate the 1911 birth of Raymond Arthur Lyttleton, who researched stellar evolution and composition. Thanks to Lyttleton's work, we know a lot more about interstellar hydrogen! In his time, people thought space was devoid of anything, including gas. Lyttleton even showed how stars produce energy through nuclear reactions. One of his books—*Mysteries of the Solar System*—is still on many library shelves.

Return to the Moon tonight to have a look on the terminator near the southern cusp for two outstanding features. The easiest is crater Schickard, a class V mountain-walled plain that spans 227 kilometers. Named for German astronomer Wilhelm Schickard, this beautiful old crater with the subtle interior details has another crater caught on its northern wall named Lehmann.

Look further south for one of the Moon's most incredible features—Wargentín. Among the many strange things on the lunar surface, Wargentín is unique. Once upon a time, it was a very normal crater and had been that way for hundreds of millions of years. Then it happened. Either a fissure opened in its interior, or the meteoric impact that formed it caused molten lava to begin to rise. Oddly enough, the breaks in Wargentín's walls were too small to allow the lava to escape, so it continued to fill the crater to the rim. Often referred to as the "Cheese," enjoy Wargentín tonight for its unusual appearance, and be sure to note Nasmyth and Phocylides as well!



Figure 5.7a. Schickard and Wargentín (credit—Roger Warner).



Figure 5.7b. Raymond Arthur Lyttleton (historical image).

Friday, May 8

As the skies darken this evening, scan the western horizon for Mercury. Just beginning its retrograde motion, it won't be long before it slips back into the glare of the Sun!

Tonight the Moon will command the sky. Why not take this opportunity to have a look at a very curious feature? Scan the lunar surface just a little southeast of the gray oval of Grimaldi. The area we are looking for is called the Sirsalis Rille, and on an orb devoid of magnetic fields—it's magnetic! Like a dry riverbed, this ancient "crack" on the surface runs 480 kilometers along the surface and branches off in many areas. The Sirsalis Rille is a favored area for lunar geophysics. Although no complete explanation yet exists for its magnetic properties, it's believed the Rille could be the surface remains of a channel that once fed magma to Oceanus Procellarum. If you look carefully, you will notice that Sirsalis crosses the ejecta of the Mare Orientale impact, leading the scientists to believe it formed after the Imbrium Basin.

There is also a theory that the Sirsalis Rille could be a graben—an impression left when two parallel faults shift. This is in line with the theory that rising magma may have disturbed the crust. Although there's no firm evidence of volcanic activity, solidified magma under the surface may account for Sirsalis' magnetic properties.

Lastly, there should be some fascinating effects at sunrise over Darwin, including an unexplained "string of pearls" effect, a possible result of light passing through a series of sharp, steep ridges. Keep a close watch on crater Darwin if you are watching as the Sun rises over the rim. Note what you see, including exact time the effect was spotted, the date, and your location. If you are interested in contributing, send your observing reports to the Association of Lunar and Planetary Observers (ALPO).

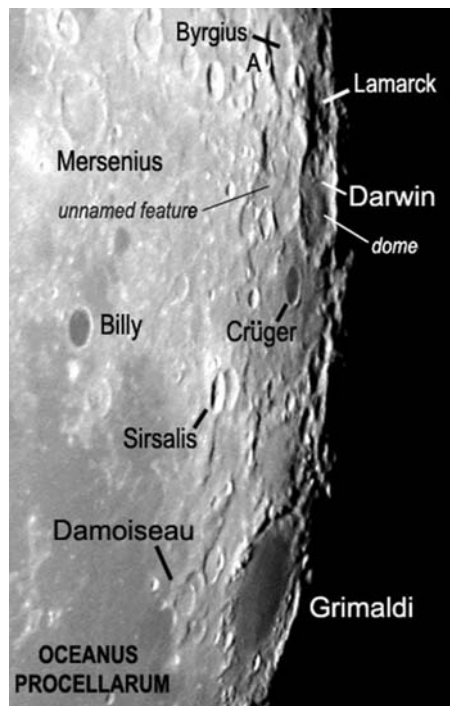


Figure 5.8. Sirsalis Rille and region (credit—Alan Chu).

Saturday, May 9

On this date in 1962, Massachusetts Institute of Technology (MIT) scientists bounced a laser beam off the Moon, which illuminated an area with a diameter of 4 miles! The “Luna See” project was a ruby optical laser radiating pulses of approximately 50 joules energy for half a millisecond. It was transmitted through a 12” Cassegrain telescope and detected with a 48” Cassegrain. It proved laser light could travel through space!

Tonight is the “Full Flower Moon.” Earth is awakening again! Agricultural literature refers to it as the “Full Corn Planting Moon,” or the “Milk Moon.” No matter what it’s named, Moonrise is majestic to watch. Participate in a Lunar Club Challenge and do some outreach work by demonstrating “Moon Illusion” to someone. We know it’s purely psychological and not physical, but the fact remains that the Moon seems larger on the horizon. Using a small coin held at arm’s length, compare it to Luna as it rises, and then again as it seems to “shrink” as it moves up! You’ve now qualified for extra credit. . .

Try using colored or Moon filters to look at the many surface features that throw amazing patterns across its surface. If you have none, a pair of sunglasses will suffice. Look for things you might not ordinarily notice, such as the huge streak emanating from crater Menelaus, the pattern projected from Proclus, or the bright tiny dot of little-known Pytheas north of Copernicus. It’s hard to miss the blinding beacon of Aristarchus! Check the southeastern limb, where the edge of Furnerius lights up the landscape. . .or how a nothing crater like Censorinus shines on the southeast shore of Tranquillitatis, while Dionysus echoes it on the southwest. Could you believe Manlius just north of central could be such a perfect ring, or that Anaxagoras would look like a northern polar cap? Although it might be tempting to curse the Moon for hiding the stars when it’s full, there is no other world out there that we can view in such detail. . .even if you just look with your eyes!

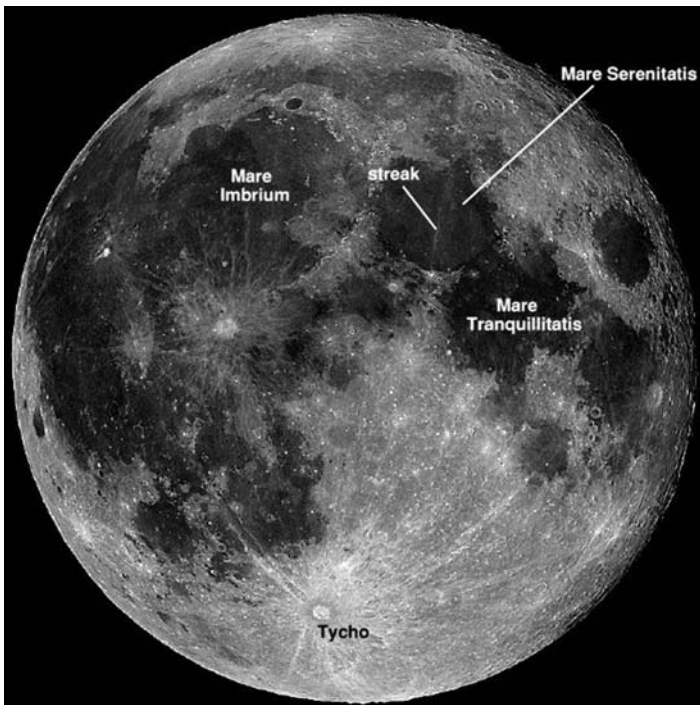


Figure 5.9a. Full Moon (credit—NASA).



Figure 5.9b. Project Luna See (credit—courtesy of MIT Museum).

Sunday, May 10

Today we celebrate the birth of Cecilia Payne in 1900. Payne was the first to apply the laws of atomic physics to study the temperature and density of stars. It was a difficult time for female astronomers, and she had quite a time getting her peers to take her work seriously. Payne proved that hydrogen and helium are the two most common elements in the universe and, with the later help of Fred Hoyle, proved that our Sun was 99% hydrogen and helium.

Before the Moon rises, take a look at the constellation of Leo and its brightest stars. Our first destination is 85 light-year-distant Regulus. As the 21st brightest star in the night sky, 1.35-magnitude Alpha Leonis is a helium star about 5 times larger and 160 times brighter than our own Sun. Speeding away from us at 3.7 kilometers per second, Regulus is also a multiple system whose 8th magnitude B companion is easily seen in small telescopes. Regulus B is also a double, with a magnitude 12 dwarf companion of uncertain type. There's an additional 13th magnitude star in this grouping, but it's probably not associated with Regulus, since the "Little King" is moving toward it and will be very close to it in 800 years.

About a fist-width northeast of Regulus is 2.61-magnitude Gamma Leonis. Algieba is a very fine double star, but difficult to see at low power, since the 90 light-year-distant pair is bright and close. Separated by about twice the diameter of our own Solar System, the gap between Algieba and its companion is slowly widening! Another two finger-widths north is 3.44-magnitude Zeta. Aldhafera is about 130 light-years away and also has an optical companion—35 Leonis. Remember this binocular pair, because they'll lead you to galaxies later! Before we leave, look east for 3.34-magnitude Theta. Mark this one in your memory, because Chort and 3.94-magnitude Iota to the south serve as markers for a galaxy hop! Last is easternmost 2.14-magnitude Beta. Denebola is the "Lion's Tail" and has several faint optical companions.

Now watch the Moon. . .because for some areas Antares is about to be occulted!

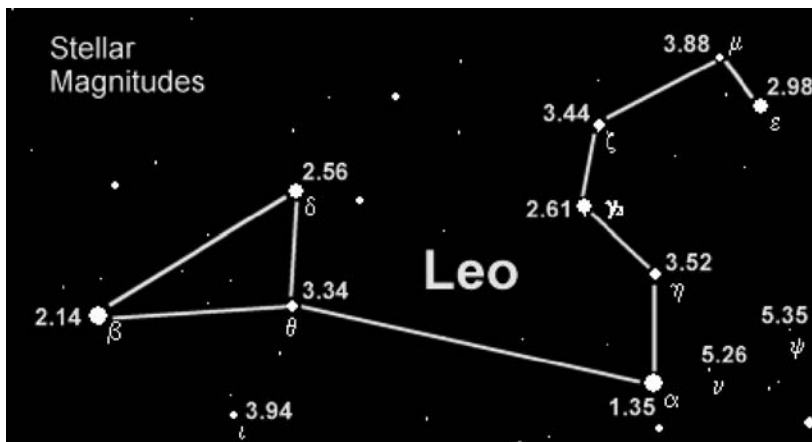


Figure 5.10a. Stellar magnitudes in Leo (credit—NASA).



Figure 5.10b. Cecilia Payne (historical image).

Monday, May 11

Today we start with celebrating the 1924 birth on this date of Antony Hewish, who (with the aid of his brilliant student Jocelyn Bell) won the Nobel Prize for Physics in 1974 for the discovery of pulsars. Hewish and Bell observed an unusual signal corresponding to a sharp burst of radio energy occurring at regular intervals, now known to be from a rapidly rotating neutron star: a pulsar. Today also celebrates the 1871 birth of Frank Schlesinger, who mapped stellar positions and measured stellar parallaxes photographically. Schlesinger published ten catalogs containing 150,000 stars, and with Louise Jenkins created the first Yale Bright Star Catalog.

Tonight's study is for mid- to large-aperture telescopes. Begin by heading west about a fist-width from Regulus and identify 52 Leonis. Our mark is 1.5 degrees south. At lower power, you'll see a triangle of galaxies. The largest and brightest is M105 (RA 10 47 49 Dec +12 34 54). This dense elliptical galaxy appears evenly distributed, but the Hubble Space Telescope (HST) revealed a huge mass within the core equal to about million suns. The companion elliptical to the northeast—NGC 3384—reveals a bright nucleus and an elongated form. The faintest of this group—NGC 3389—is a receding spiral; larger scopes will see "patchiness" in structure.

Continue another degree south and enjoy another galactic pair. The widely spaced M96 (RA 10 46 45 Dec +11 49 10) and M95 (RA 10 43 57 Dec +11 42 12) belong to a galaxy grouping called Leo I. The dusty spiral—M96—will appear as a silver oval, with a nucleus much sharper than its faint spiral arms. M96 hosted a supernova as recently as 1998. To its west, you'll discover a beautiful barred spiral—M95—a prime target of the HST. Visually, we enjoy M95 for its unique ring-like arms and unmistakable barred core, but the HST was looking for Cepheid variables to help determine the Hubble constant. Although we don't need a space telescope to view this group of galaxies, we can appreciate taking a 38-million-light-years journey from our own backyard!



Figure 5.11a. M105 and companions (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.11b. M95 (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, May 12

Today we'd like to wish a happy anniversary to the Adler Planetarium and Astronomical Museum, which opened its doors to the public in Chicago, Illinois, on this date in 1930! The building was donated to the city by Max Adler Planetarium and Astronomical Museum (a retired vice president of Sears), who was so fascinated by his visit to the world's first planetarium in Munich that he decided to open the first American planetarium in his hometown!

Tonight we'll return to Leo for another galaxy worth a visit...and even binoculars can spot it! You'll need to identify slightly fainter Lambda to the southwest of Epsilon and head south about one finger-width for NGC 2903 (RA 09 32 09 Dec + 21 30 02). William Herschel discovered this awesome oblique spiral galaxy in 1784. At slightly brighter than magnitude 9, it's in easy range of most binoculars. It is odd that Messier missed this one, considering both its brightness and the fact that three of the comets he discovered passed by it! Perhaps it was cloudy when Messier was looking, but we can thank Herschel for cataloging NGC 2903 as H I.56.

Although small optics will only perceive this 25-million-light-year-distant beauty as a misty oval with a slightly brighter core region, larger aperture will light this baby up. Soft suggestions of its spiral arms and concentration will begin to appear. One such knot is star cloud NGC 2905—a detail in a distant galaxy so prominent that it received its own New General Catalog designation. NGC 2903 is roughly the size of our own Milky Way and includes a central bar, yet the nucleus of our distant cousin has "hot spots" that were studied by the HST and extensively by the Arecibo telescope. Although our own galactic halo is filled with ancient globular clusters, this galaxy sports brand new ones! Be sure to mark your notes with your observations, because many different organizations consider this to be on their "Best of" lists.



Figure 5.12a. NGC 2903 (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.12b. Adler Planetarium (credit—courtesy of Adler Planetarium).

Wednesday, May 13

Today we note the anniversary of the 1983 passing of Otto Heckmann. Born in 1901, this German astronomer charted stellar positions. Thanks to his knowledge of cosmology, Heckmann found open and flat solutions to the Einstein's field equations for a homogeneous, isotropic universe, and he introduced the possibility of a rotating universe.

Tonight we'll take a look at our moving universe, and we begin by locating 5th magnitude 6 Coma Berenices about three finger-widths east of Beta Leonis. Remember this star! We are going on a galaxy hop to a Méchain discovery that is less than a degree west, and its designation is M98 (RA 12 13 48 Dec + 14 53 58). At magnitude 10, this beautiful galaxy is a telescope-only challenge and a bit on the difficult side for small aperture. Long considered part of the Virgo Cluster, M98 is approaching us at a different rate than other cluster members, giving rise to speculation that it may simply be in the line of sight. Quite simply put, it has a blue shift instead of red! But considering that all these galaxies (and far fainter ones than we can see), are in close proximity leads some researchers to believe it is a true member by virtue of the extreme tidal forces that must exist in the area—pushing it toward us at this point in time, rather than away.

In a small telescope, M98 will appear like a slim-line with a slightly brighter nucleus, a characteristic of an edge-on galaxy. To large aperture, its galactic disk is hazy and contains patchiness in structure. These are regions of newly forming stars and vast regions of dust, yet the nucleus remains a prominent feature. M98 is a very large galaxy, so be sure to use a minimum of magnification and plenty of aversion to make out small details in this fine Messier object!



Figure 5.13a. M98 (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.13b. Otto Heckmann (historical image).

Thursday, May 14

On this date in 1973, the United States launched its first manned space station and largest payload up to that time, Skylab 1. The orbiting laboratory housed crews of astronauts, performed experiments, and taught us much before its fiery return to Earth in July 1979.

Tonight we'll start with an object you can view unaided from a dark location, and which is splendid in binoculars. As a matter of fact, it's so outstanding it has even been viewed and photographed from the International Space Station (ISS)! Just northeast of Beta Leonis, look for a hazy patch of stars known as Melotte 111. Often called the "Queen's Hair," this 5-degree span of 5–10th magnitude stars is wonderfully rich and colorful. As legend has it, Queen Berenice offered her beautiful long tresses to the gods for the king's safe return from battle. Touched by her love, the gods took Berenice's sacrifice and immortalized it in the stars.

The cluster is best in binoculars because of its sheer size, but you'll find other things of interest there as well. Residing about 260 light-years away, this collection is one of the nearest of all star clusters, including the Pleiades and the Ursa Major moving group. Although Melotte 111 is more than 400 million years old and contains no giant stars, its brightest members have just begun their evolution. Unlike the Pleiades, the Queen's Hair has no red dwarfs either and a low stellar concentration, which leads astronomers to believe it is slowly dispersing. Like many clusters, it contains double stars, most of which are spectroscopic. With binoculars, it is possible to split star 17, but it will require very steady hands.



Figure 5.14a. Melotte 111 (credit—ISS Astronaut Don Pettit/NASA).



Figure 5.14b. Sky Lab (credit—NASA).

Friday, May 15

Today we celebrate the 1857 birth on this date of Williamina Paton Stevens Fleming, who pioneered in the classification of stellar spectra and discovered the stars we now call white dwarfs. Now get this: she began by working as a maid for Harvard Observatory's Edward Pickering, who then took her to the observatory to do clerical work. Fleming ended up cataloging over 10,000 stars for Harvard in a period 9 years. You go, girl!

Tonight let's head out into space where we might get a "blackeye." You'll find it located just 1 degree east-northeast of 35 Coma Berenices, and it is most often called M64 (RA 12 56 43 Dec +21 41 00). Discovered by Bode about a year before Messier cataloged it, M64 is about 25 million light-years away and holds the distinction of being one of the more massive and luminous spiral galaxies. It has a very unusual structure and is classified as an "Sa" spiral in some catalogs and as an "Sb" in others. Overall, its arms are very smooth and show no real resolution to any scope, yet its bright nucleus has an incredible dark dust lane that consumes the northern and eastern regions around its core, giving rise to its nickname—the Blackeye Galaxy.

In binoculars, you can perceive this 8.5-magnitude galaxy as a small oval with a slightly brighter center. Small telescope users will pick out the nucleus more easily, but it will require both magnification and careful attention to dark adaptation to catch the dust lane. In larger telescopes, the structure is easily apparent, and you may catch the outer wisps of arms on nights of exceptional seeing. No matter what you use to view it, this is one compact and bright little galaxy!



Figure 5.15a. M64: the Blackeye Galaxy (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.15b. Williamina Paton Stevens Fleming (historical image).

Saturday, May 16

Today we'd like to wish Roy Kerr a happy birthday! Born on this date in 1934, Kerr solved Einstein's field equations of general relativity to describe rotating black holes, or the space/time around them. The solution, called now a Kerr black hole, shows a vortex-like region outside the event horizon known as the ergoregion. In this region, space and time are dragged around with the rotating parent black hole.

Tonight let's use our binoculars and telescopes to hunt down one of the best globular clusters for the Northern Hemisphere— M3 (RA 13 42 11 Dec + 28 22 31). You will discover this ancient beauty about halfway between the pair of Arcturus and Cor Caroli, just east of Beta Comae. The more aperture you use, the more stars you will resolve. Discovered by Charles Messier on May 3, 1764, this ball of approximately a half-million stars is one of the oldest formations in our galaxy. At around 40,000 light-years away, the awesome M3 globular cluster spans about 220 light-years and is believed to be as much as 10 billion years old. To get a grasp on this concept, our own Sun is less than half that age!

M3 is 40,000 years away, traveling at the speed of light; yet we can still see this great globular cluster. Now let's locate M53 (RA 13 12 55 Dec + 18 10 09), near Alpha Comae. Aim your binoculars or telescopes there and you will find M53 about a degree northeast. This very rich, magnitude 8.7 globular cluster is almost identical to M3, but look at what a difference an additional 25,000 light-years can make to how we see it! Binoculars can pick up a small, round, fuzzy patch, while larger telescopes will enjoy the compact bright core as well as resolution at the cluster's outer edges. As a bonus for scopes, look 1 degree to the southeast for the peculiar round cluster NGC 5053. Classed as a very loose globular, this magnitude 10.5 grouping is one of the least luminous objects of its type, due to its small stellar population and the wide separation between members, yet its distance is almost the same as that of M3.



Figure 5.16a. M3 (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.16b. M53 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, May 17

If you're up before dawn this morning, take a look at the close pairing of Jupiter and the Moon! Only about a finger-width apart, the magnificent duet will make starting the day a little more pleasant. . . . Now, as the Sun rises, salute the 1837 birth of Sir Joseph Norman Lockyer, who discovered and named the element helium that he found in the Sun's atmosphere, even before it had been detected on Earth. Lockyer was the first to coin the term chromosphere for the Sun's outer layer and was the co-discoverer of solar prominences!

Tonight we'll return once again to 6 Coma Berenices, and head no more than a half degree southwest for another awesome galaxy— M99 (RA 12 18 49 Dec + 14 25 00). Discovered by Pierre Méchain on the same night as he found M98, this is one of the largest and brightest of the spiral galaxies in the Virgo Cluster. Recognized second after M51 for its structure, Lord Rosse proclaimed it to be “a bright spiral with a star above.” It is an “Sc” class, and unlike its similarly structured neighbors, it rotates clockwise. Receding from us at 2,324 kilometers per second, its speedy retreat through the galaxy fields and close pass to approaching M98 may be the reason that it is asymmetrical, with a wide arm extending to the southwest. Three documented supernovae have been recorded in M99—in 1967, 1972, and 1986.

Possible in large binoculars with excellent conditions, this roughly 9th magnitude object is of low surface brightness and requires clean skies to see details. For a small telescope, you will see this one as fairly large, round, wispy, and with a bright nucleus. But, unleash aperture if you have it! For large scopes, the spiral pattern is very prominent, and the western arm shows well. Areas within the structure are patchworked with bright knots of stars and thin dust lanes, which surround the concentrated core region. During steady seeing, a bright, pinpoint stellar nucleus will come out of hiding. A worthy study!



Figure 5.17a. M99 (credit—Palomar Observatory, courtesy of Caltech).

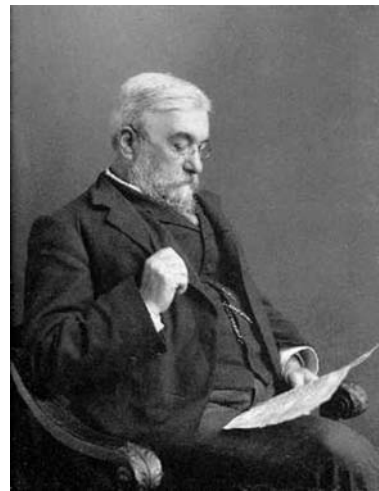


Figure 5.17b. Sir Norman Lockyer (historical image).

Monday, May 18

Today we begin with the 1711 birth on this date of Ruggero Giuseppe Boscovich, who mastered the equations for computing the diameters and orbits of rotating planets using just three observation points. He shares this date with Malcolm Sim Longair, who was born in 1941. Longair was once Astronomer Royal of Scotland and still works at the Cavendish Laboratory. His research interests include the emission from dust in the distant universe, observational cosmology, galaxy formation, and gravitational lensing. For those of us who love astrophysics, his book, *The Cosmic Century*, is definitely required reading!

No galactic tour through Coma Berenices would be complete without visiting one of the most incredible “things that Messier missed.” You’ll find NGC 4565 (RA 12 36 21 Dec +25 59 13) located less than 2 degrees east of 17 Comae. Residing at a distance of around 30 million light-years, this large 10th magnitude galaxy is probably one of the finest edge-on structures you will ever see. Perfectly suited for smaller scopes, this ultra-slender galaxy with the bright core has earned its nickname of the “Needle.” Although photographs sometimes show more than what can be observed visually, mid-to-large aperture can easily trace out NGC 4565’s full photographic diameter.

Although Lord Rosse in 1855 saw the nucleus of the Needle as stellar, most telescopes will resolve a bulging core region with a much sharper point in the center and a dark dust lane upon aversion. The core itself has been extensively studied for its cold gas and emission lines, pointing to the fact that it has a barred structure. This is much how the Milky Way would look if viewed from the same angle! It, too, shines with the light of 30 billion stars. Chances are NGC 4565 is an outlying member of the Virgo Cluster, but its sheer size points to the fact that it is probably closer than the others. If we were to place it at the accepted distance of 30 million years, its diameter would be larger than any galaxy yet known! Get acquainted with it tonight.



Figure 5.18a. NGC 4565: the Needle Galaxy (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.18b. Malcolm Sim Longair (public image).

Tuesday, May 19

On this date in 1910 Earth began passing through the tail of Halley's Comet. Since this was the first time in recorded history that humankind was aware of contact between Earth and space, the event was met with much hype. Only a few years earlier, astronomers had found the spectral lines for cyanogen in cometary signatures, and the press had a field day with the possibility of everyone dying from gas poisoning. Oddly enough, all were still alive the next day!

If you'd like to take a look at a "habitable zone," look no further than AX Microscopii (RA 21 17 15 Dec - 38 52 02). AX is a dwarf red flare star, which resides only 12.9 light-years from us. Although it might not seem that important, it is the target of interferometric studies searching for planets that may have formed in habitable zones around stars similar to our own. Even though AX is slightly smaller than Sol, this cool main sequence star might in fact be *inhospitable*, due to its daily flare activity.

Now let's hop less than two handspans south of Spica, for globular cluster NGC 5139, or Omega Centauri (RA 13 26 45 Dec - 47 28 36). As the most luminous of all globular clusters, Lacaille reported it as a "nebula in Centaurus; with simple view, it looks like a star of 3rd magnitude viewed through light mist, and through the telescope like a big comet badly bounded."

Yet, through even the most modest of today's telescopes, Omega Centauri will explode into a fury of stars. Located about 17,000 light-years away, it took around 2 million years to form and may actually be the remnant of another galaxy's core captured by our own. With more than 1 million members, Omega Centauri is the size of a small galaxy in itself! Although this object is very low for northern observers, it is not impossible for those who live lower than 40 degrees North. Our atmosphere will rob this giant of a cluster of some of its luster, but please try! It's a sight you'll never forget. . .



Figure 5.19a. AX Microscopii/Lacaille 8760 (credit—Palomar Observatory, courtesy of Caltech).

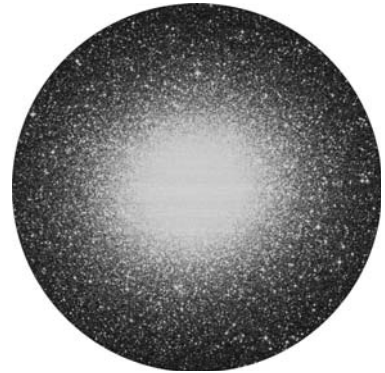


Figure 5.19b. NGC 5139: Omega Centauri (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, May 20

Today we celebrate the 1825 birth on this date of George Phillips Bond. Bond made the first photograph of a double star and discovered a number of comets. While observing Saturn with his father, the pair discovered the tumbling Saturnian satellite Hyperion! Why not take a look at Saturn for yourself this evening? Even very small telescopes can spot the brightest moon, Titan. Look along the ring edge for others.

Tonight let's venture to Canes Venatici as we pick out the "Sunflower Galaxy"—M63 (RA 13 15 49 Dec +42 01 46). Located roughly mid-way between Alkaid and Cor Caroli, and originally discovered in 1779 by Méchain, bright M63 is located about 37 million light-years away and is believed to be part of a group of galaxies that includes M51. To binoculars, M63 appears as a faint misty oval, but larger scopes will reveal the galaxy's spiral arms as a grainy background, brightening considerably toward the center. The most interesting feature of M63 is its arm structure. Most typical spiral galaxies contain just two or three distinct arms, yet M63's structure is multiple, showing short spiral arcs and reminding many observers of its namesake flower. Studies of M63 show that the galactic material at the edges of these arms is moving much faster than normal. Given the amount of visible matter, this additional rotational velocity indicates the presence of significant amounts of dark matter in its overall structure.

A celestial treat!



Figure 5.20a. M63 (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.20b. George Phillips Bond (historical image).

Thursday, May 21

Today we'd like to wish a happy birthday to Nils Christofer Dunér. Born in 1839, this classical astronomer studied the rotational period of the Sun. Dunér was an outstanding observer and made 2,679 measurements of 445 double and multiple stars. He also specialized in observing the spectra of red stars, and later made a series of measurements of the Doppler shift caused by solar rotation. Before the Sun rises this morning, get thee outside! Like a cosmic salute to Dunér's work, Venus, Mars, and the Moon are putting on a spectacular show!

As you know, one of our own Sun's main ingredients is helium. If you would like to see a helium-rich star, look no further tonight than Alpha Virginis *See* Spica—Spica. As the 16th brightest star in the sky, this brilliant blue-white "youngster" appears to be about 275 light-years away and is about 2,300 times brighter than our own Sun. Although we cannot see it visually, Spica is a double star. Its spectroscopic companion is roughly half its size and is also helium rich.

Now, shake your fist at Spica—because that's all it takes to find the awesome M104, 11 degrees due west (RA 12 39 59 Dec -11 37 23). If you still have trouble finding M104, don't worry. Try this trick! Look for the upper left hand star in the rectangle of Corvus—Delta. Between Spica and Delta is a diamond-shaped pattern of 5th magnitude stars. Aim your scope or binoculars just above the one furthest south. Also known as the "Sombrero," this gorgeous 8th magnitude galaxy discovered by Pierre Méchain in 1781 was added by hand to Messier's catalog and observed independently by Herschel as H I.43, who was probably the first to note its dark inclusion. The Sombrero's rich central bulge comprises several hundred globular clusters and can be hinted at using only just large binoculars or a small telescope. Large aperture will revel in this galaxy's "see through" qualities and bold, dark dust lane—making it a seasonal favorite!



Figure 5.21. M104: the Sombrero Galaxy (credit—R. Jay GaBany).

Friday, May 22

Let's begin the day by honoring the 1920 birth on this date of Thomas Gold, an astronomer known for proposing the "steady-state" theory of the universe; for explaining pulsars; and for giving the magnetosphere its name. Gold was also an auditory research genius. In his interview with D.T. Kemp he stated:

"I'm a compulsive thinker, I never turn my brain off, I've never in my life complained of being bored because I'm constantly thinking about some problem, mostly physics I suppose. A problem is always on my mind—evidently even in my sleep because I often wake up with a solution clearly spread out."

For the large telescope and seasoned observer, the challenge for this evening will be 5.5 degrees south of Beta Virginis, and one half degree west (RA 11 46 45 Dec -03 50 53). Classified as Arp 248, and more commonly known as " Wild's Triplet ," these three very small interacting galaxies are a real treat! Best with around a 9-mm eyepiece, use wide aversion, and try to keep the star just north of the trio at the edge of the field to cut glare. Be sure to mark your Arp Galaxy challenge list!



Figure 5.22a. Arp 248: Wild's Triplet (credit—Adam Block/NOAO/AURA/NSF).

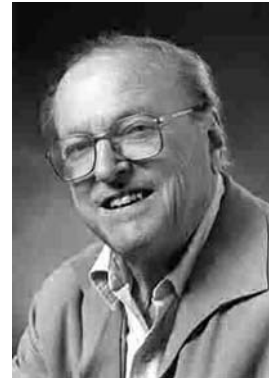


Figure 5.22b. Thomas Gold (historical image).

Saturday, May 23

Tonight let's hop to far northern skies for a look at two gems. Start with Beta Ursae Majoris—the southwestern star of the Big Dipper—and begin scanning about a finger-width southeast for M108 (RA 11 11 31 Dec +55 40 31). At magnitude 10, you'll appreciate this splendid edge-on galaxy! Discovered by Pierre Méchain on February 19, 1781, and later verified by Charles Messier, it didn't formally enter the Messier's catalog until 1953 at the hand Owen Gingerich. Despite its low surface brightness, M108 can be spotted by mid-aperture telescopes, and larger scopes will make out irregular patches of detail.

Now, hop on less than a finger-width further southeast (RA 11 14 47 Dec +55 01 08) where you'll spot M97, the "Owl Nebula." Discovered by Pierre Méchain 3 days earlier than M108, the Owl is often thought of as one of the most difficult of the Messier studies to detect from urban locations. . .and it may require a light pollution filter to help bring it to life. About the apparent size of Jupiter, the Owl gets its name from the vague gray-greenness of its light, and the two curious eye-like voids visible through larger scopes. Scientists believe the voids are the result of a line-of-sight phenomenon, where the lowest-density poles lie at an oblique angle from our vantage point. The structure of M97 and its fluorescence are associated with a high surface temperature central star in the last stages of life. Can you spot the faint 16th magnitude dying star at its heart?



Figure 5.23a. M108 (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.23b. M97—the Owl Nebula (credit—Palomar Observatory, courtesy of Caltech).

Sunday, May 24

Tonight is the New Moon and time to tour the galaxy fields of Virgo. For large telescopes, this is the “field of dreams”...

Start four finger-widths east-southeast of Beta Leonis for part of “Markarian’s Chain” and discover M84 and M86 (RA 12 25 03 Dec +12 53 13)! Good binoculars and small telescopes reveal the matched ellipticals of M84/86, while mid-sized telescopes will note that western M84 is slightly brighter and smaller. Larger scopes see these two galaxies literally “leap” out of the eyepiece at even modest magnifications!

In large telescopes, the bright galactic forms of M84/86 can be held with direct vision, while aversion welcomes many other mysterious strangers into view. Forming an easy triangle with the two Messiers, and located about 20' south, is 11th magnitude NGC 4388, a classic edge-on spiral. Dim NGC 4387 (magnitude 12) appears in the center of a triangle as a small face-on spiral with a noticeable dust lane. In large scopes, the central structure forms a curved “bar” of light, and the dust lane cleanly separates the central bulge of the core. East of M86 are two brighter NGC galaxies—4435 and 4438. In an average telescope, NGC 4435 has a simple star-like core and wispy round body structure, while NGC 4438 is a dim elliptical. The beauty of the pair is their proximity to each other! At times, a conspicuous wisp of galactic material can be seen stretching back toward the nearby (brighter) galaxy pair M84/86.

Happy hunting!



Figure 5.24. Wide-field image of the Virgo galaxy cluster with M84/86 region to the upper right (credit—NOAO/AURA/NSF).

Monday, May 25

Would you like to start your morning in a strange and unusual way? Then get up well before dawn to check out Jupiter. . . . It has company! Located less than a half degree to the north, you'll find the blue planet Neptune. What a great photographic opportunity!

Today we honor the 1939 passing of Sir Frank Watson Dyson. Born in 1868, and one-time Astronomer Royal, Dyson was a master of measurements of terrestrial magnetism, latitude, and time. We can thank him for the first radio broadcast using Universal Time (UT)! Dyson determined the proper motions of circumpolar stars and contributed to the International Carte du Ciel project. Along with Sir Arthur Eddington, he was present in 1919 when Einstein's theory of relativity was confirmed when he witnessed the bending of starlight by the Sun's gravitational field during a total solar eclipse.

Tonight we'll head for the northern skies to chase down 7.7-magnitude M101 (RA 14 03 12 Dec +54 20 53). If you have trouble locating this galaxy, simply form a triangle with Mizar/Alcor and Eta Ursae Majoris. M101 is the apex of the triangle, away from the curve of the Big Dipper's Handle. The sprawling nature of this face-on spiral means that the light of an 8th magnitude star has to be spread very thin to cover all that celestial terrain, so minimal magnification is a must. Its 10th magnitude core region allowed Pierre Méchain to view it on March 27, 1781, and its inclusion was the last published entry in Charles Messier's catalog. Meanwhile, William Parsons (Lord Rosse), described M101 as "Large, spiral, faintish, several arms and knots. 14' diameter at least"—a description comparable to what is seen through the largest backyard telescopes used today. At a distance of 27 million light-years, the true size of M101 is quite extraordinary—some 170,000 light-years in diameter. Its total luminosity is equivalent to over 30 billion suns. Even as large as this galaxy is, it only approaches the size of the Milky Way!



Figure 5.25a. M101 (credit—Palomar Observatory, courtesy of Caltech).

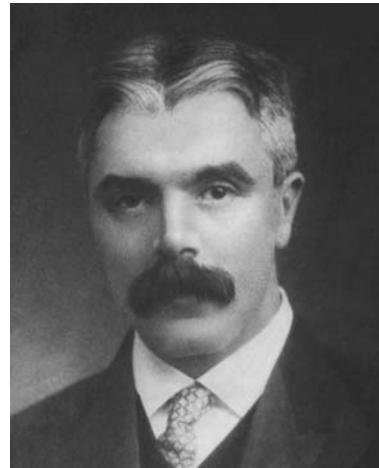


Figure 5.25b. Sir Frank Watson Dyson (historical image).

Tuesday, May 26

Today we wish astronaut Sally Ride a happy birthday! She became the first American woman to orbit Earth aboard the space shuttle Challenger on June 18, 1983. Sharing her date in 1826 is Richard Christopher Carrington, who was first to map sunspot motions and observe a solar flare.

Tonight, we'll head a finger-width northeast of 6 Comae for a galaxy discovered on this date in 1781 by Pierre Méchain. Its name is M100 (RA 12 22 54 Dec +15 49 19). . .

As one of the brightest members of the Virgo Cluster, M100 is much like our own galaxy. From our point of view, we see it "face-on," and even Lord Rosse in 1850 detected spiral form. Thanks to its proximity to other cluster members, its two grand arms contain recently formed, young, hot, and massive stars. Regardless of its perfect shape, in the nucleus younger stars have formed more toward the south side than the north. Perhaps due to interaction with its dwarf neighbors?

Binoculars and telescopes will see a soft, round glow, but extensive photography has shown M100 to be far larger than previously believed, with a substantial portion of its mass contained in faint outer regions. The Hubble telescope discovered over 20 Cepheid variables and 1 nova in our spiral friend and was able to accurately determine its distance as 6 million light-years. NASA's Ultraviolet Imaging Telescope has shown starburst and star formation activity at the edges of M100's inner arms. Larger telescopes see this galaxy's intense core region as slightly elliptical and will sometimes reveal patchiness in structure. Be sure to look carefully because five supernova events have been observed in this hot galaxy—one as recently as February 2006!



Fig 5.26a. M100 (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.26b. (Sally Ride (public image)).

Wednesday, May 27

Today we'd like to begin by saluting the 1972 passing on this date of Dr. Roy K. Marshall. Born in 1907, Dr. Marshall was the first director of Morehead Planetarium, Chapel Hill, North Carolina. Those readers who have been in the astronomy game for some time may recognize his name from the book *Star Maps For Beginners*, which he co-authored with I.M. Levitt; or for his classic television series *The Nature Of Things*. Dr. Marshall was truly an inspiration!

Tonight the slender crescent Moon will make a very brief appearance at dusk along the western skyline. If your atmosphere is very steady, why not set the telescope down on it and look for some very unusual features that will soon wash out as the Sun overtakes the Moonscape. Almost central along the eastern lunar limb, look for Mare Smythii and Mare Marginis to its north. Between them, you will see the long oval crater Neper bordered by Jansky at the very limb.

With tonight's thin Moon setting early, let's have a look at the superb "Southern Pinwheel" galaxy, M83. You'll find it a little more than a fist-width south-southeast of Gamma Hydrae (RA 13 37 00 Dec -29 51 58). M83 is often shown to young astronomers as an example of what our galaxy would look like if we could view it from space. In astrophotos, M83 shows a luminous central core with two broad bars of almost equally intense light extending outward across from one another. These bars of stars are the main concentration of the galactic core and from them spring the softer look of the galaxy's main spiral arms. Well away from the core, three spiral extensions are seen coiling outward to ultimately dissipate into space. But, that's where the comparison with our own galaxy ends. This 15-million-light-year-distant, 30,000-light-year-diameter, class SB spiral is but a miniature of our giant spiral!



Figure 5.27a. M83 (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.27b. Vintage Morehead Planetarium (courtesy of UNC Chapel Hill and Morehead Planetarium).

Thursday, May 28

Today, we begin by saluting the 1930 birth on this date of Frank Drake, father of Project Ozma and formulator of the “Drake Equation,” used to estimate the number of technological civilizations that may exist in our galaxy. Dr. Drake also worked with Carl Sagan on the plaques placed aboard Pioneers 10 and 11, which greet any visitors the probes might encounter. Also remember Rudolph Leo B. Minkowski on this 114th anniversary of his birth. Minkowski studied spectra and contributed to the discovery of more than half of the planetary nebulae now known. Along with Walter S. Baade, Minkowski separated supernovae into spectral types and identified optical counterparts for early radio source galaxies.

Tonight the Moon is brilliantly lit with Earthshine. Power up and look for crater Petavius! Located almost centrally along the terminator in the southeast quadrant, at times you’ll see 177 kilometer diameter Petavius (1) cut in half by the terminator. This is a great time to spot the small range of central mountain peaks and the deep rima that runs for 80 kilometers across its otherwise fairly smooth surface. To the east lies a long furrow in the landscape—Palitzsch and its Vallis. The primary crater that forms this deep gash is 41 kilometers wide, and the valley stretches for 110 kilometers. Look for crater Haas on Petavius’s southern edge with Snellius (2) and its Vallis (3) to the southwest, and Wrottesley along its northwest wall. Can you spot Stevius (4)?

When the Moon sets, head for Minkowski’s own radio source, M87, capital of the Coma–Virgo galaxy cluster (RA 12 30 49 Dec +12 23 28). Long-exposure photographs of M87 reveal this 120,000-light-year-diameter galaxy as an “all stars” phenomenon. . . similar to a massive globular cluster! M87 has collected tens of thousands of globular clusters and numerous smaller galaxies, and converted almost all of its matter to stars—a galaxy with a total mass exceeding several trillion suns.

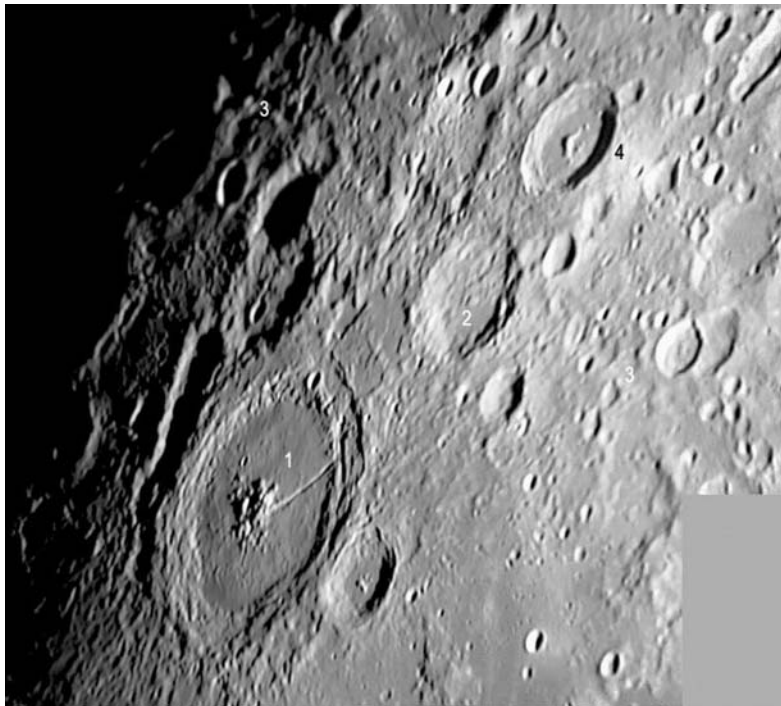


Figure 5.28a. Petavius (credit—Alan Chu).



Figure 5.28b. M87 (credit—Palomar Observatory, courtesy of Caltech).

Friday, May 29

Today we begin with the 1794 birth on this date of Johann Heinrich von Mädler who, along with Wilhelm Beer, published the most complete map up to that time of the Moon, *Mappa Selenographia* Johann Heinrich von. How fitting, then, that we should visit the Moon tonight! We're going in search of another Lunar Club Challenge that will prove difficult because you'll be working without a map. Relax! This will be much easier than you think. Starting at Mare Crisium, move along the terminator to the north following the chain of craters until you identify a featureless oval that looks similar to Plato seen on a curve. This is Endymion, and if you can't spot it tonight don't worry. We'll look in the days ahead at some features that will point you to it!

Since tonight will be our last chance to galaxy hunt for a while, let's take a look at one of the brightest members of the Virgo Cluster—M49 (RA 12 29 46 Dec +07 59 59). Located about 8 degrees northwest of Delta Virginis, and almost directly between a pair of 6th magnitude stars, the giant elliptical M49 holds the distinction of being the first galaxy in the Virgo Cluster to be discovered—and just the second beyond our local group. At magnitude 8.5, this type E4 galaxy will appear as an evenly illuminated egg shape in almost all scopes, and as a faint patch in binoculars. Although a possible supernova event occurred in 1969, don't confuse the foreground star noted by Herschel with something new! Most telescopes won't be able to pick this region apart—especially with the Moon so near—but there are also many fainter companions near M49, including NGC 4470. A sharp-eyed observer named Halton Arp noticed them and listed them as "Peculiar Galaxy 134"—one with "fragments"!



Figure 5.29a. M49 (credit—Palomar Observatory, courtesy of Caltech).



Figure 5.29b. Johann Heinrich von Mädler (historical image).

Saturday, May 30

Today we begin with the 1423 birth of Georg von Peurbach on this date, a follower of Ptolemy's astronomy. Georg calculated eclipses; observed Halley's Comet before it was so named; and created astronomical instruments. Following Georg nearly half a millennium later was Hannes Alfvén, born in 1908. Alfvén's life work was plasma and its electric and magnetic forces. Lastly, we have Aleksei Arkhipovich Leonov, who was born in 1934. Leonov was the first man to climb out of a spacecraft (the Voskhod II) and into space. He was the first true "astrophotographer" as he filmed for 10 minutes while orbiting!

Tonight let's take our own journey to the Moon and look at a beautiful series of craters—Fabricius, Metius, and Rheita. Bordered on the south by shallow Janssen, Lunar Club Challenge Fabricius is a 78-kilometer diameter crater highlighted by two small interior mountain ranges. To its northeast is Metius, which is slightly larger, with a diameter of 88 kilometers. Look carefully at the two. Metius has much steeper walls, while Fabricius shows differing levels and heights. Metius's smooth floor also contains a very prominent B crater on the inside of its southeast crater wall. Further northeast is the lovely Rheita Valley, which stretches almost 500 kilometers and appears more like a series of confluent craters than a fault line. The 70-kilometer diameter crater Rheita is far younger than this formation because it intrudes upon it. Look for a bright point inside the crater, its central peak.

While the Moon is still west, let's have a look at telescopic star W Virginis located about 3.5 degrees southwest of Zeta (RA 13 26 02 Dec -03 22 43). This 11,000 light-year-distant Cepheid-type variable is, oddly enough, a Population II lying outside the galactic plane. This expanding and contracting star goes through its changes in a little over 17 days and will vary between 8th and 9th magnitude. Although it is undeniably a Cepheid, it breaks the rules by being both out of place in the cosmic scheme and displaying abnormal spectral qualities!

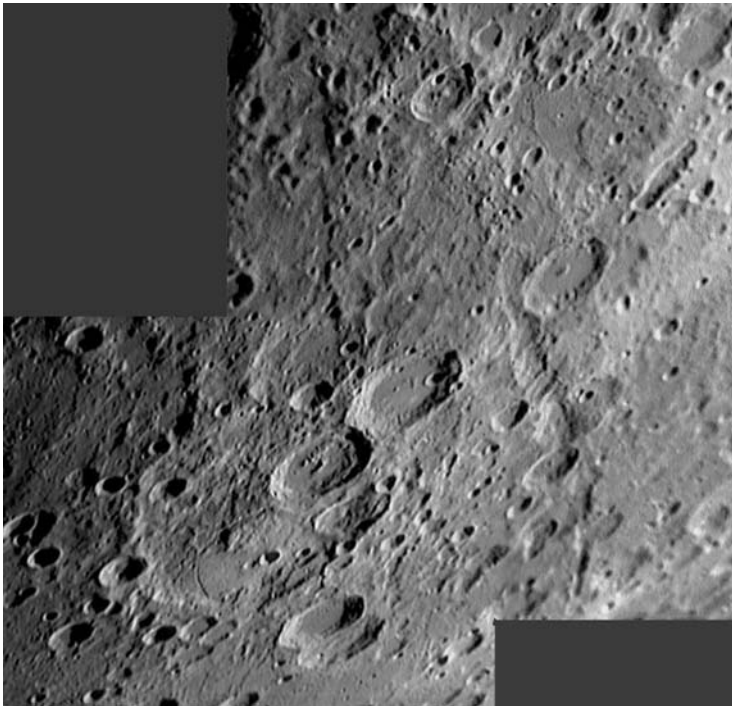


Figure 5.30a. Fabricius, Metius, and Rheita (credit—Alan Chu).



Figure 5.30b. Aleksey Arkhipovich Leonov (archival image).

Sunday, May 31

Today we begin with noting the 1872 birth on this date of Charles Greeley Abbot, who may very well have been the first astronomer to suspect that the radiation from the Sun might vary over time, and thus it was technically a variable star. When Abbot became the director of the Smithsonian Astrophysical Observatory (SAO), the SAO established a network of solar radiation observatories around the world. After many decades of study, a connection was made between solar variations and weather on Earth.

Tonight the Moon will be our companion. Now well risen above atmospheric disturbance, this would be a great time to have a look for several Lunar Club Challenges you might have missed.

Most prominent of all will be two craters to the north named Atlas and Hercules. The easternmost Atlas was named for the mythical figure who bore the weight of the world on his shoulders. The crater spans 87 kilometers and contains a vivid Y-shaped rima in the interior basin. Western Hercules is considerably smaller at 69 kilometers in diameter and shows a deep interior crater, called G. Power up, and look for the tiny E crater, which marks the southern crater rim. North of both is another unusual feature that many observers miss. It is a much more eroded and far older crater showing only a basic outline; this crater is known as Atlas E.

Since we're here, let's take a crater walk and see how many features we can identify... Good luck and clear skies!

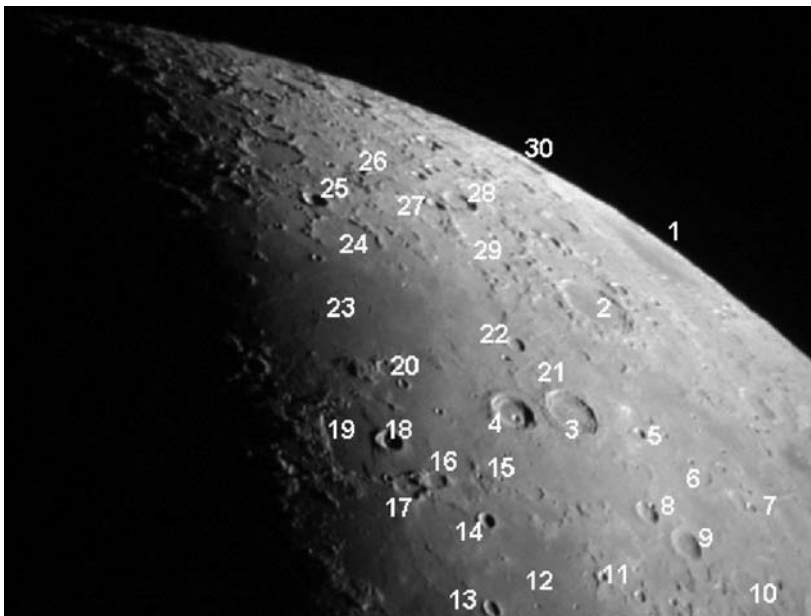


Figure 5.31a. Atlas region (credit—Greg Konkel). (1) Mare Humboldtianum, (2) Endymion, (3) Atlas, (4) Hercules, (5) Chevalier, (6) Shuckburgh, (7) Hooke, (8) Cepheus, (9) Franklin, (10) Berzelius, (11) Maury, (12) Lacus Somniorum, (13) Daniel, (14) Grove, (15) Williams, (16) Mason, (17) Plana, (18) Burg, (19) Lacus Mortis, (20) Bailly, (21) Atlas E, (22) Keldysh, (23) Mare Frigoris, (24) Democritus, (25) Gartner, (26) Schwabe, (27) Thales, (28) Strabo, (29) de la Rue, and (30) Hayn.

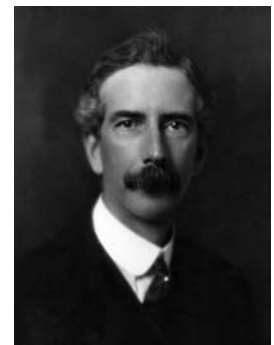



Figure 5.31b. Charles Greeley Abbot (historical image).

CHAPTER SIX



June, 2009

Monday, June 1

On this date in 2002, the first national law prohibiting “light pollution” went into effect. Thanks to Czech astronomers who lobbied for the legislation, the Czech Republic became the first nation to outlaw excess outdoor lighting, and required all outdoor lighting to be directional and shielded. If you’re reading this book, you realize the consequences of light pollution and the role it plays in astronomy. Why not do some lobbying of your own today?

Tonight no two lunar features in the north will be more prominent than Aristoteles and Eudoxus. Viewable even in small binoculars, let’s take a closer look at larger Aristoteles to the north.

As a Class I crater, this ancient beauty has some of the most massive walls of any lunar feature. Named for the great philosopher, it stretches across 87 kilometers of lunar landscape and drops below the average surface to a depth of 366 meters—a height similar to Earth’s tallest waterfall, the Silver Cord Cascade. Although it has a few scattered interior peaks, the crater floor remains almost unscarred. As a telescopic Lunar Club Challenge, be sure to look for a much older crater that sits on Aristoteles’ eastern edge. Tiny Mitchell is extremely shallow by comparison and only spans 30 kilometers. Look carefully at the formation, for although Aristoteles overlaps Mitchell, the smaller crater is actually part of the vast system of ridges that supports the larger.

Now let’s have a look at Iota Virginis (RA 14 16 00 Dec -06 00 02). Although there is nothing particularly special about this spectral F-type star, it does reside in a very interesting field for low power. Enjoy the colors!



Figure 6.1a. Aristoteles (credit—Wes Higgins).



Figure 6.1b. Iota Virginis (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, June 2

Today honor the 1930 birth on this date of Charles Peter Conrad—Apollo 12 astronaut and third man to set foot on the Moon. Conrad also served on the Gemini 5, Gemini 11, and Skylab II missions, and later was a crewmember for a record-breaking flight around the world in a Lear jet. Unfortunately, he died at age 69 doing what he loved best, riding a motorcycle. Tonight we'll remember him as we take our own journey to the Moon. . .

Our first telescope lunar challenge will be Hadley Rille. Find Mare Serenitatis and look for the break along its western shoreline that divides the Caucasus and Apennine mountain ranges. South of this break is the bright peak of Mons Hadley, which is of great interest for several reasons, so power up as much as possible. Impressive Mons Hadley measures about 24 by 48 kilometers at its base and reaches up an incredible 4,572 meters. If volcanic activity had created it, Mons Hadley would be comparable to some of the very highest volcanically formed peaks on Earth, like Mount Shasta and Mount Rainer. South is the secondary peak, Mons Hadley Delta. It is home to the Apollo 15 landing site just a breath north of where it extends into the cove created by Palus Putredinus. Along this ridgeline and smooth floor, look for a major fault line, winding its way across 120 kilometers of lunar surface; this is Hadley Rille. In places, the Rille spans 1,500 meters in width and drops to a depth of 300 meters below the surface. Believed to have been formed by volcanic activity 3.3 billion years ago, we can see the impact lower gravity has on this type of formation. Earthly lava channels are usually less than 10 kilometers long, and only around 100 meters wide. During the Apollo 15 mission, Hadley Rille was visited at a point where it was only 1.6 kilometers wide, still a considerable distance as seen by comparison with astronaut James Irwin and the lunar rover! Over a period of time, the Rille's lava may have continued to flow through this area, yet it remains forever buried beneath years of regolith.

Pete Conrad? We remember. . .



Figure 6.2a. Hadley Rille (credit—Wes Higgins).



Figure 6.2b. Astronaut Pete Conrad (historical image).

Wednesday, June 3

Today we'll take a look at the 1659 birth on this date of David Gregory, a specialist in the study of chromatic aberration. Gregory noticed something Sir Isaac Newton had missed, that certain kinds of glass spread the colors of the spectrum by different amounts. Why not combine two different types of glass in a telescope to eliminate unwanted color? Although it would be half a century later before his vision was implemented, Gregory still contributed to astronomy through improvements he made in the refractor telescope.

Tonight on the Moon we'll be looking for another challenging feature and the craters that conjoin it—Stofler and Faraday. Located along the terminator to the south, crater Stofler was named for Dutch mathematician and astronomer Johan Stofler. Consuming lunar landscape with an immense diameter of 126 kilometers, and dropping 2,760 meters below the surface, Stofler is a wonderland of small details in an eroded surrounding. Breaking its wall on the north is Fernelius, but sharing the southeastern boundary is Faraday. Named for English physicist and chemist Michael Faraday, this crater is more complex and deeper (4,090 meters) but far smaller in diameter (70 kilometers). Look for myriad smaller strikes that bind the two together!

When you're done, let's have a look at another delightful pair—Gamma Virginis (RA 12 41 41 Dec -01 26 54). Better known as Porrima, this is one cool binary whose components are of almost equal spectral type and brightness. Discovered by Bradley and Pound in 1718, John Herschel was the first to predict this pair's orbit in 1833, and stated that one day they would become inseparable to all but the very largest of telescopes—and he was right. In 1920 the A and B stars had reached their maximum separation, and during 2007 they were as close together as they ever can be. Observed as a single star in 1836 by William Herschel, its 171-year orbit puts Porrima in almost the same position now as it was when Sir William saw it!

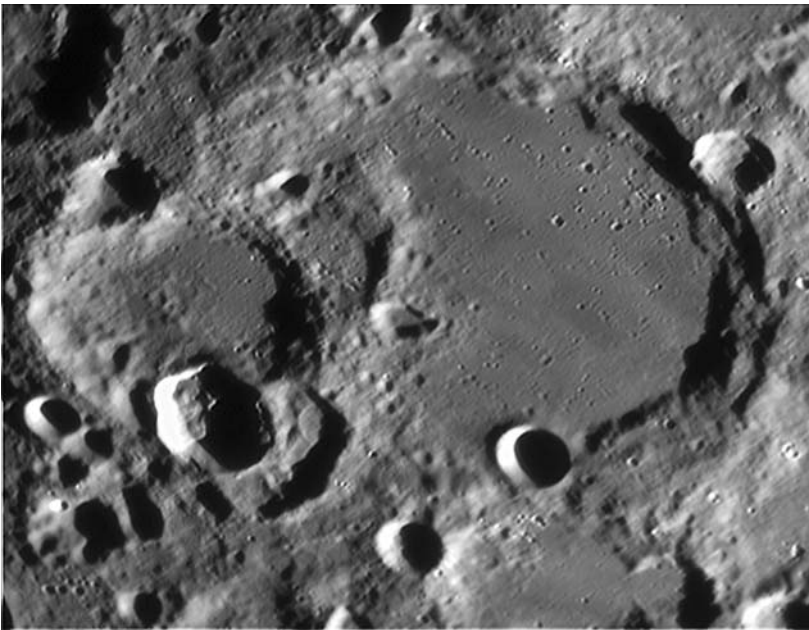


Figure 6.3a. Stofler and Faraday (credit—Wes Higgins).



Figure 6.3b. Gamma Virginis: Porrima (credit—Palomar Observatory, courtesy of Caltech).

Thursday, June 4

Did you ever wonder who was the first to organize an astronomy group? No less a personage than Baron Franz Xaver Freiherr von Zach. Born on this date in 1754, von Zach was the director of an observatory near Gotha, and in 1798 he organized the first congress of astronomers, with Joseph LaLande as the honored guest. He later formed another group of two dozen astronomers to help locate the “missing planet” between the orbits of Mars and Jupiter. I wonder what they discovered?

Are you ready to explore some more history? Then tonight have a look at the Moon and identify Alphonsus; it’s the centermost in a line of rings and looks much like the Theophilus, Cyrillus, and Catharina trio.

Alphonsus is a very old Class V crater, spans 118 kilometers in diameter, drops below the surface to about 2,730 meters, and contains a small central peak. Eugene Shoemaker had studied this partially flooded crater and found dark haloes on the floor. Again, this could be attributed to volcanism. Shoemaker believed they were maar volcanoes, and the haloes were dark ash. Power up and look closely at the central peak, for not only did Ranger 9 hard land just northeast, but this is the only area on the Moon where an astronomer has observed a change and backed up that observation with photographic proof.

On November 2, 1958, Nikolai Kozyrev long and arduous study of Alphonsus was about to be rewarded. Some two years earlier Dinsmore Alter had taken a series of photographs from the Mt. Wilson 60” reflector that showed hazy patches in this area that could not be accounted for. Night after night, Kozyrev continued to study at the Crimean Observatory, but with no success. During the process of guiding the scope for a spectrogram, the unbelievable happened—a cloud of gaseous molecules containing carbon had been captured!

Selected as the last target for the Ranger series of photographic missions, Ranger 9 delivered 5,814 spectacular high-resolution images of this mysterious region before it crashed nearby. Capture it yourself tonight!



Figure 6.4a. Ranger 9 image of Alphonsus taken 3 minutes before impact (credit—NASA).



Figure 6.4b. Alphonsus’ central peak taken 54 seconds before Ranger 9 impact (credit—NASA).

Friday, June 5

If you'd like a challenge this morning, see if you can spot Venus and Mars no more than 30 minutes before dawn. The pair will be very low—only about 20 degrees above the horizon—and about 5 degrees apart. Good luck!

Now, let's take a look at John Couch Adams, a discoverer of Neptune who was born on this date in 1819. Said he:

"...the beginning of this week of investigating, as soon as possible after taking my degree, the irregularities in the motion of Uranus...in order to find out whether they may be attributed to the action of an undiscovered planet beyond it."

But that's not all Adams contributed! He was the first to associate the Leonid meteor shower with the orbital path of a comet, and he also observed the Moon.

As we begin observing Selene this evening, let's have a look at awesome crater Clavius. As a huge mountain-walled plain, Clavius will appear near the terminator tonight in the lunar Southern Hemisphere, rivaled only in sheer size by similarly structured Deslandres and Bailly. Rising 1,646 meters above the surface, the interior wall slopes gently downward for a distance of almost 24 kilometers and spans 225 kilometers. Its crater-strewn walls are over 56 kilometers thick! Clavius is punctuated by many pockmarks and craters; the largest on the southeast wall is named Rutherford. Its twin, Porter, lies to the northeast. Long noted as a test of optics, Clavius crater can offer up to 13 such small craters on a steady night at high power. How many can you see?

If you want to continue tests of resolution, why not visit nearby Theta Virginis (RA 13 09 56 Dec -05 32 20)? It might be close to the Moon, but it's 415 light-years away from Earth! The primary star is a white A-type subgiant, but it's also a spectroscopic binary comprising two companions that orbit each other about every 14 years. In turn, this pair is orbited by a 9th magnitude F-type star that is a close 7.1" away from the primary. Look for the fourth member of the Theta Virginis system, well away at 70" but shining at a feeble magnitude 10.4.

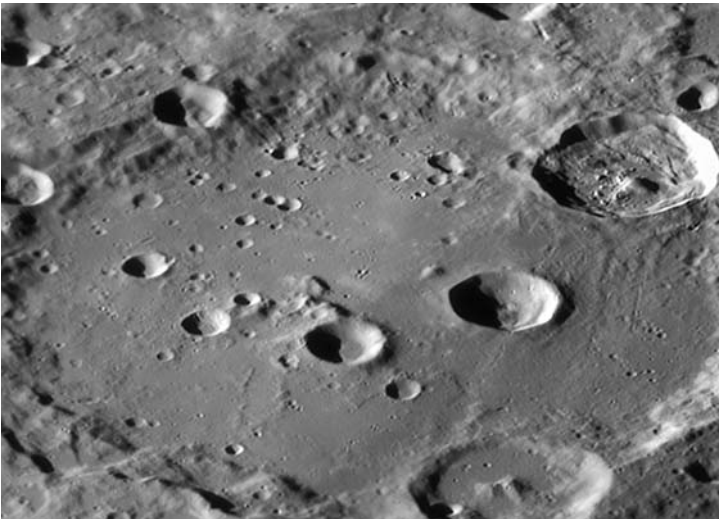


Figure 6.5a. Clavius (credit—Wes Higgins).

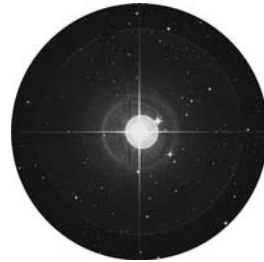


Figure 6.5b. Theta Virginis (credit—Palomar Observatory, courtesy of Caltech).

Saturday, June 6

Today is all about lunar history! We begin with the 1932 birth on this date of David Scott, the seventh person to walk on the Moon and the first to ride the Lunar Rover on the surface during the Apollo 15 mission. Sharing his birth date, but almost 500 years earlier, was the astronomer Regiomontanus (1436). Regiomontanus made observations of a comet, which were accurate enough to associate it with Comet Halley 210 years later, and his interest in the motion of the Moon led him to make the important observation that lunar distances could be used to determine longitude at sea! Let's head to the Moon...

Although at first glance tonight crater Copernicus will try to steal the scene, head further south to capture another Lunar Club Challenge—Bullialdus. Even binoculars can make out this crater with ease near the center of Mare Nubium. If you're scoping, power up—this one is fun! Very similar to Copernicus, note Bullialdus' thick, terraced walls and central peak. If you examine the area around it carefully, you can note it is a much newer crater than shallow Lubiniezsky to its north and almost non-existent Kies to the south. On Bullialdus' southern flank, it's easy to make out its A and B craters, as well as the interesting little Koenig to the southwest. Although it will be a bit overlit, if you head to the southeast shore of Mare Humorum, you can spot crater Regiomontanus as well. It's just south of Purbach.

Now let's starhop four finger-widths northwest of Beta Virginis for another unusual star—Omega (RA 11 38 27 Dec +08 08 03). Classed as an M-type red giant, this 480 light-year-distant beauty is also an irregular variable that fluxes by about half a magnitude. Although you won't notice much change in this 5th magnitude star, it has a very pretty red coloration and is worth the time to view.

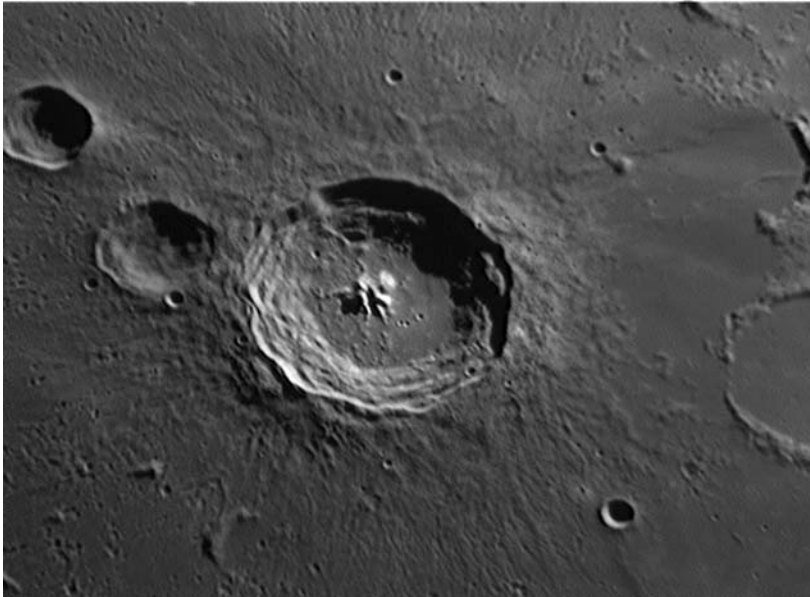


Figure 6.6a. Bullialdus (credit—Wes Higgins).



Figure 6.6b. Omega Virginis (credit—Palomar Observatory, courtesy of Caltech).

Sunday, June 7

Today we celebrate the birth of Bernard Burke, co-discoverer of radio waves emitted from Jupiter. Listening to Jupiter's radio signals is a wonderful hobby that can be practiced by anyone with enough room to set up a dipole antenna. If you'd like more information—or want to hear a recording of Jupiter yourself—visit *Radio JOVE* on the web! Tonight is Full Strawberry Moon, a name used by every Algonquin tribe in North America because the short season for harvesting the tasty red fruit comes each year during the month of June!

Tonight let's have a look at a tasty red star—R Hydrae (RA 13 29 42 Dec -23 16 52)—located a fist-width south of Spica. R Hydrae was the third long-term variable star discovered and was credited to Maraldi in 1704. Although Hevelius observed it 42 years earlier, it wasn't recognized as variable because its changes happen over more than a year. At maximum, R Hydrae reaches near 4th magnitude, but drops well below naked-eye perception to magnitude 10. During Maraldi's and Hevelius's time, this incredible star took over 500 days to cycle, but it has speeded up to around 390 days in the present century. Why such a wide range? Scientists aren't really sure. R Hydrae is a pulsing M-type giant whose evolution may be progressing more rapidly than expected due to changes in structure. What we do know is that it's around 325 light-years away and approaching us at 10 kilometers per second! To the telescope, R will have a pronounced red coloration, which deepens near minimum. Nearby is 12th magnitude visual companion star Ho 381, which was first measured for angle position and distance in 1891. Since then, no changes in separation have been noted, leading us to believe the pair may be a true binary. Now watch as the Moon devours a red star! Brilliant Antares will be less than a half degree away from the limb for most observers and will be occulted for some lucky others! Be sure to check the Resources section of this book and websites such as *IOTA* for exact times and locations.



Figure 6.7a. Nearside of the Moon as imaged by Apollo 11 (credit—NASA).



Figure 6.7b. R Hydrae (credit—Palomar Observatory, courtesy of Caltech).

Monday, June 8

Born on this date in 1625 was Giovanni Cassini, the most notable observer following Galileo. As head of the Paris Observatory for many years, he was the first to observe seasonal changes on Mars and measure its parallax (and so its distance). This set the scale of the Solar System for the first time. Cassini was the first to describe Jovian features and studied the Galilean moons' orbits. He also discovered four moons of Saturn, but he is best remembered for being the first to see the namesake division between the A and B rings. Oddly enough, it was on Cassini's fourth birthday that astronomer Christian Huygens died. How fitting both mission and probe were named after these two greats!

Tonight let's honor both Cassini and Huygens by taking a look at Saturn. To the unaided eye, this creamy-yellow "star" outshines most stars in the region and holds competition with Regulus in Leo. To binoculars, it reveals itself as a planet—one with ears! While great detail cannot be seen, even the slightest optical aid makes it a joy.

To the small telescope, Saturn's ring system becomes very clear, and bright Titan can easily be seen. To the mid-sized telescope, the "Lord of the Rings" easily shows the Cassini division as well as other small details, and reveals the many smaller moons that dance along the ring edge. For the large telescope, Saturn continues to be one of the most fascinating of planets. Several ring divisions are easily apparent, and subtle shading details on the planet's surface are easily discerned. Titan shines very brightly and under good conditions will display a certain amount of limb darkening, making it perceivable as an orb. Tethys, Rhea, and Dionne are easily visible, and the three dimensionality of Saturn revealed through shadow play is incredible.

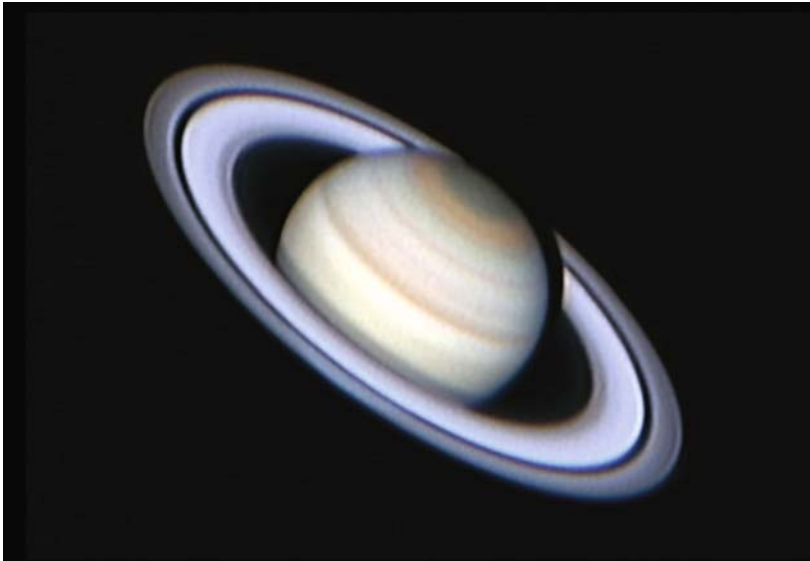


Figure 6.8a. Saturn (credit—Wes Higgins).



Figure 6.8b. Giovanni Cassini (historical image).

Tuesday, June 9

This date is the birthday of Johann Gottfried Galle. Born in Germany in 1812, Galle was the first observer to locate Neptune. He is also known for being Encke's assistant, and he's one of the few astronomers ever to have observed Halley's Comet twice. Unfortunately, he died 2 months after the comet passed perihelion in 1910, but at a ripe old age of 98! Is it possible he knew Mark Twain?

Tonight while we're out, let's have a look at a Virgo galaxy bright enough for smaller instruments and detailed enough to delight larger scopes. Starting at Delta Virginis, move about a fist-width to the west, where you will see two fainter stars, 16 (south) and 17 (north) Virginis. You'll find M61 located about one-half degree south of the yellow double star 17 (RA 12 21 55 Dec +04 28 28). Credit for its discovery goes to Barnabus Oriani during that fateful year of 1779 when Messier was so avid about chasing comets that he mistook it for one. Although Charles had seen M61 on the same night as Oriani, it took him 2 days to figure out it wasn't moving, and 4 more before he cataloged it. Fortunately, 7 years later, Mr. Herschel assigned it his own number of H I.139, even though he wasn't fond of assigning his own numbers to Messier's catalog objects.

At near 10th magnitude, M61 will show a slightly elongated form and brighter core area to small telescopes and really come to life in larger ones. Close to our own Milky Way Galaxy in size, this larger member of the Virgo cluster has great spiral arm structure that displays both knots and dark dust lanes, as well as a beautifully developed nucleus region. M61 has also been host to four supernova events between 1926 and 1999, all of which have been well within range of amateur telescopes.

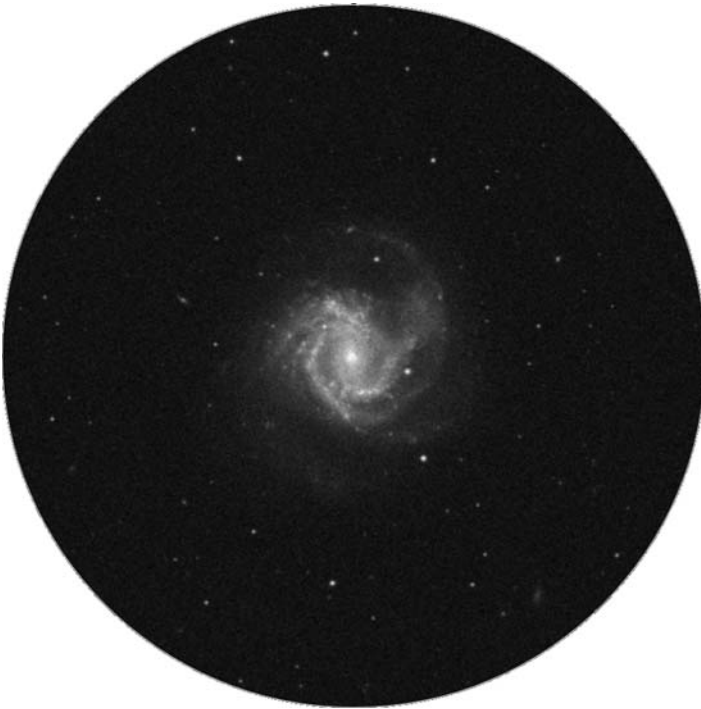


Figure 6.9a. M61 (credit—Palomar Observatory, courtesy of Caltech).

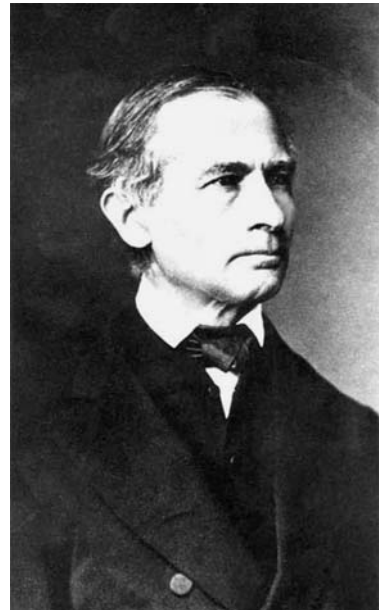


Figure 6.9b. Johann Galle (widely used public image).

Wednesday, June 10

Today celebrate the 1710 birth of James Short, telescope maker. He was first to produce a true parabolic mirror and created nearly 1,400 other instruments. One of his telescopes traveled onboard the Endeavour with Captain Cook to observe the transit of Venus on June 3, 1769, but Short himself unfortunately died before this event took place. Why not salute Short's long-lived telescopes by observing Venus yourself this morning? Watch over the next 9 days as the Moon sweeps past the planets. . .

Before we leave Virgo for the year, there is one last seldom-explored object that we must visit before we go. You'll find NGC 5634 halfway between Iota and Mu Virginis (RA 14 29 37 Dec -05 58 35). This small magnitude 9.5 globular cluster isn't for everyone, but an 11th magnitude line-of-sight star on its eastern edge makes it interesting. At Class IV, it's more concentrated than many globular clusters but nearly impossible to resolve with backyard equipment. Located a bit more than 82,000 light-years from our Solar System, and about 69,000 light-years from the galactic center, you'll enjoy this globular for the randomly scattered stellar field. In the finderscope, the 8th magnitude star will lead the way, but it's not truly a member of the cluster. Look for a concentrated central area surrounded by a haze of stellar members—a large number of which are recently discovered variables.

While studying, keep this in mind. Based on observations with the Italian Telescopio Nazionale Galileo, it is surmised that NGC 5634 has the same position and radial velocity as does the Sagittarius dwarf spheroidal galaxy. Because of the dwarf galaxy's metal-poor population of stars, it is believed that NGC 5634 may have once been part of the dwarf galaxy—and been pulled away by our own tidal field to become part of the Sagittarius stream!



Figure 6.10a. NGC 5634 (credit—Palomar Observatory, courtesy of Caltech).



Figure 6.10b. James Short's Telescope used by George III to observe the transit of Venus in 1769 (credit—courtesy of Armagh Observatory).

Thursday, June 11

Today wish Charles Fabry a happy birthday! Born in 1857 on this date, Fabry was a master in optics, devising methods for accurate measurement of interference effects. He collaborated with Alfred Pérot to design the Fabry–Pérot interferometer, an instrument meant specifically for high-resolution spectroscopy. The device was composed of two thinly silvered parallel glass plates, producing interference due to multiple reflections.

Tonight jump to Serpens Caput, which is a challenge to recognize. Using Spica as a guide, look about a handspan northeast for two of the brightest stars in the constellation—Alpha, and northeast Lambda. Using binoculars, locate a pairing with Delta to the north-northwest and southern Mu. Return to Alpha and hop a less than a fist-width southwest for double star 5 Serpens and the mighty M5 (RA 15 18 33 Dec +02 04 57).

Although Gottfried Kirch and his wife Maria were watching a comet on May 5, 1702, they stumbled across a huge, bright object they considered a “nebulous star.” Forty-two years later, it was found again by Messier, who labeled it M5 and described it as a round nebula that didn’t contain any stars. Thank heaven for William Herschel! Some 27 years later, he counted 200 resolvable stars in this globular cluster and reported “the middle is so compressed that it is impossible to distinguish the components.”

Even in today’s binoculars, M5 shows a grainy texture that begins to resolve with even the smallest of telescopes, and invites larger ones to an explosion of stellar population. Slightly elliptical in appearance, M5 may be one of the oldest globular clusters (calculated age: 13 billion years) and contains 105 known variable stars and a dwarf nova. At a distance of 24,500 light-years and stretching across 165 light-years of space, this magnificent object so dominates its territory that it would gather in any stars straying within 400 light-years of its tidal influence! Mid-to-large telescopes begin awesome resolution on Class V M5’s many chains and bright core region. M5 is a cluster you’ll visit again and again over the years!



Figure 6.11a. M5 (credit—Palomar Observatory, courtesy of Caltech).



Figure 6.11b. Charles Fabry (historical image).

Friday, June 12

Today, remember the 1843 birth of Sir David Gill on this date, who took measurements of solar and stellar parallax, computed the distances of the Sun and other stars from Earth, and was first to use photography in mapping the heavens. To determine parallaxes, Gill perfected the heliometer, a telescope that uses a split image to measure the angular separation of celestial bodies. He later re-determined the solar parallax with such precision that almanacs used his value as late as 1968!

Completing astronomical projects is very challenging, and tonight we'll hunt down a difficult globular cluster study by using M5 as a guide. Palomar 5 is by no stretch of the imagination easy. For GoTo systems, aiming is easy, but for large telescopes, starhopping instructions are critical. From M5 drop south for double 5 Serpens, and again south and slightly west for another, fainter double. Don't confuse it with eastern 6 Serpens. A half degree west you'll encounter an 8th magnitude star, with 7th magnitude 4 Serpens a half degree south. Continue south another half degree, for a triangle of 9th magnitude stars. The southern apex star is home to Palomar 5 (RA 15 16 05 Dec -00 06 41). Discovered by Walter Baade in 1950, this 11.7 magnitude, Class XII globular was first believed to be a dwarf elliptical galaxy, possibly a member of our Local Group. Later studies showed Palomar 5 to be a globular cluster but one being ripped apart by the tidal forces of the Milky Way—at 60,000 light-years from the galactic center! Palomar 5's members are escaping, leaving trails spanning 13,000 light-years—a several billion year process. Telescopes of 6" can distinguish a few individual members northwest of the 9th magnitude marker star, but even ones as large as 31" fail to show more than a handful of resolvable stars. This may be the toughest locating job you'll ever tackle, but be sure to make a quick sketch of the region to complete your studies. Good luck!



Figure 6.12a. Palomar 5 (credit—Palomar Observatory, courtesy of Caltech).



Figure 6.12b. Sir David Gill (historical image).

Saturday, June 13

Before dawn, Mercury reaches its highest morning elevation, and you'll find the asteroid Psyche less than half a degree north of the Moon. Look a finger-width south of Luna, and you'll see Neptune and Jupiter separated by less than a degree! Perhaps they're saluting the 1831 birth on this date of James Clerk Maxwell? Maxwell calculated that the speed of propagation of an electromagnetic field is approximately the speed of light, thereby inferring that light is an electromagnetic phenomenon. Born on the same day but 28 years before him was Thomas Young, who had demonstrated the wave nature of light.

For us, tonight's light waves will be from Herschel II.76, also known as NGC 5970. Begin by identifying Beta and Delta Serpentis, and look for finderscope Chi between them. Less than a degree southwest, you will see a similar-magnitude double star. Hop about one-third degree northwest, and you'll find the galaxy just a fraction southwest of a 7th magnitude star (RA 15 38 302 Dec -12 11 11). NGC 5970 isn't particularly easy for smaller scopes (even near 11th magnitude), because of its low surface brightness, but its structure makes it a distant cousin of the Milky Way. At 105 million light-year-distant, it's no great surprise we see it as faint, for its light left around the time the dinosaurs ruled Earth. Stretching across 85,000 light-years of space, the nuclear region, obscuring dust regions, and the stellar population of this grand spiral have been extensively studied. And—like us—it is also part of its own Local Group. Although smaller telescopes will make out a slightly elongated mist, in mid-to-large apertures NGC 5970 will appear oval-shaped with a bright core and evidence of a central bar. Although the edges of the galaxy seem well-defined, look closely at the narrower ends, where material seems more wispy. Seen averted, the nucleus will sometimes take on a stellar appearance yet lose this property with direct vision. Be sure to mark your Herschel notes on this one!



Figure 6.13a. NGC 5970 (credit—Palomar Observatory, courtesy of Caltech).

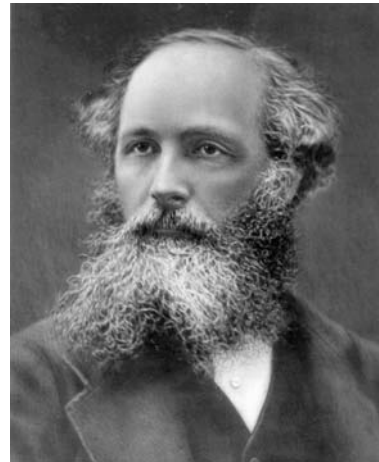


Figure 6.13b. James Clerk Maxwell (historical image).

Sunday, June 14

As the new hours of the day begin and you wait on dawn, keep watch for the peak of the Ophiuchid meteor shower with the radiant near Scorpius. The fall rate is poor, with only 3 per hour, but fast-moving bolides are common. This meteor stream will last for 25 days. While you're out, see if you can spot Mercury! What planet is the Moon near now?

Tonight, let's go south in Libra and have a look at the galaxy pairing NGC 5903 and NGC 5898. You'll find these about 3 degrees northeast of Sigma, and just north of a pair of 7th magnitude stars (RA 15 18 36 Dec -24 04 05). Although northernmost NGC 5903 seems to be nothing more than a faint elliptical with a brighter concentration toward the center and an almost identical elliptical—NGC 5898—to the southwest, you're probably asking yourself. . . why the big deal over two small ellipticals? First off, NGC 5903 is Herschel III.139 and NGC 5898 is Herschel III.138—two more to add to your studies. And second? The Very Large Array has studied this galaxy pair in the spectral line of neutral hydrogen. The brighter of the pair, NGC 5898, shows evidence of ionized gas that has been collected from outside its galactic realm, while NGC 5903 seems to be running streamers of material toward it. A double-galaxy, double-accretion event!

But there's more. . .

Look to the southeast, and you'll double your pleasure and double your fun as you discover two double stars instead of just one! Sometimes we overlook field stars for reasons of study, but don't do it tonight! Even mid-sized telescopes can easily reveal this twin pair of galaxies sharing "their stuff," as well as a pair of double stars in the same low power field of view. (Psst. . . slim and dim MCG 043607 and quasar 1514-241 are also here!) Ain't it grand?



Figure 6.14. NGC 5903 and NGC 5898 field (credit—Palomar Observatory, courtesy of Caltech).

Monday, June 15

For a special morning treat, get up early to capture asteroid Juno less than half a degree north of the Moon! At magnitude of 8, you'll need larger binoculars or a small telescope to cut it away from the lunar glare, but it's worth the time. Juno was the third asteroid discovered and the object of the first documented stellar occultation. For meteorite fans, Juno may be the source of many ordinary chondrites in your collection!

Tonight let's go globular and hunt up two worthy studies. Starting at Alpha Librae, head 5 degrees southeast for Tau, and a degree southeast for splendid NGC 5897 (RA 15 17 24 Dec $-21\ 00\ 36$). This Class XI globular might appear very faint to binoculars, but it makes up for it in size and beauty of field. It was first viewed and logged by William Herschel on April 25, 1784—but with less than perfect notation of position. When he reviewed it on March 10, 1785, he logged it correctly and relabeled it. At more than 40,000 light-years away, this 8.5-magnitude globular shows some details to larger telescopes, but remain unresolved to smaller ones. Halo globular cluster, NGC 5897 certainly shows signs of being disrupted and has a number of blue stragglers as well as four newly discovered variables of the RR Lyrae-type.

Now return to Alpha Librae and head a fist-width south into Hydra and 2 degrees east of star 57 for NGC 5694—also attractive field (RA 14 39 37 Dec $-26\ 32\ 18$). Discovered by Herschel and cataloged as H II.196, this Class VII cluster is far too faint for binoculars and barely within reach of smaller scopes. Why? It's one of the most remote globular clusters in our galaxy. Few telescopes can hope to resolve this 13,000-light-year-distant ball of stars. Traveling at 190 kilometers per second, metal-poor NGC 5694 will not have the same fate as NGC 5897. This globular cluster isn't being pulled apart by our galaxy, but by trying to escape it!



Figure 6.15a. NGC 5897 (credit—Palomar Observatory, courtesy of Caltech).



Figure 6.15b. NGC 5694 (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, June 16

Stay up later, or get up early, but right now is the time to catch the peak of the June Lyrids meteor shower! Although it's not the most outstanding of displays, the waning Moon will make it easier for those wishing to log their observations. Look for the radiant near Vega. You may see up to 15 faint blue meteors per hour from this branch of the May Lyrid meteor stream. While you're out, take a close look at the Moon! Even small binoculars can spot the small greenish disk of Uranus around 5 degrees south. For an added treat, check out Saturn and asteroid Ceres at 8.7 degrees north. Keep an eye on the ecliptic plane...because even more is about to happen!

On this date in 1963, Valentina Tereshkova, aboard the Soviet spacecraft Vostok 6, became the first woman to go solo into space.

For observers of all skill levels, it's time to look at a seasonal favorite now nearly overhead—M13. This massive globular cluster is easy to locate on the western side of the Hercules "keystone," about a third of the way between the northern and southern stars Eta and Zeta. Brighter than magnitude 6, this 25,100-light-year-distant globular cluster can be seen unaided from a dark-sky location. First noted by Edmond Halley in 1714, the "Great Hercules Cluster" was cataloged by Messier on June 1, 1764. Filled with hundreds of thousands of stars, yet with only one true young blue star, M13 may be 14 billion years old. Thirty-three years ago, the Great Hercules Cluster was chosen by Arecibo Observatory as the target for the first radio message dispatched into space, yet the message won't be received for over 250 centuries. Look at it with wonder tonight...for the light you're viewing left when Earth was coming out of the Ice Age. Our early ancestors were living in caves and learning to use rudimentary tools. How evolved would our civilization be if we ever received an answer to our call?!



Figure 6.16. M13: the Great Hercules Cluster (credit—R. Jay GaBany).

Wednesday, June 17

Today we begin by celebrating the birth on this date of William Parsons in 1800. Perhaps you'd know Parsons' better as Lord Rosse. At age 27, Parsons learned how to polish metal mirrors and devoted several years to creating a 36" telescope. By the time he'd reached age 45, he had completed the 72" telescope which he had affectionately named the "Leviathan." Over 200 years have passed since Parsons' birth, and look how far astronomy has progressed!

Tonight we'll salute Lord Rosse by hunting down a cluster of galaxies southwest of Iota Draconis. To locate the field begin at a visible star (SAO 29407) about half a fist-width away. Centering on it, shift a little more than a degree due north to view the brightest galaxy in this group, NGC 5866, otherwise known as M102 (RA 15 06 29 Dec +55 45 47). Tenth magnitude M102 is both bright and large, despite its 40-million-light-year distance. This spiral is a superb example of an edge-on galaxy, even in modest-sized scopes. Mid-sized scopes should look for a faint halo surrounding a bright core region, and a dark lane bisecting the galaxy to the southeast. Large instruments will detect faint spiral arms extending outward, considerably further than expected from a spindle-shaped edge-on.

Continue north another 2 degrees and slightly east to reveal 11.5-magnitude NGC 5879 (RA 15 09 47 Dec +57 00 00), a slightly tilted spiral galaxy with wispy, curved extensions. A little more than a degree east is a very thin, but brighter, 10.4-magnitude edge-on: NGC 5907 (RA 15 15 53 Dec +56 19 43). The "Splinter" galaxy is the second brightest member of the group. Continue less than a degree due south for faint pair NGC 5905 and NGC 5908, which are barely visible to modest telescopes. In larger telescopes, 12th magnitude NGC 5908 (RA 15 16 43 Dec +55 24 32) resembles a smaller, dimmer version of its Messier (M102) counterpart. Continue about 12' due west for 12th magnitude NGC 5905 (RA 15 15 23 Dec +55 31 01). In average scopes, it will appear as a faint edge-on, but look closely if you have aperture. Its appearance is an illusion caused by a barred spiral structure!



Figure 6.17a. M102 (credit—Palomar Observatory, courtesy of Caltech).



Figure 6.17b. William "Lord Rosse" Parsons (historical image).

Thursday, June 18

Let's begin the day by recognizing the 1799 birth on this date of William Lassell, telescope maker and discoverer of Triton (a moon of Neptune), and Ariel and Umbriel (satellites of Uranus). As often happens, great astronomers share birth dates, and this time it's 187 years later for Allan Rex Sandage. A Bruce Medalist, Dr. Sandage is best known for his 1960 optical identification of a quasar, with his junior colleague, Thomas Matthews.

As the sky darkens, let's discover the wonderful world of low power. Start by re-locating the magnificent M13 and move about 3 degrees northwest. What you will find is a splendid loose open cluster of stars known as Dolidze/Dzimselejsvili (DoDz) 5, and it looks much like a miniature of the constellation of Hercules. Just slightly more than 4 degrees to its east—and just about a degree south of Eta Herculis—is DoDz 6, which contains a perfect diamond pattern and an asterism of brighter stars resembling the constellation of Sagitta.

Now we're going to move across Hercules toward Lyra. East of the "keystone," you will see a tight configuration of three stars—Omicron, Nu, and Xi. You will find DoDz 9 in line with these three, about the same distance further northeast as separates each of them. Using minimal magnification, you'll see an open cluster of around two dozen mixed magnitude stars that are quite attractive. Now look again at the keystone and identify Lambda and Delta to its south. About mid-way between them and slightly to the southeast you will discover the stellar field of DoDz 8. The last is easy; all you need to do is know the beautiful red/green double, Ras Algethi (Alpha). Move about 1 degree to the northwest to discover the star-studded open cluster DoDz 7. These great open clusters are very much off the beaten path and will add a new dimension to your large binocular or low-power telescoping experiences.



Figure 6.18a. DoDz 9 (credit—Palomar Observatory, courtesy of Caltech).



Figure 6.18b. Alan Sandage (photo by Dr. Sandage).

Friday, June 19

This morning, begin by noting the 1846 birth on this date of Italian astronomer, Antonio Abetti. Although his name might seem a bit obscure, what he studied was not—small planets, comets, and star occultations. This morning your mission is to observe one of the nicest alignments you'll see this year—the Moon, Venus, and Mars. Look for this beautiful trio on the anniversary of Abetti's birth about a half-hour before dawn!

Ready tonight for a new direction in observing? Then look no further than the tail of the Scorpion, and get ready to head south, then north. The Summer Milky Way is upon us! Let's start with a "bright star and globular cluster" view. Some of the easiest studies to find are ones residing in the same field as bright, recognizable stars. And, some the most difficult things to observe in the night sky are—you guessed it—faint studies lying near overwhelmingly bright stars! But there are compromises. . .

Less than 3' east of 3.3-magnitude σ Scorpii (the tail star of the Scorpion) is 7.4-magnitude globular cluster NGC 6441 (RA 17 50 12 Dec -37 03 03). This 38,000-light-year-distant compact cluster is about 13,000 light-years from the galactic core. It was first noted from southeastern Australia in 1826 by James Dunlop. Around 2.5 degrees northeast of σ Scorpii (and NGC 6441) is another interesting deep-sky twosome—bright open cluster M7 and faint globular NGC 6453. M7 (RA 17 53 51 Dec -34 47 34) was first recorded as a glowing region of faint stars by Ptolemy, circa 130 BC. Located 800 light-years away, the cluster includes more than half a dozen 6th magnitude stars. It is easily resolved with the least amount of optical aid, and as many as 80 stars can be seen in a small telescope. Now head northeast, and the faint haze of the 31,000-light-year-distant globular cluster NGC 6453 (RA 17 50 51 Dec -34 35 59) will reveal itself to mid- and large-sized scopes. Like NGC 6441, this globular was discovered from the Southern Hemisphere, in this case by John Herschel on June 8, 1837, while he was observing from the Cape of Good Hope in South Africa.



Figure 6.19a. M7 (credit—Burrell Schmidt/NOAO/AURA/NSF).

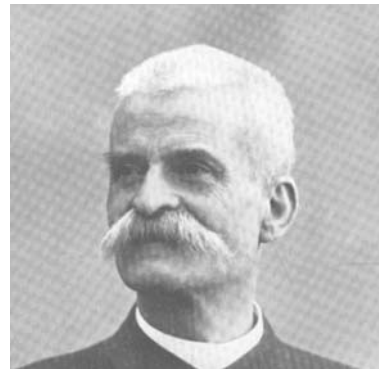


Figure 6.19b. Antonio Abetti (historical image).

Saturday, June 20

In the predawn hours, we welcome the “shooting stars” as we pass through another portion of the Ophiuchid meteor stream. The radiant for this pass lies nearer Sagittarius, and the fall rate varies from 8 to 20 per hour, but the Ophiuchids can sometimes produce more than expected! Before day breaks, enjoy the “Old Moon in the New Moon’s Arm” as it heads toward a later occultation of the Pleiades. Perhaps the sky acknowledges the 1966 passing of Georges Lemaître on this date? Lemaître researched cosmic rays and the three-body problem and in 1927 formulated the Big Bang theory using Einstein’s theories.

Tonight locate Lyra’s southernmost pair of stars—Beta and Gamma—for the Ring Nebula (RA 18 53 35 Dec +33 01 42). Discovered by Antoine Darquier in 1779, the Ring was cataloged later that year by Charles Messier as M57. In binoculars, it appears slightly larger than a star, but cannot be focused to a sharp point. Through a modest telescope, and even at low power, M57 turns into a glowing, elongated donut against a wonderful stellar backdrop. How you see the 1,400 light-year distant “King of the Rings” on any given night is highly subject to conditions. As aperture and power increase, so do details. It’s not impossible to see braiding in the nebula’s structure with scopes as small as 8” on a fine night, or to pick up the faint 13th magnitude star caught on the edge in even smaller apertures.

Like many planetary nebulae, seeing the central illuminating star is considered the ultimate in celestial viewing. This “shy friend” is a peculiar blue dwarf, which gives off a continuous spectrum and might be variable. At times, this near 15th magnitude star can be seen with ease through a 12.5” telescope, yet remains elusive to 31” in aperture a few weeks later. Can you spot faint IC 1296, which floats majestically nearby?

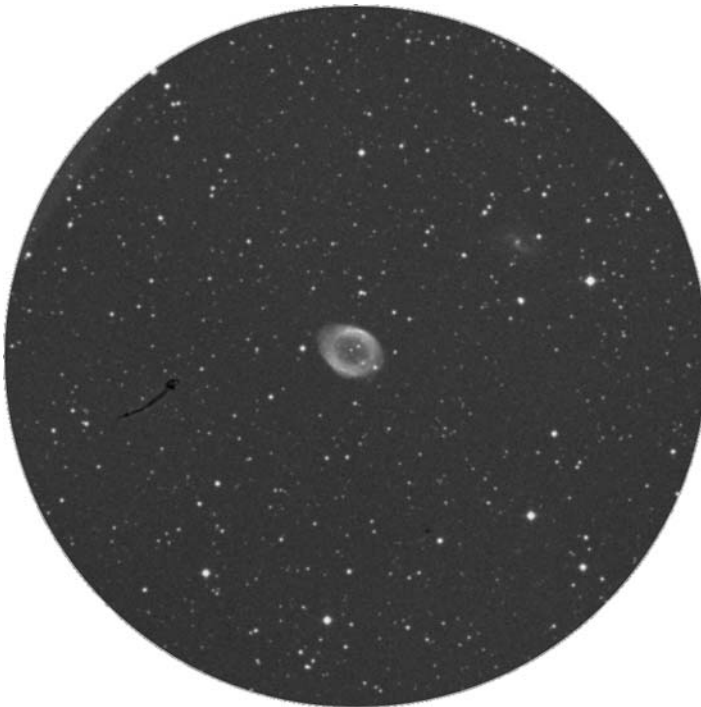


Figure 6.20a. M57 and IC 1296 (credit—Palomar Observatory, courtesy of Caltech).

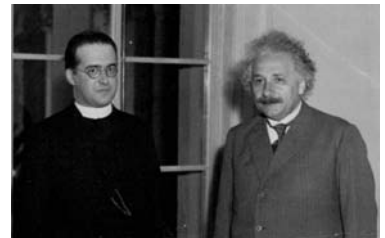


Figure 6.20b. Georges Lemaître and Albert Einstein (historical image).

Sunday, June 21

If you're out before dawn, look for Mercury a little more than 6 degrees south of the Moon. No luck spotting it? Try binoculars. Mercury is only about 3 degrees north of red Aldebaran! Summer solstice occurs today, but what exactly is it? A solstice is nothing more than an astronomical term for the moment when one hemisphere of Earth is tilted the most toward the Sun. Today, the Sun is about 24 degrees above the celestial equator—its highest point of the year. Summer solstice is also the day of the year with the longest period of daylight—and the shortest of night; this occurs around 6 months from now for the Southern Hemisphere.

Today is also the anniversary of the 1863 birth of Maximilian Franz Joseph Cornelius Wolf. Wolf used wide-field photography to study the Milky Way, and statistical treatment of star counts to prove the existence of clouds of dark matter. Wolf was one the first to prove spiral nebulae contained star-like spectra, and he introduced photography to help discover hundreds of asteroids!

Dark skies continue tonight, and so we'll continue following the great expanse of the Summer Milky Way. Our first stop will be the Butterfly Cluster—M6 (RA 17 40 20 Dec -32 15 15). About the size of the Full Moon, this scattering of 7–12th magnitude stars looks like its namesake. The “wings” of M6 are easily seen as two lobes east and west of the cluster's main body. Around 75 blue and blue-white stars are visible at low power. Want more? Head northeast a little more than 1 degree to reveal the expansive, 5.5-magnitude open cluster NGC 6383. Continue to sweep west at low power to find what might be expected as a very faint sheen of stars—9th magnitude NGC 6374. What's that? You can't find it? Then you've just learned an invaluable lesson. Some things in J.L.E. Dreyer's catalogue simply don't exist!



Figure 6.21a. M6 (credit—Nigel Sharp, Mark Hanna, REU program/NOAO/AURA/NSF).

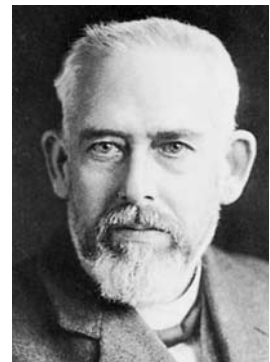


Figure 6.21b. Max Wolf (historical image).

Monday, June 22

Today we celebrate the founding of the Royal Greenwich Observatory on this date in 1675. That's 334 years of astronomy in a single location! Home to Flamsteed and Halley, the observatory was established by King Charles II to study human and sidereal time. We know it as the landmark for the Prime Meridian of Earth, and the Universal Time (UT) standard. Also on this date in history (1978), James Christy of the United States Naval Observatory in Flagstaff, Arizona, discovered Pluto's satellite Charon. Originally discovered in Gemini, Pluto is now just hours from opposition. At magnitude 13.9, the planet can just be detected in a mid-size scope, but recognizing the "God of the Underworld" is another matter. It takes very careful chart work.

Tonight let's resume our trip north from Scorpio's "tail." Starting with Antares, head east-northeast less than a fist-width to put yourself in the general location of M19. With a visual magnitude of 6.8, this bright globular cluster can be seen with small binoculars but requires a telescope to take on form. Discovered by Messier in 1764, M19 (RA 17 02 37 Dec -26 16 04) is the most oblate globular cluster known. Harlow Shapely, who studied globular clusters and cataloged their shapes, estimated that M19 has about twice as many stars along the major axis as the minor. This "stretch" is due to its proximity to the Galactic Center, a distance of only about 5,200 light-years. Very rich and dense, the cluster's faint blue tinge can be picked up by even small telescopes.

For the adventurous, there are two more. Eighth magnitude NGC 6293 (RA 17 10 10 Dec -26 34 54) is less than a finger-width east-southeast of M19 and far brighter than you might expect. Note how much more round and concentrated the core appears to be. About the same distance north-northeast of M19 is fainter NGC 6284 (RA 17 04 28 Dec -24 45 51), which is of similar apparent size but more loosely constructed.



Figure 6.22a. M19 (credit—Doug Williams, REU Program/NOAO/AURA/NSF).



Figure 6.22b. Royal Greenwich Observatory (historical image).

Tuesday, June 23

Today let's begin by learning about astronomer Otto Heckmann on the anniversary of his 1901 birth. Heckman is best known for his work in stellar position measurement and statistical mechanics, but his studies included relativity and cosmology. On his 30th birthday, he proved that the theory of general relativity could result in an open universe just as easily as a closed one. Heckmann also organized an international program to photograph and chart the positions of the stars in the Northern Hemisphere. This work became part of the third German Astronomical Society catalog.

This evening, we'll return to Scorpio from Ophiuchus and locate three globular cluster studies. M4 (RA 16 23 35 Dec -26 31 31), located 1 degree west of Alpha (Antares). Antares is one of the most easily located of all globular clusters and provides a fine view with binoculars or scopes. First noted by Philippe Loys de Chéseaux in 1746, M4 is one of the nearest globulars, at some 7,200 light-years away. At magnitude 5.9, it approaches unaided visibility. This misty-looking globular improves with both aperture and magnification, revealing a chain of 11th and 12th magnitude stars across the cluster's core.

Less than a degree east-northeast of M4 is large and faint NGC 6144 (RA 16 27 14 Dec -26 01 29). Because of its position in the same low power field with Antares, it's a 9.1-magnitude, low-surface-brightness challenge! A challenge of a different type is M80 (RA 16 17 02 Dec -22 58 30), one of the most densely packed globular clusters in the Milky Way. Located about halfway between Antares and Beta Scorpii, this 33,000-light-year-distant cluster resists resolution. Although it was originally discovered by Charles Messier in 1781, William Herschel was the first to resolve it into individual stars. And with the right scope and conditions, so can you!



Figure 6.23a. M4 (credit—KPNO 0.9-meter telescope, NOAO, AURA, NSF).



Figure 6.23b. Otto Heckmann (archival image).

Wednesday, June 24

Today we begin by honoring the 1915 birth of Sir Fred Hoyle, champion of the steady-state theory of the universe. In 1950 Hoyle became a British icon as he expounded his theory on the broadcast *The Nature of the Universe*. Hoyle never accepted the now-popular Big Bang theory.

On that same date Sir William Herschel was busy at the eyepiece. After 2 months of incredible galaxy research, the master himself had located an open cluster that would survive the years as one of the sky's greatest mysteries. Although it will be a while before it reaches prime position, let's go have a look about 3 degrees west of Gamma Sagittarius at NGC 6451 (RA 17 50 42 Dec -30 13 00). Cataloged on this night in 1784 as H VI.13, and a member of the "400" list, sky-savvy observers may know this 8th magnitude stellar collection as the "Tom Thumb cluster." For a great many years, NGC 6451 was considered to be the second oldest galactic cluster, but Strömgren's photometry changed all that. After careful research, scientists proved that not only did it contain a chemically peculiar star, but there was also a wide discrepancy in interstellar reddening values as well. With the realization that it contains an A2-type, and that some of the readings were taken originally from a foreground star, its status was changed.

Regardless of the true age of and distance to this open cluster, I'm sure even smaller optics can appreciate this round, loose collection of stars set in the magnificent backdrop of one of our galaxy's spiral arms. For those brave observers who stayed out late to view? Take the time to drop about a half-degree south and pick up a 33 Doubles challenge—Stone 37. This 1,250-light-year-distant study is an easy split for most optics, and the 6.7-magnitude primary white shows a nice color contrast with the 8.2-magnitude pale blue secondary.



Figure 6.24a. NGC 6451 (credit—Palomar Observatory, courtesy of Caltech).

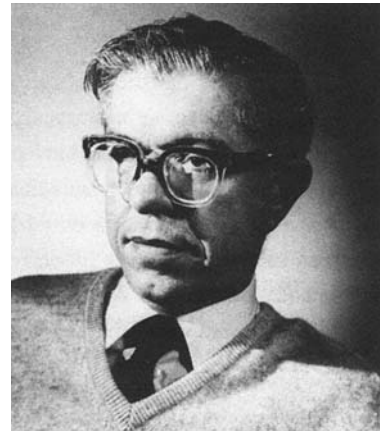


Figure 6.24b. Sir Fred Hoyle (archival image).

Thursday, June 25

Today celebrates the birth of Hermann Oberth. Born in 1894 on this date, Oberth is considered to be the father of modern rocketry and space travel. But you won't need a rocket to travel skyward as we celebrate tonight's da Vinci Moon. No special equipment is needed to see this event, and thanks to Leonardo da Vinci, we can see the ghostly effect on the Moon as quite logical. He was the first to theorize that sunlight was reflecting off Earth and illuminating the portion of the Moon not lit by the Sun. We more commonly refer to this as "Earthshine." But no matter what scientific explanation is given for this phenomenon, it remains beautiful.

While you're out tonight, take a look at the skies for a cirlet of seven stars that reside about halfway between orange Arcturus and brilliant blue-white Vega. This quiet constellation is named Corona Borealis, or the Northern Crown. Just northwest of its brightest star is a huge concentration of over 400 galaxies that reside over a billion light-years away from us. Known as Abell 4065, the Corona Borealis Galaxy Cluster is an area so small in apparent size that from our point of view we could cover it with our thumbnails held at arm's length!



Figure 6.25a. Abell 4065: the Corona Borealis Galaxy Cluster (credit—Palomar Observatory, courtesy of Caltech).

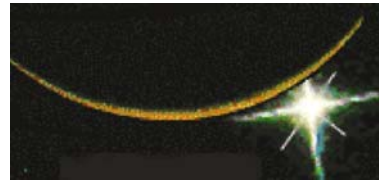


Figure 6.25b. Crescent effect (credit—NASA).

Friday, June 26

Happy Birthday, Charles Messier! Born in 1730 on this date, almost everyone recognizes the name of this French astronomer who discovered 15 comets. He was the first to compile a systematic catalog—the “M objects.” The Messier Catalogue (1784) contains 103 star clusters, nebulae, and galaxies. But did you know Lyman Spitzer, Jr, shared this birthday? Born in 1914, Spitzer advanced our knowledge of physical processes in interstellar space and pioneered efforts to harness nuclear fusion as a clean energy source. He studied star-forming regions and suggested that the brightest stars in spiral galaxies formed recently. Not only that, but Spitzer was the first person to propose placing a large telescope in space, and so launched the development of the Hubble Space Telescope!

Tonight the mighty Regulus will be very close to the Moon, providing a wonderful opportunity for stargazers. Why not grab a telescope and view the lunar surface for a couple of telescopic challenges that are easy to catch? All you have to know is Mare Crisium! On the southeastern shoreline is a peninsula that reaches into Crisium’s dark basin. This is Promontorium Agarum. On the western shore, bright Proclus lights the banks, but look into the interior for the two dark pockmarks of Pierce to the north and Picard to the south. Be sure to mark them on your notes!

When you’re finished, point your binoculars or telescopes back toward Corona Borealis and about three finger-widths northwest of Alpha for variable star R (RA 15 48 35 Dec +28 09 24). This star is a total enigma. Discovered in 1795, most of the time R carries a magnitude near 6 but can drop to magnitude 14 in a matter of weeks—only to unexpectedly brighten again! It is believed that R emits a carbon cloud, which blocks its light. Oddly enough, scientists can’t even accurately determine the distance to this star! When studied at minimum, the light curve resembles a “reverse nova” and has a peculiar spectrum. It is very possible that this ancient Population II star has used all of its hydrogen fuel and is now fusing helium to form carbon.



Figure 6.26a. Mare Crisium (credit—Greg Konkel).



Figure 6.26b. Lyman Spitzer (credit—courtesy of hubblesite.org).

Saturday, June 27

Tonight we'll again honor the June 26 birth of Charles Messier by heading toward the lunar surface first, in order to pick off another study object on our list—the twin crater pair Messier and Messier A.

Located in Mare Fecunditatis about a third of its width from west to east, these two craters will be difficult to find in binoculars, but not hard for even a small telescope and intermediate power. Indeed named for the famed French astronomer, the easternmost crater is somewhat oval in shape, with dimensions of 9 by 11 kilometers. At high power, Messier A to the west appears to have overlapped a smaller crater during its formation, and it is slightly larger at 11 by 13 kilometers. Although it is not on the challenge list, you'll find another point of interest to the northwest. Rima Messier is a long surface crack, which runs diagonally across Mare Fecunditatis's northwestern flank and reaches a length of 100 kilometers.

For variable star fans, let's return to and focus our attention on S Coronae Borealis, located just west of Theta and the westernmost star in the constellation's arc formation (RA 15 21 23 Dec +31 22 02). At magnitude 5.3, this long-term variable takes almost a year to go through its changes—usually far outshining the 7th magnitude star to its northeast—but will drop to a barely visible magnitude 14 at minimum. Compare it to the eclipsing binary U Coronae Borealis about a degree northwest. In slightly over 3 days, this Algol-type will range by a full magnitude as its companions draw together.



Figure 6.27a. Mare Fecunditatis and Messier/Messier A (credit—Greg Konkel).



Figure 6.27b. S Coronae Borealis (credit—Palomar Observatory, courtesy of Caltech).

Sunday, June 28

As we head out into the night, let's observe a moment of silence to remember the 1889 passing on this date of Maria Mitchell, the first professional woman astronomer. While pursuing amateur astronomy, she gained fame from her October 1, 1947, observation of a comet, about which she was the first to report. Mitchell was also the first female member of the American Academy of Arts and Sciences. Said Mitchell, "The eye that directs a needle in the delicate meshes of embroidery will equally well bisect a star with the spider web of the micrometer."

Tonight let's honor Mitchell by locating the lunar crater named in her honor. Begin by visiting the northeast quadrant of the Moon and identify crater Aristoteles. On its eastern edge, you'll find Mitchell. Measuring only 30 kilometers in diameter, it is dwarfed by Aristoteles' 87-kilometer diameter, but Maria Mitchell was never dwarfed in life!

To further honor Mitchell, let's have a look at the 250-light-year-distant silicon star Iota Librae (RA 15 12 13 Dec -19 47 28). This is a challenge for binoculars, but not because the components are so close. In Iota's case, the near 5th magnitude primary simply overshadows its 9th magnitude companion! In 1782, Sir William Herschel measured them and determined they were a true physical pair. Yet, in 1940 Librae A was determined to have an equal-magnitude companion only 0.2" away...and the secondary was proved to have a companion of its own, which echoes the primary. A four-star system!



Figure 6.28a. Aristoteles and Mitchell (credit—Wes Higgins).



Figure 6.28b. Iota Librae (credit—Palomar Observatory, courtesy of Caltech).

Monday, June 29

Today we celebrate the birthday of George Ellery Hale, who was born in 1868 on this date. Hale was the founding father of the Mt. Wilson Observatory. Although he had no education beyond his Baccalaureate in physics, Hale became the leading astronomer of his days. He invented the spectroheliograph, coined the word astrophysics, and founded both the *Astrophysical Journal* and Yerkes Observatory. At the time, Mt. Wilson dominated the world of astronomy, confirming the nature of galaxies and verifying the expanding-universe cosmology—and thereby making Mt. Wilson one of the most productive facilities ever built. When Hale went on to found Palomar Observatory, the 5-meter (200") telescope was named for him and was dedicated on June 3, 1948. Palomar continues to be the largest telescope in the continental United States.

If you observe the Moon tonight, be sure to note both Gemma Frisius and Maurolycus on your Lunar Challenge list. While at Gemma Frisius, let's look for a little more off-the-beaten-path crater about halfway toward Catharina. Under tonight's lighting, and at low power, you'll see it first as a sunken oval, but power up and let's explore Sacrobosco. Named for the English mathematician "John of Hollywood" (Johannes Sacroboschus), this Class III crater spans 98 kilometers and drops down to a floor level of 2,800 meters—making those crater walls about as high as the West Ridge of Mt. Everest. On its troubled floor you will see the evidence of three far newer impacts: Crater C to the north, which spans 13 kilometers and drops down 2,630 meters; Crater A to the west, which is 18 kilometers in diameter and 1,830 meters deep; and Crater B to the east, at 15 kilometers wide and 1,210 meters deep. Although these strikes are fascinating. . . look again. Sacrobosco itself is imprinted over the top of a far older crater!



Figure 6.29a. Sacrobosco (credit—Wes Higgins).



Figure 6.29b.
Credit—George Ellery Hale (widely used public image).

Tuesday, June 30

Keep watch tonight for the June Draconids. The radiant for this meteor shower will be near the handle of Big Dipper—Ursa Major. The fall rate varies from 10 to 100 per hour, and lack of lunacy in the early morning hours makes this a great time for the offspring of comet Pons-Winnecke. On a curious note, on this date in 1908 was when the great Tunguska impact happened in Siberia. Was it a fragment of a comet or an asteroid, perhaps?

This date in 1973, a group of British, French, and American scientists aboard the French prototype Concorde 001 supersonic aircraft set a total solar eclipse viewing record. The eclipse itself was predicted to be the longest for the next 1,000 years, its shadow traveling across the path of totality at a rate of 3,000 kilometer per hour. But onboard, the jet's speed made it possible to get a continuous view of totality for 74 minutes, 10 times longer than could be seen by an observer on the ground! Lucky birds. . .

As you head out tonight, check out the beautiful visage of Spica just a few degrees away from tonight's Moon! Our Lunar Challenge feature for this evening is prominent enough to be spotted in binoculars, but well worth the time to power up with the telescope and explore. Starting with the recognizable slash of the Alpine Valley, follow the mountain trail south to the double strike of crater Cassini. Named for Giovanni Cassini, this smashing old Class V crater rises above the lunar topography by 1,067 meters, making its shallow walls alone as tall as the Catskill Mountains. It covers about 57 kilometers of lunar landscape in diameter, and the crater floor is 1,240 kilometers below the surface. At one time Cassini may very well have had a central peak, but something quite took care of that when it formed Cassini A. This double-stepped feature is 57 kilometers in diameter and drops down an additional 2,830 meters. Although both Cassini and Cassini A are Lunar Club Challenges, look carefully for yet another interior crater. Small Crater B is often referred to as the "Washbowl" for its almost perfect concave structure.



Figure 6.30a. The Diamond Ring at totality (credit—Terry Mann).



Figure 6.30b. Cassini and Cassini A (credit—Wes Higgins).

CHAPTER SEVEN



Wednesday, July 1

On this date in 2004, the Cassini mission (a joint effort of NASA/ESA/ASI) became the first spacecraft to orbit Saturn. In 1917, astronomers at Mt. Wilson were celebrating as their 100" primary mirror arrived, though it didn't see "first light" until 5 months later! Start your stargazing evening off right by having a look at the Moon's wasted Southern Highland area. Familiarize yourself with the many craters, and we'll return in the months ahead to identify them!

Now turn binoculars or telescopes toward magnitude 2.7 Alpha Librae, the second brightest star in the celestial "Scales." Its proper name is Zuben El Genubi, and, as *Star Wars* as that sounds, the "Southern Claw" is actually quite close to home at a distance of only 65 light-years. No matter what size optics you are using, you'll easily see Alpha's widely spaced 5th magnitude companion, which shares the same proper motion. Alpha itself is a spectroscopic binary, as was verified during an occultation event, and its inseparable companion is only a half-magnitude dimmer according to the light curves. Enjoy this easy pair tonight!

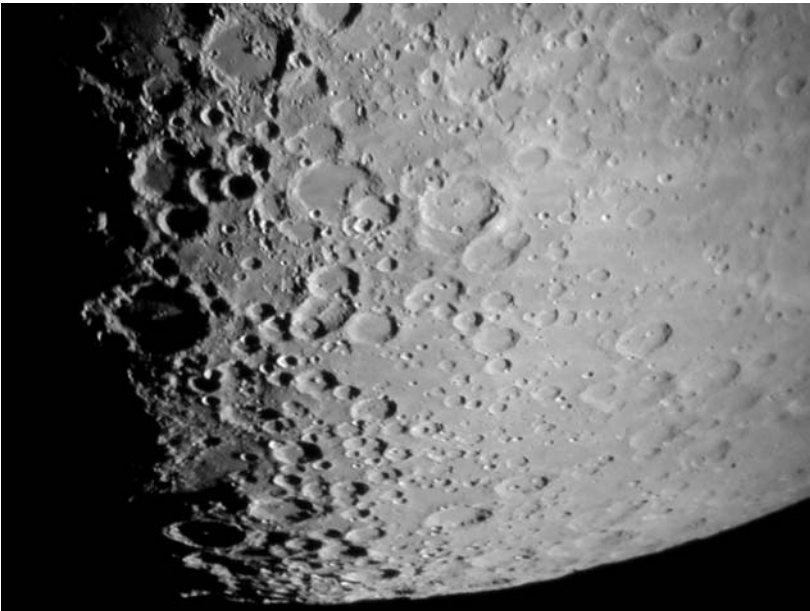


Figure 7.1a. Southern Highlands (credit—Greg Konkel).



Figure 7.1b. Alpha Librae (credit—Palomar Observatory, courtesy of Caltech).

Thursday, July 2

This date marks the 1820 passing of British optician Peter Dollond, inventor of the triple achromatic lens. Dollond's improvements to the refracting telescope included placing convex lenses of crown glass on either side of a biconcave flint glass lens to make the achromatic triplet lens we know today!

Tonight, turn your telescope toward the northeast shore of Mare Cognitum and the Apollo 14 mission landing site, Fra Mauro. As craters go, 3.9-billion-year-old Fra Mauro is on the shallow side and spans 95 kilometers. At some 730 meters deep, standing at one of its walls would be like standing at the bottom of the Grand Canyon. Yet time has so eroded this crater that its west wall is completely missing, and its floor is covered with fissures.

Even though ruined Fra Mauro seemed like a foreboding place to land a manned mission, it remained high on the priority list because it is geologically rich. Ill-fated Apollo 13 was to land in a formation north of this crater, which was formed by ejecta belonging to the Imbrium Basin—material that had already been mapped telescopically. By returning samples of this material from deep within the Moon's crust, scientists could then determine the exact time these changes came about. As you view Fra Mauro tonight, picture yourself in a lunar rover traversing this barren and rock-strewn landscape, with the material around you thrown out from a long-ago impact. How willing would you be to travel to another world?

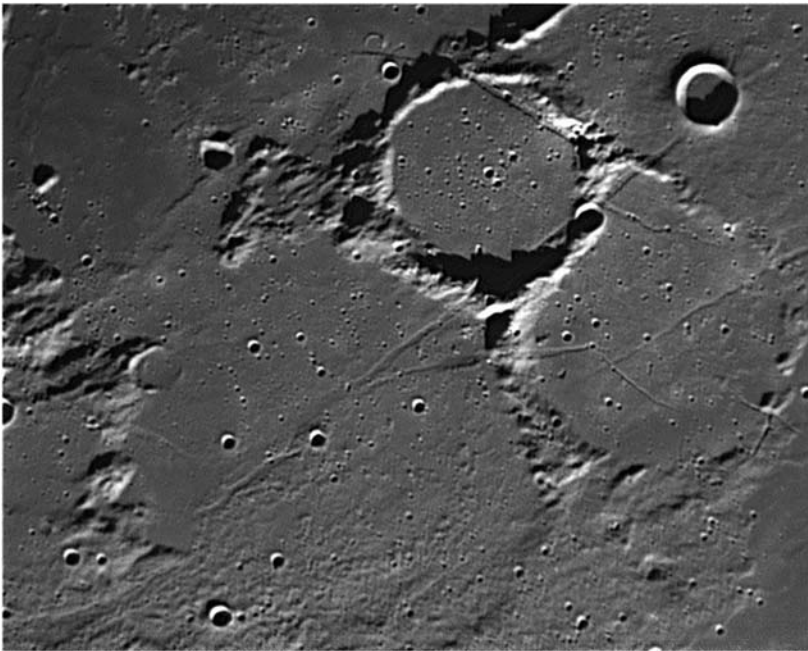


Figure 7.2a. Fra Mauro (credit—Greg Konkel).



Figure 7.2b. Peter Dollond (historical image).

Friday, July 3

Tonight let's venture toward the south shore of Palus Epidemiarum to have a high-power look at crater Capuanus. Named for Italian astronomer Francesco Capuano di Manfredonia, this 60-kilometer-wide crater boasts a still tall southwest wall, but the northeast one was destroyed by lava flow. At its highest, it reaches around 1,900 meters above the lunar surface, yet drops to no more than 300 meters at the lowest. Look for several strikes along the crater walls as well as more evidence of a strong geological history. To the north is the Hesiodus Rima, a huge fault line that extends 300 kilometers across the surface!

When you're done, why not have a look at 156-light-year-distant Mu Serpentis (RA 15 49 37 Dec -03 25 48)? Its name is *Leiolepis*, which means "smooth scaled." Perhaps a fitting name, because this normal A-type main sequence star is also known as the head of the serpent. Have a look in binoculars, and you'll note several optical companions. Or use a telescope to locate delicate binary Struve 1985 (RA 15 56 01 Dec -02 11 00) nearby!

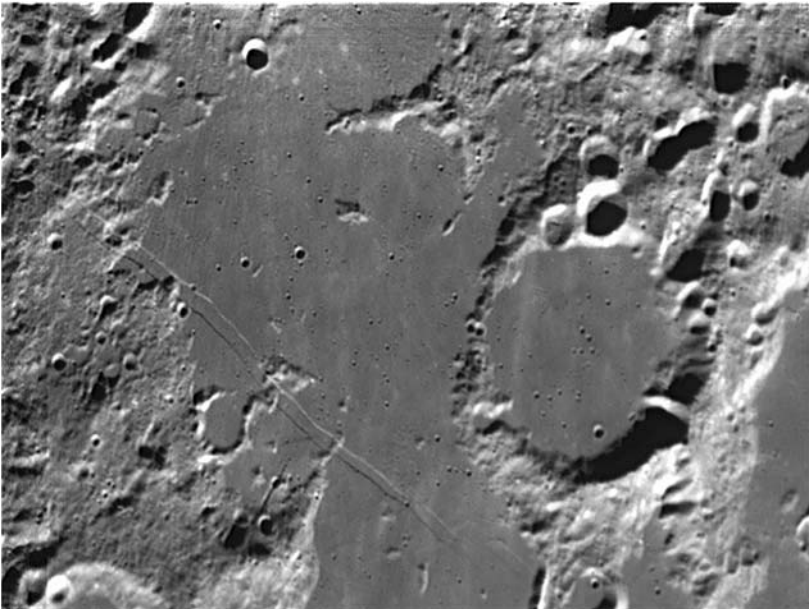


Figure 7.3a. Capuanus (credit—Wes Higgins).



Figure 7.3b. Mu Serpentis (credit—Palomar Observatory, courtesy of Caltech).

Saturday, July 4

Look closely at the Moon. For some lucky viewers, it's about to occult Antares! Check International Occultation and Timing Association (IOTA) for times and locations.

Also be sure to look for the "Cow Jumping over the Moon," but power up with a telescope to study some very wild looking features—lunar lava domes. North of Aristarchus, west of Promontorium Heraclides, and near the terminator is Rumker—the largest of the lava domes. Only visible when near the terminator, this roughly 77-kilometer-diameter "soft hill" ranges anywhere from 60 to 760 meters tall. Although it is not much more than a bump on the lunar surface, it does contain a few summit craters at its highest points. What we are looking at is really an important part of the geology that shaped the Moon's surface. In all likelihood, Rumker is a shield volcano. . . in an area of many! Now continue east toward the prominent crater Marian, set in a bright peninsula extending into Sinus Roris and Mare Imbrium. Just southwest are two more—Mons Gruithuisen Gamma (the "Megadome") and Mons Gruithuisen Delta. Although you might not find these features particularly impressive, consider that we're looking at something only 20 kilometers wide and only a few meters high!

Tonight we honor American astronomer Henrietta Swan Leavitt, the discoverer of the relationship between period and luminosity in Cepheid variables. This led to understanding the distance to the galaxies! Said Leavitt, "Since the variables are probably nearly the same distance from Earth, their periods are apparently associated with their actual emission of light, as determined by their mass, density, and surface brightness."

Do her memory honor and check out Delta Cephei (RA 22 29 10 Dec +58 24 54) tonight! Thirty to forty times more massive than our own Sun, Delta varies from magnitude 3.6–4.3 in just slightly over 5 days. And look for its companion star as well.



Figure 7.4a. Marian and the Megadome (credit—Wes Higgins).



Figure 7.4b. Delta Cephei (credit—Palomar Observatory, courtesy of Caltech).

Sunday, July 5

Tonight let's go deep south and have look at an area that once held something almost half as bright as tonight's Moon and over four times brighter than Venus. Only one thing could light up the skies like that—a supernova.

According to historical records from Europe, China, Egypt, Arabia, and Japan, 1,003 years ago the very first supernova event was noted. Appearing in the constellation of Lupus, it was at first believed to be a comet by the Egyptians, yet the Arabs saw it as an illuminating "star." Located less than a finger-width northeast of Beta Lupi (RA 15 02 48 Dec -41 54 42) and half a degree east of Kappa Centaurus, no visible trace is left of a once-grand event that spanned 5 months of observation, beginning in May and lasting until it dropped below the horizon in September 1006. It is believed that most of the star was converted to energy, and very little mass remains. In the area, a 17th magnitude star that shows a tiny gas ring and radio source 1459-41 remains our best candidate for pinpointing this incredible event.

Why you're at it, try a challenging double star—Upsilon Librae (RA 15 37 01 Dec -28 08 06). This beautiful red star is right at the limit for a small telescope, but quite worthy, as the pair is a widely disparate double. Look for the 11.5-magnitude companion to the south in a very nice field of stars!



Figure 7.5a. Field of SN 1006 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.5b. Upsilon Librae (credit—Palomar Observatory, courtesy of Caltech).

Monday, July 6

Now that the Moon has passed it by, tonight let's really go look at Antares. Like many red giants, the 520-light-year-distant Antares A is a variable, having a cycle of about 5.8 years. Such a cycle occurs because Antares' photosphere alternately swells and cools, then shrinks and warms. Driving this cycle are events deep within the star itself. As Antares' nuclear fuel waxes and wanes—delivering more, then less food to feed its enlarged form—a tug-of-war between radiation and gravity occurs within it. Think of a red giant as a “star within a star.” Antares' massive core and mantle is actually a fiercely radiant blue-white star surrounded by an expansive shroud of diffuse hydrogen and helium gas. This shroud is so large that it could engulf all our Solar System's inner planets plus the Asteroid Belt.

Ready for real challenge? Then take on one of the toughest, and most beautiful, doubles in the night sky—Antares itself. The “Rival of Mars” may be sufficiently dimmed by Moonglow to try to spot its 5.4-magnitude green companion. Like winter's Sirius, the Antares pair needs especially still—but not necessarily dark—skies. It also requires a well-chosen magnification, one high enough to separate the two close stars (2.9”) but low enough to concentrate the fainter star's (magnitude 5.4) light. Good luck!

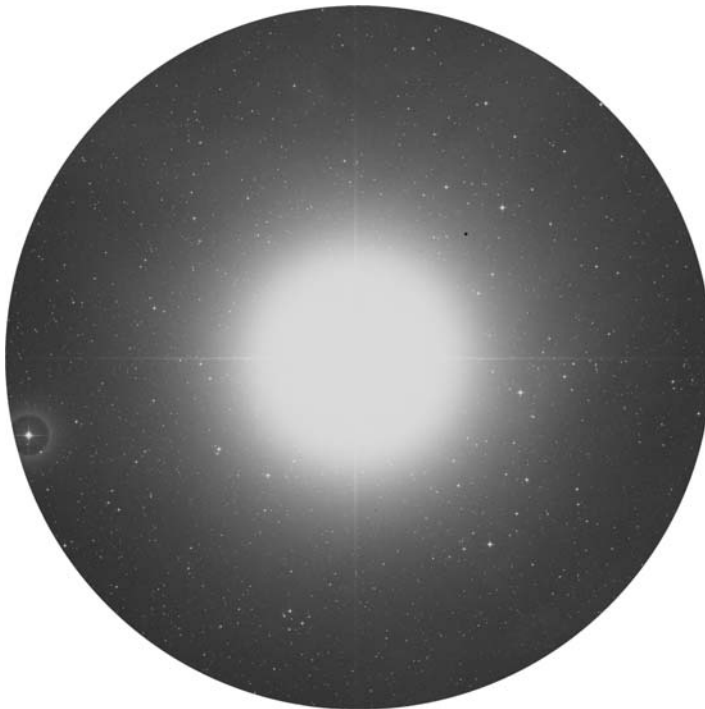


Figure 7.6. Antares (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, July 7

During July, something strange is happening in the woods. . . deer sprout antlers. Due to this natural phenomenon, tonight's Full Moon is sometimes referred to as the "Buck Moon." For some of us, however, the month of July also brings fearsome storms, and Luna is also referred to as the "Thunder Moon." In more agricultural regions it's the "Hay Moon." Among coast dwellers, this is the "Sturgeon Moon"—a name given by ancient fishers whose best catches occurred during this month. Elsewhere it has been called the "Red Moon," because hazy heat rising from Earth's surface at low angles gives the Moon color as it rises. This month's Moon is also the "Grain Moon," or for scholars, the "Green Corn Moon." For viewers in western Australia, it will be a penumbral eclipsing Full Moon as it rises in the evening and in the eastern Americas as it sets this morning. Although penumbral eclipses aren't as exciting as totals, it's still a great opportunity to watch the subtle and unusual shadings! Do it to honor the 1476 date of astronomer Regiomontanus's death. Regiomontanus also observed several eclipses of the Moon, and his interest in its motion led him to make the important observation that the method of measuring lunar distances could be used to also determine longitude at sea.

While you're out try your hand at a super challenging double—Mu Librae (RA 14 49 19 Dec -14 08 56). This pair is only a magnitude apart in brightness and right at the limit for a small telescope. Up the power slowly, and look for the companion just to the southwest of the primary. Good luck, and mark your observation because Mu's blues are on many observing lists!



Figure 7.7a. Lunar eclipse (credit—NASA).



Figure 7.7b. Mu Librae (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, July 8

Tonight as the Moon forecasts its brilliant rise to the south-southeast, let's have a look at 400-light-year-distant Rasalgethi—Alpha Herculis (RA 17 14 38 Dec +14 23 25). Known as the "Head of the Kneeling One," it's an easily resolved double and is noted for its fine color contrast. At magnitude 3.5, the variable bright primary is one of the largest known stars, with a diameter four times the Earth–Sun distance. Rasalgethi's photospheric temperature is so low (3,000 Kelvin) that it barely glows a warm reddish orange. Meanwhile, its 5.4-magnitude companion is a yellow giant with a temperature twice the primary. The two together make Rasalgethi A seem a deeper red, while Rasalgethi B takes on a lovely yellow-green hue.

Tonight let's use a bright feature on the Moon to help us locate something very cool on the lunar surface. Start by identifying unmistakable Tycho to the south. Northeast of Tycho you will see a bright ray running toward Mare Serenitatis and the equally bright spot of Cassini. If you trace the great double ray northwest, you will see the fainter branch extend all the way to Bullialdus and its central peak!



Figure 7.8a. Alpha Herculis (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.8b. Lunar rays (credit—NASA).

Thursday, July 9

On this date in 1979, Voyager 2 quietly made its closest approach to Jupiter. How about if we take a close approach before dawn as well? Enjoy the waltz of the Galileans and all the fine details. . .but look closely. Does there appear to be a “guest” in the field? Neptune is only about half a degree north!

Tonight we will hustle off before Moonrise to explore a single small globular—M80 (RA 16 17 02 Dec -22 58 30). Located about 4 degrees northwest of Antares (about two finger-widths), this little globular cluster is a powerpunch. Located in a region heavily obscured by dark dust, M80 will shine like an unresolvable star to small binoculars, but reveal itself to be one of the most heavily concentrated globulars in the telescope. Discovered within days of each other by Messier and Méchain, respectively, in 1781, this intense Class I globular cluster is around 36,000 light-years distant. In 1860, M80 became the first globular cluster that was known to host a nova. As stunned scientists watched, a centrally located star brightened to magnitude 7 over a period of days, becoming known as T Scorpii. The event then dimmed more rapidly than expected, making observers wonder exactly what they had seen. Since most globular clusters’ stars are all about the same age, the hypothesis was put forward that perhaps they had witnessed an actual collision of stellar members. Given that the cluster contains more than a million stars, the probability is that some 2,700 collisions of this type may have occurred during M80’s lifetime.



Figure 7.9a. M80 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.9b. Jupiter (credit—Wes Higgins).

Friday, July 10

If you're out when the Moon rises, look for the asteroid Psyche nearly brushing the limb 0.2 degrees north. You'll find the pairing of Jupiter and Neptune about a degree and a half apart and a little more than a finger-width south!

Today we celebrate the 1832 birth on this date of Alvan Graham Clark. An astronomer himself, Clark was also a member of a famous American family of telescope makers. He helped to create the largest refractor in the world—the lenses for the 40" Yerkes Telescope. Perhaps the stress of worrying for their safety took its toll on Alvan, for he died shortly after their first use.

Before the Moon rises tonight, let's honor Clark's work by studying a globular cluster suitable for all optics, M4. All you have to know is Antares! Just slightly more than a degree west (RA 16 23 35 Dec -26 31 31), this major 5th magnitude Class IX globular cluster can even be spotted unaided from a dark location. In 1746 Philippe Loys de Chéseaux happened upon this 7,200-light-year-distant beauty, one of the nearest to us. It was also included in Lacaille's catalog as object I.9 and in Messier's in 1764. Much to Charles's credit, he was the first to resolve it!

As one of the loosest, or most "open," globular clusters, M4 would be tremendous if we were not looking at it through a heavy cloud of interstellar dust. To binoculars, it is easy to pick out a very round, diffuse patch, yet it will begin to resolve with even a small telescope. Large telescopes will also easily see a central "bar" of stellar concentration across M4's core region, which was first noted by Herschel. As an object of scientific study, in 1987, the first millisecond pulsar was discovered within M4, which turned out to be ten times faster than the Crab Nebula pulsar. Photographed by the Hubble Space Telescope in 1995, M4 was found to contain white dwarf stars—the oldest in our galaxy—with a planet orbiting one of them! A little more than twice the size of Jupiter, this planet is believed to be as old as the cluster itself. At 13 billion years, it would be three times the age of the Solar System!



Figure 7.10a. M4 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.10b. Alvan Clark with Yerkes objective (historical image).

Saturday, July 11

Today marks the 1732 birth on this date of Joseph Jérôme Le Français de Lalande, who determined the Moon's parallax and published a comprehensive star catalog in 1801.

Tonight let's head on out toward two more giants that appear differently from the rest (and each other)—same-field binocular pair M10 and M12. Located about half a fist-width west of Beta Ophiuchi, M12 (RA 16 47 14 Dec -01 56 52) is the northern most of this pair. Easily seen as two hazy round spots in binoculars, let's go to the telescope to find out what makes M12 tick. Since this large globular is much more loosely concentrated, smaller scopes will begin to resolve individual stars from this 24,000-light-year-distant Class IX cluster. Note that there is a slight concentration toward the core region, but for the most part the cluster appears fairly even. Large instruments will resolve out individual chains and knots of stars.

Now let's drop about 3.5 degrees southeast and check out Class VII M10 (RA 16 57 08 Dec -04 05 57). What a difference in structure! Although they seem to be close together and similar in size, the pair is actually separated by some 2,000 light-years. M10 is a much more concentrated globular, showing a brighter core region to even the most modest of instruments. This compression of stars is what differentiates one type of globular cluster from another and is the basis of their classification. M10 appears brighter, not because of this compression but because it is about 2,000 light-years closer than M12.



Figure 7.11a. M12 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.11b. M10 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, July 12

Today marks the 1682 passing of Jean Picard. No, not he of *Star Trek* fame but the Jesuit astronomer who created a movable-wire micrometer to measure the diameters of celestial objects such as the Sun, Moon, and planets!

For hard-core observers, tonight's globular cluster study will require at least a mid-aperture telescope, because we're staying up a bit later to go for a same-low-power-field pair—NGC 6522 (RA 18 03 34 Dec -30 02 02) and NGC 6528 (RA 18 04 49 Dec -30 03 20). You will find them easily at low power just a breath northwest of Gamma Sagittarii, better known as Al Nasl, the tip of the "teapot's" spout. Once located, switch to higher power to keep the light of Gamma out of the field, and let's do some study. The brighter, and slightly larger, of the pair to the northeast is Class VI NGC 6522. Note its level of concentration compared to the Class V NGC 6528. Both are located around 2,000 light-years away from the galactic center and are seen through a very special area of the sky known as "Baade's Window"—one of the few areas toward our galaxy's core region not obscured by dark dust. Although each is similar in concentration, distance, etc., NGC 6522 has a slight amount of resolution toward its edges, while NGC 6528 appears more random.

Although both NGC 6522 and NGC 6528 were discovered by Herschel on July 24, 1784, and both are the same distance from the galactic core, they are very different. NGC 6522 has an intermediate metallicity. At its core, the red giants have been depleted, or stripped tidally by evolving into blue stragglers. It is possible that core collapse has already occurred. NGC 6528, however, contains one of the highest metal contents of any known globular cluster collected in its bulging core!

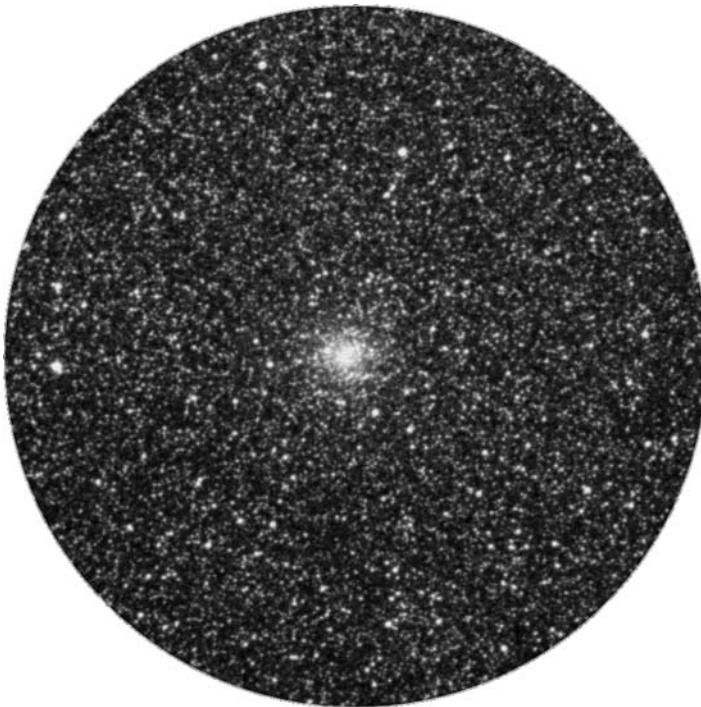


Figure 7.12a. NGC 6522 (credit—Palomar Observatory, courtesy of Caltech).

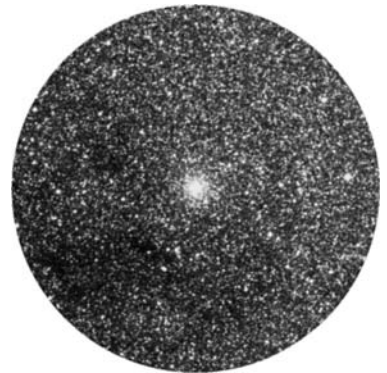


Figure 7.12b. NGC 6528 (credit—Palomar Observatory, courtesy of Caltech).

Monday, July 13

Today celebrate the 1924 birth of Donald E. Osterbrock, a leading authority on the history of astronomy. Osterbrock was the director of Lick Observatory, and among his many achievements was the discovery of new types of active galactic nuclei, which are powered by black holes in the centers of galaxies!

Tonight for all observers, let's take a closer look at the fascinating constellation of Lupus, southwest of brilliant Antares. Although more northerly latitudes will see only roughly half of this constellation, it sits well at this time of year for those in the south. So why bother? Cutting through our Milky Way galaxy at a rough angle of about 18 degrees is a disk-shaped zoned called Gould's Belt. Lupus is part of this area, whose perimeter contains star-forming regions that came to life about 30 million years ago, when a huge molecular cloud of dust and gas compressed, much like in the Orion area. But what about its gamma rays?

Although little is known about gamma rays bursts, we do know they occur about once a day with the photon energy of 100 million electric volts. Though some are attributed to our own Milky Way, most are now known to be extra-galactic—and over 800 were once charted on a single map! One such source of gamma rays is a special type of star known as a Wolf-Rayet, a hot, huge star that is undergoing significant mass loss and exposing its central core. Tonight for more southern viewers, take the time to look up at one such incredible system, IC 4406. You'll find it about 5 degrees northwest of Alpha Lupi, or just about a finger-width northwest of the Tau collection (RA 14 22 26 Dec -44 09 04). This roughly 10th magnitude planetary nebula is sometimes referred to as the "Retina Nebula" for its photographic resemblance to the human retina. The squarish patch is a Wolf-Rayet nebula, and color photographs show green sparkles as evidence of gamma rays!



Figure 7.13a. IC 4406 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.13b. Donald E. Osterbrock (historical image).

Tuesday, July 14

On this date in 1965, Mariner 4 sent back its first close-up photo of the planet Mars. If you're up before sunrise this morning, try taking a look at Mars yourself!

Tonight return to Lupus and discover Theta, about a fist-width south-southwest of the mighty Antares (RA 16 06 35 Dec -36 48 08). Although this rather ordinary looking 4th magnitude star appears to be nothing special, there's a lesson to be learned here. So often in our quest to look at the bright and incredible—the distant and impressive—we often forget about the beauty of a single star. When you take the time to seek the path less traveled, you just might find more than you expected. Hiding behind a veil of "ordinariness" is a trio of three spectral types and three magnitudes in a diamond-dust field. An undiscovered gem. . .

Now shift 5 degrees west for NGC 5986 (RA 15 46 03 Dec -37 47 10), a 7th magnitude globular cluster that can be spotted with binoculars as long as good conditions prevail. Although this Class VII cluster is not particularly dense, many of its individual stars can be resolved in a small telescope. Sweep the area north of NGC 5986 (RA 17 57 06 Dec -37 05 00) and write down what you see. That's right! Nothing. This is dark nebula B 288—a cloud of dark, obscuring dust that blocks incoming starlight. Look carefully at the stars you *can* see, and you'll notice they appear quite red. Thanks to B 288, much of their emitted light is absorbed by this region, providing us with a pretty incredible on-the-edge view of something you can't see—a Barnard dark nebula.

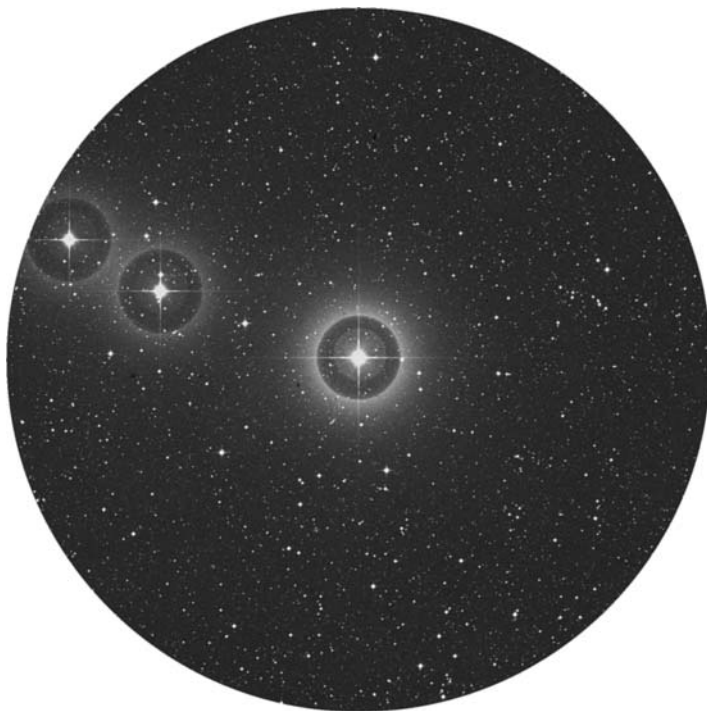


Figure 7.14a. Theta Lupi (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.14b. Region of B 288 (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, July 15

Wish happy birthday to Jocelyn Bell Burnell! In 1967 on this date she picked up an unusual stellar radio signal, a rapid series of pulses repeating every 1.337 seconds. Nicknamed LGM (for “little green men”), the source didn’t turn out to be an interstellar visitor but the first recorded pulsar! Astronomers eventually linked the pulsar phenomenon with the final stage of the evolution of massive stars—supernovae.

But could such an event happen in our own celestial “backyard?” Look no further than HR 8210 (RA 21 26 27 Dec +19 22 32). It may be nothing more than a white dwarf star hiding out in late-night Capricornus, but it’s a star that has almost run out of fuel. This rather ordinary binary system has a companion white dwarf star that’s 1.15 times the mass of our Sun. As the companion also expends its fuel, it will add mass to HR 8210 and push it over the Chandrasekhar limit—the point of no return in mass. This will result in a supernova—one located only 150 light-years away from our Solar System. . .and 50 light-years too close for comfort! Just 470 light-years away in the Gould Belt, and roughly 1.5 million years ago, a similarly massive star exploded in the Upper Scorpius association. No longer able to support its mass, it unleashed a supernova event, which left as evidence a layer of iron here on Earth, and may have caused a certain amount of extinction when its gamma rays directly affected our ozone layer.



Figure 7.15a. HR 8210 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.15b. Jocelyn Bell Burnell (widely used image).

Thursday, July 16

Today celebrates the 1746 birth of Giuseppe Piazzi. Although we know Piazzi best for his discovery of the asteroid Ceres, did you know he was also the first to notice that 61 Cygni had a large proper motion? Nine days and 38 years later, the man responsible for measuring 61 Cygni, Friedrich Bessel, was born.

This would indeed be a great evening to check out 61 Cygni for yourself. You'll easily locate it between Deneb and Zeta on the eastern side. Look for a small trio of just visible stars and choose the westernmost (RA 21 06 54 Dec +38 44 44). Not only is it famous because of Piazzi and Bessel's work, but it is one of the most noteworthy of double stars for a small telescope. Of the unaided visible stars, 61 is the fourth closest to Earth, with only Alpha Centauri, Sirius, and Epsilon Eridani closer. Just how close is it? Try right around 11 light-years.

Visually, the two components have a slightly orange tint, are less than a magnitude apart in brightness, and have a nice separation of around $30''$ to the south-southeast. Back in 1792, Piazzi first noticed its abnormally large proper motion and dubbed it the "Flying Star." At that time, it was only separated by around $10''$, and the B star was to the northeast. It takes nearly seven centuries for the pair to orbit each other, but there is another curiosity here. Orbiting the A star around every 4.8 years is an unseen body that is believed to be about 8 times larger than Jupiter. A star—or a planet? With a mass considerably smaller than any known star, chances are good that when you view 61 Cygni, you're looking toward a distant world!



Figure 7.16. 61 Cygni (credit—Palomar Observatory, courtesy of Caltech).

Friday, July 17

This date marks the 1904 passing of Isaac Roberts, an English astronomer who specialized in photographing nebulae. As an ironic twist, this is also the date on which a star was first photographed at Harvard Observatory!

Tonight let's have a look at a real little powerpunch globular cluster located in northern Lupus—NGC 5824. Although it's not an easy star hop, you'll find it about 7 degrees southwest of Theta Librae, and exactly the same distance south of Sigma Librae (RA 15 03 58 Dec -33 04 04). Look for a 5th magnitude star in the finderscope to guide you to its position southeast.

A Class I globular cluster, you won't find any others that are more concentrated than this. Holding a rough magnitude of 9, this little beauty has a deeply concentrated core region that is simply unresolvable. Discovered by E.E. Barnard in 1884, it enjoys its life in the outer fringes of its galactic halo about 104 light-years away from Earth and contains many recently discovered variable stars. Oddly enough, this metal-poor globular may have been formed by a merger. Research on GC 5824's stellar population leads us to believe that two less dense and differently aged globulars may have approached one another at a low velocity and combined to form this ultra-compact structure. Be sure to mark your observing notes on this one! It also belongs to the Bennett catalog and is part of many globular cluster lists.



Figure 7.17a. NGC 5824 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.17b. Isaac Roberts (historical image).

Saturday, July 18

Celestial scenery alert! Get up before dawn to witness the Moon graze by the Pleiades. For some observers, the pair will be separated by around half a degree; it will be an occultation event for others. Check the Resources section in this book for more details. Still not enough? Then be sure to look for the twin red pair of Mars and Aldebaran spaced equidistant to the Moon's south!

Tonight let's begin with the 1689 birth of Samuel Molyneux. This British astronomer and his assistant were the first to measure the aberration of starlight. What star did they choose? Alpha Draconis, which oscillated with an excursion of $39''$ from its lowest declination in May. Why choose a single star during an early dark evening? Because Alpha Draconis—Thuban—is far from bright. At magnitude 3.65, Thuban's "alpha" designation must have come from a time when it, not Polaris, was the northern celestial pole star. If you're aware that the two outer stars of the "dipper" point to Polaris, then use the two inner stars to point to Thuban (RA 14 04 23 Dec +64 22 33). This 300-light-year-distant white giant is no longer main sequence, a rare binary type.

Now head to binary Eta Lupi, a fine double star resolvable with binoculars. You'll find it by staring at Antares and heading due south two binocular fields to center on bright H and N Scorpii—then one binocular field southwest. Now hop 5 degrees southeast (RA 16 25 18 Dec -40 39 00) to encounter the fine open cluster NGC 6124. Discovered by Lacaille, and known as object I.8, this 5th magnitude open cluster is also Dunlop 514, Melotte 145, and Collinder 301. Situated about 19 light-years away, it shows a fine, round, faint spray of stars to binoculars and is resolved into about 100 stellar members to larger telescopes. Although NGC 6124 is low for northern observers, it's worth the wait to try at culmination. Be sure to mark your notes because this delightful galactic cluster is also a Caldwell object and counts for a southern skies binocular award.



Figure 7.18a. Alpha Draconis (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.18b. NGC 6124 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, July 19

Want a picturesque sight before dawn? Then look for the close pairing of Venus and the Moon. Which has the greater crescent? This probably would have interested Edward Charles Pickering, who was born on this date in 1864. Pickering was the director of Harvard College Observatory for 42 years and published the first all-sky photographic map in 1902!

Tonight for unaided observers, let's begin by identifying Zeta Ophiuchi, the centermost in a line of stars marking the edge of the constellation of Ophiuchus, about a handspan north of Antares. As a magnificent 3rd magnitude blue-white Class O, this hydrogen-fusing dwarf is eight times larger than our own Sun. Hanging out some 460 light-years away, it is dulled by the interstellar dust of the Milky Way and would shine two full magnitudes brighter if it were not obscured. Zeta is a "runaway star"—a product of a one-time supernova event of a double-star system. Now roughly halfway through its 8-million-year life span, the same fate awaits this star! Now point binoculars or small scopes about three finger-widths south to have a look at Phi Ophiuchi. This is a spectroscopic double star, but it has several delightful visual companions!

Almost in between these two bright stars is our telescopic target for tonight—M107. Discovered by Pierre Méchain in 1782, and added to the catalog in 1947, it's probably one of the last of the Messier objects to be discovered and wasn't resolved into individual stars until studied by Herschel in 1793. M107 isn't the most impressive of globulars, but this Class X is notable as a faint, diffuse area with a core region in binoculars and is surprisingly bright in a small telescope. It's a curious cluster, for some believe it contains dark, dust-obscured areas, which make it unusual. Located around 21,000 light-years away, this little beauty contains around 25 known variable stars. Visually, the cluster begins to resolve around the edges to mid-aperture, and the structure is rather loose. If sky conditions permit, the resolution of individual chains at the globular's edges makes this globular well worth a visit!



Figure 7.19a. M107 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.19b. Edward Pickering (historical image).

Monday, July 20

On this date in 1969, the world held its breath as the Apollo 11 lander touched down, and Neil Armstrong and Edwin Aldrin became the first humans to touch the lunar surface. "A small step for a man. A giant leap for mankind." Humankind's success continued on July 20, 1976, when Viking 1 landed on Mars, sending back the first surface images.

Tonight it's Hercules for another globular study—M92. Although in a relatively open field for starhoppers, it's not too hard to find if you can imagine it as the apex of a triangle with the northern keystone stars—Eta and Pi—as the base (RA 17 17 07 Dec +43 08 11). Magnitude 6, Class IV M92 was discovered by Johann Bode in 1777 and cataloged as Bode 76. Independently recovered by Messier in 1781, and resolved by Herschel in 1783, this bright, compact globular is around 26,700 light-years away and is about 12 billion years old. It contains 14 RR Lyrae variables among its 330,000 stars and a very rare eclipsing binary. Viewable unaided under the right conditions and very impressive in even small binoculars, M92 is a true delight with its bright, unresolvable core and many outlying stars. Larger scopes will appreciate its fiery appearance!

Hop south to Beta Ophiuchi to have a look at NGC 6426 (RA 17 44 54 Dec +03 10 12) about a finger-width south. You'll want to at least try with Herschel II.587 because it's even older than M92! Discovered by Sir William in 1786 and cataloged as H II.587, this 11th magnitude Class IX globular looks destroyed in comparison. At 67,500 light-years away, it's far over twice the distance from us as M92! Residing 47,600 light-years from the galactic center, NGC 6426 contains 15 RR Lyrae variables (three of which are newly discovered) and is the most metal-poor globular known. Forget about finding this one in binoculars and very small telescopes. Faint and diffuse, a large telescope is required to begin resolution.



Figure 7.20a. M92 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.20b. NGC 6426 (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, July 21

This day in 1961, Mercury 4 was launched, sending Gus Grissom into suborbital space on the second U.S. manned flight and returned him safely in the Liberty Bell 7. Sadly enough, it's also the anniversary of the 1998 death of Alan Shepard, Jr—the first American in space, and one of only 12 humans to walk on the Moon.

Tonight return to the oblate and beautiful M19, and drop two finger-widths south for another misshapen globular—M62 (RA 17 01 12 Dec -30 06 44).

At magnitude 6, this 22,500-light-year-distant Class IV cluster can be spotted in binoculars, but comes to wonderful life in the telescope. M62 was discovered by Messier in 1771, although Herschel was the first to resolve it and report on its deformation. Because it is so near the galactic center, the tidal forces have “crushed” it—much like M19. You will note when studying it in the telescope that its core is very off center. Unlike M19, M62 has at least 89 known variable stars—85 more than its neighbor—and the dense core may have undergone collapse. A large number of X-ray binaries have also been discovered within its structure, perhaps caused by the close proximity of stellar members. Enjoy it tonight!



Figure 7.21a. M62 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.21b. Left to right: John Glenn, Gus Grissom, and Alan Shepard (credit—NASA).

Wednesday, July 22

We'll begin the day by honoring Ernest William Brown, who died on this date in 1938. Brown was a British astronomer whose life's work was constructing accurate tables of the Moon's motion. He said that he studied "the gravitational action of every particle of matter which can have a sensible effect on the Moon's motion." By analyzing 150 years of observations, he was able to make his tables accurate to 0.01"! He was the first to prove that the changes in the Moon's motion were related to irregular changes in Earth's rotation! And how he would have loved what is about to happen. . .

Thanks to the Moon's motion, a spectacular total solar eclipse begins just off the coast of India at 00:51:17 UT on July 22 and ends in Polynesia at 04:19:26 UT the same day. The maximum eclipse is at 02:35:21 UT on July 22, when the total phase will last a stunning 6 minutes and 39 seconds. The partial eclipse will be visible over Southeast Asia and the Pacific between 23:58:19 UT on July 21 and 05:12:25 UT on July 22. How cool is that?!

Since tonight is New Moon, what better time to look for an alternate catalog object? Let's start by Herschel hunting while we continue our globular cluster studies. Our first stop is to return to brilliant Antares and head one half-degree northwest for a Bennett list object, NGC 6144 (RA 16 27 14 Dec -26 01 29). Originally discovered by Herschel in 1784, and labeled as H VI.10, this 9th magnitude Class II globular is around 8,500 light-years from the galactic core. Although it is only about one-third the size of M4, it is also three times more distant from our Solar System. If you have trouble spotting it, try high magnification to keep Antares' glare at bay. Situated in the Rho Ophiuchi dust cloud, NGC 6144 has at least one slow variable of the RR Lyrae type.



Figure 7.22a. NGC 6144 (credit—Palomar Observatory, courtesy of Caltech).

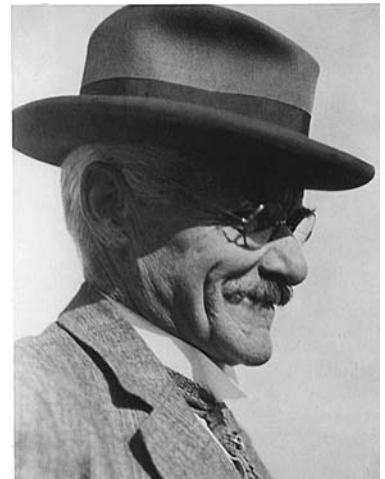


Figure 7.22b. Ernest William Brown (historical image).

Thursday, July 23

Today we salute the 1920 birth of Chushiro Hayashi, who with his coworkers created evolutionary models for stars of mass between 0.01 and 100 times that of the Sun. Hayashi also investigated the formation of the Solar System, including Earth and its atmosphere. In 2004, Hayashi received the prestigious Bruce Medal for a lifetime of contributions to astronomy.

Tonight, head a little more than a fist-width south of Antares for NGC 6139 (RA 16 27 40 Dec -38 50 55). Discovered by James Dunlop in 1820 and cataloged as Dun 536, this 9th magnitude Class II globular is much further from the galactic center (11,700 light-years) than most globulars. Within the gravitational pull of this low-metallicity cluster, at least six RR Lyrae-type variables still cling to their host.

Now that you've seen a very concentrated globular cluster, let's look at one that isn't even classified. Drop a finger-width south of Lambda Scorpii for NGC 6380 (RA 17 34 28 Dec -39 04 09). This 11th magnitude globular is a challenge! Also discovered by John Herschel and listed as h 3688, this one is also known as Tonantzintla 1, or Ton 1. It's so vague that it wasn't even classed as a globular cluster until research with a photographic plate! It is very metal-rich, and contains red giants at its bulging heart. . .what's left of it!



Figure 7.23a. NGC 6139 (credit—Palomar Observatory, courtesy of Caltech).



Figure 7.23b. NGC 6380 (credit—Palomar Observatory, courtesy of Caltech).

Friday, July 24

Today let's start with the 1853 birth on this date of Henri-Alexandre Deslandres. Do you recognize his name from our lunar studies? He invented the spectroheliograph to photograph the Sun in monochromatic light! Deslandres also observed the spectra of planets and stars and measured their radial velocities.

Did you see the very young crescent of the Moon during twilight? The Moon played an important role in history on this date. The Apollo 11 astronauts splashed down from their return from the Moon on this date in 1969! Only 15 years before, in 1954, the sound of a human voice had been reflected off the Moon's surface and returned to Earth. James H. Trexler at the Naval Research Laboratory spoke into a microphone at the laboratory's Maryland facility, and the sound was relayed back 2.5 seconds later. Although "Operation Moon Bounce" was only a repetition of vowel sounds, Trexler felt the project held promise as a communications and radar intercept device. It might be worth it to point out that many radars are very close to the theoretical possibility of contacting the Moon, and hence the practicality of building a system capable of intercepting these systems by reflections from the Moon is not beyond the realm of possibility.

Tonight we start with a group of young stars beginning their stellar evolution and end with an old solitary elder preparing to move onto an even "higher realm." Open cluster IC 4665 is easily detected with just about any optical aid about a finger-width north-northeast of Beta Ophiuchi (RA 17 46 18 Dec +05 43 00). Discovered by Philippe Loys de Chéseaux in the mid-1700s, this 1,400-light-year-distant cluster consists of about 30 mixed-magnitude stars all less than 40 million years of age. Despite its early discovery, IC 4665 did not achieve broad enough recognition for Dreyer to include it in the late nineteenth-century New General Catalog (NGC), and it was later added as a supplement to the NGC in the Index Catalog of 1908. Be sure to use low power to see all of this large group.



Figure 7.24a. IC 4665 (credit—Palomar Observatory, courtesy of Caltech).

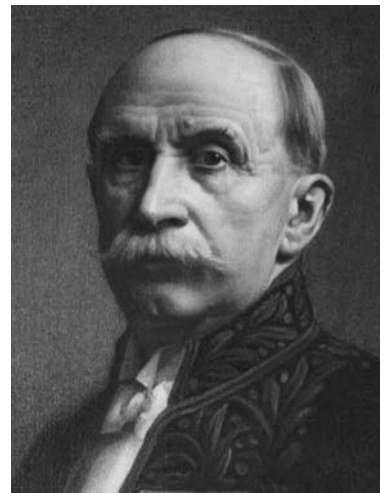


Figure 7.24b. Henri Deslandres (historical image).

Saturday, July 25

Today we celebrate a success of the U.S.S.R. space program with the achievement of cosmonaut Svetlana Savitskaya, the first woman to walk in space (in 1982 on this date) and only the second female to go into space, preceding Sally Ride. Today is also the date of the 1973 launch of Soviet Mars 5 probe. Although it didn't complete its full mission, it did send back 60 photos of the Martian Southern Hemisphere!

Although poor position makes study difficult during the first few lunar days, be sure to look for the ancient impact Vendelinus. Spanning 150 kilometers in diameter and with walls reaching up to 4,400 meters in height, lava flow has long ago eradicated any interior features. Its old walls hold mute testimony to later impact events such as crater Holden on the south shore, larger Lame on the northeast edge, and sharp Lohse northwest. Mark your challenge list!

Tonight's challenge is Herschel I.44, also known as NGC 6104, a 9.5-magnitude globular cluster around two finger-widths northeast of Theta Ophiuchi and a little more than a degree due east of star 51 (RA 17 38 37 Dec -23 54 31). Discovered by William Herschel in 1784 and often classed as "uncertain," this halo object has been pegged by today's powerful as a Class VIII and given a rough distance from the galactic center of 8,800 light-years. Although neither William nor John could resolve this globular and listed it originally as a bright nebula, studies in 1977 revealed a nearby suspected planetary nebula named Peterson 1. Thirteen years later, further study revealed this wasn't a nebula at all but evidence of a symbiotic star. Symbiotic stars are a true rarity—not a single star at all but a binary system. A red giant dumps mass toward a white dwarf in the form of an accretion disk. When this reaches critical mass, it then causes a thermonuclear explosion, resulting in a planetary nebula. Although no evidence exists that this object is located within metal-rich NGC 6401, just being able to see it in the same field makes this journey both unique and exciting!

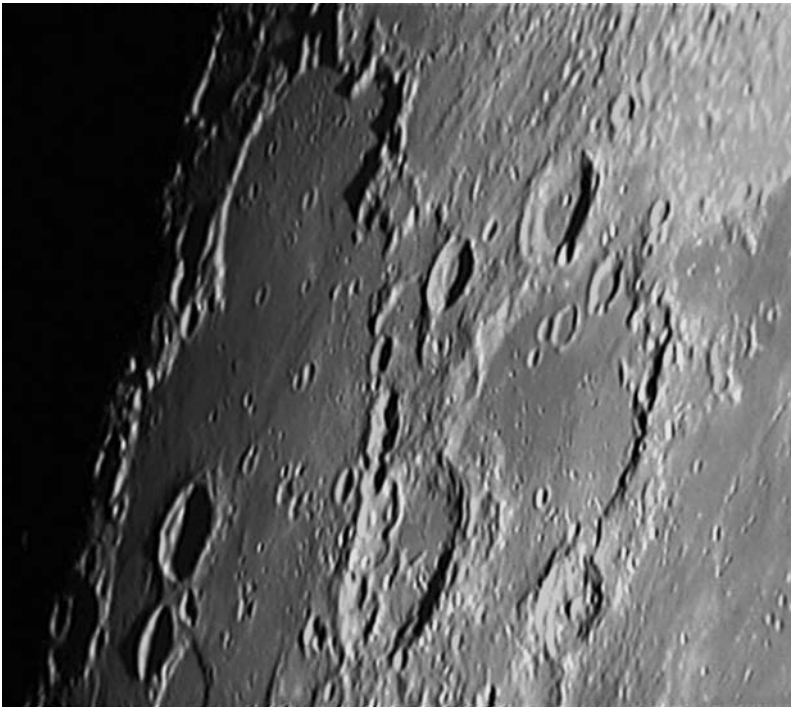


Figure 7.25a. Vendelinus (credit—Alan Chu).



Figure 7.25b. NGC 6401 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, July 26

On this date in 1969 in a vacuum-sealed room, the very first sample return of Moon rocks was studied. Our own vacuum of space awaits as we view the area around Mare Crisium to have a look at this month's lunar challenge—Macrobius. You'll find it just northwest of the Crisium shore. Spanning 64 kilometers in diameter, this Class I impact crater drops to a depth of nearly 3,600 meters—about the same as many of our Earthly mines. Its central peak rises to 1,100 meters and may be visible as a small speck inside the crater's interior. Be sure to mark your lunar challenge lists, and look for other features you may have missed before!

Since the moonlight will now begin to interfere with our globular cluster studies, let's waive these for a while as we take a look at some of the region's most beautiful stars. Tonight your goal is to locate Omicron Ophiuchi, about a finger-width northeast of Theta (RA 17 18 00 Dec -24 17 02). At a distance of 360 light-years, the Omicron system is easily split by even small telescopes. The primary star is slightly dimmer than magnitude 5 and appears yellow to the eye. The secondary is near 7th magnitude and tends to be more orange in color. This wonderful star is on many doubles' observing lists, so be sure to note it!

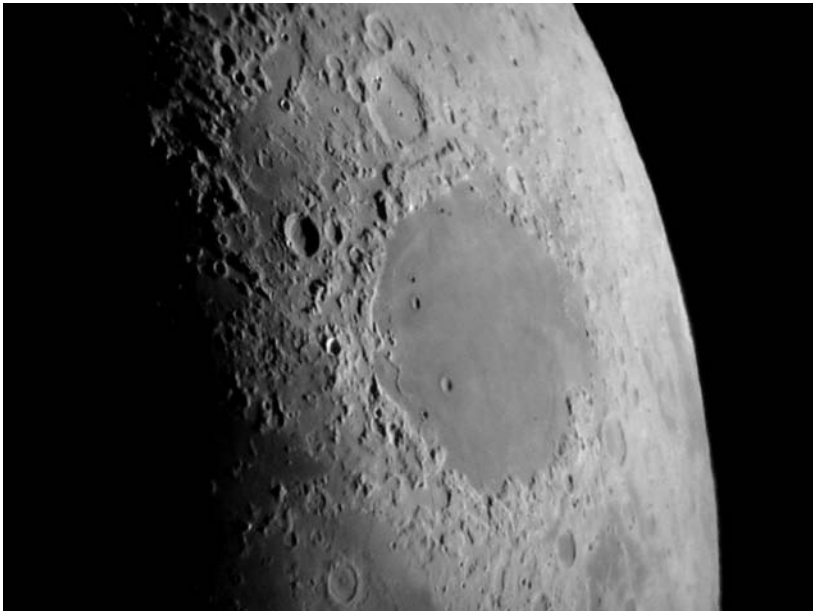


Figure 7.26a. Macrobius on the edge of Crisium (credit—Greg Konkel).



Figure 7.26b. Omicron Ophiuchi (credit—Palomar Observatory, courtesy of Caltech).

Monday, July 27

With plenty of Moon to explore tonight, why don't we try locating an area that doesn't really appear like a crater but is classified as one. Binoculars will easily reveal the fully disclosed areas of Mare Serenitatis and Mare Tranquillitatis. Then you'll need to identify the deep, bright ring of Arago toward the western shore. Although Arago itself is beautiful and rather small at 26 kilometers in diameter, what lies to its southeast is even more unusual. Look for a series of Rilles where the walls conjoin to form a feature named Lamont. It is unclear whether this 75-kilometer-diameter feature is just a chance arrangement of lava wrinkles or the remains of a crater eradicated by lava flow. No matter how it formed, you'll find Lamont on many crater challenge lists. . .and the alpha and beta lava domes as well!

This night is also the anniversary of the 1801 birth of Sir George Biddell Airy, an astronomer who studied optical interference fringes that we now call "Airy Disks." Try spotting the effect around variable star RR Scorpii about two finger-widths northeast of Eta and less than a finger-width southwest of 62 (RA 16 56 38 Dec -30 34 48). This very red Mira type can reach as high as magnitude 5 and drop as low as 12 in about 280 days!

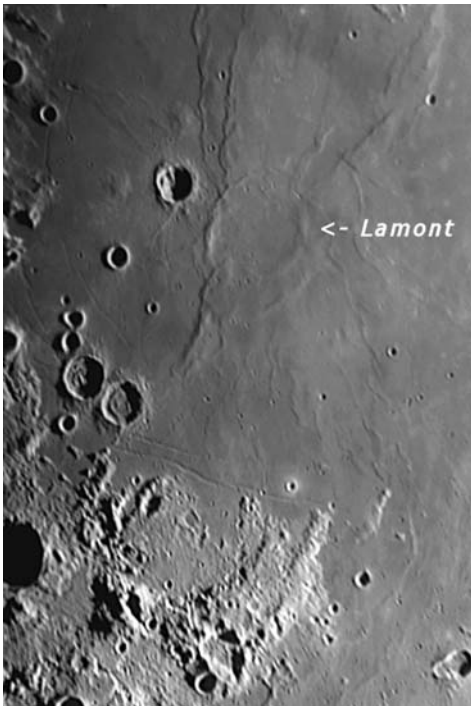


Figure 7.27a. Lamont (credit—Alan Chu).



Figure 7.27b. RR Scorpii (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, July 28

Today is anniversary of the 1867 birth of Charles Dillon Perrine, who discovered the sixth and seventh moons of Jupiter in 1904 and 1905, respectively. Tonight we'll discover more about our own Moon, as we celebrate 40 years of space exploration and view where the first human set foot. For sky-watchers, the dark round area you see on the northeastern limb is Mare Crisium, and the dark area below that is Mare Fecunditatis. Now look mid-way on the terminator for the dark area that is Mare Tranquillitatis, the southwest edge of this is where history was made.

In binoculars, trace along the terminator where the Caucasus Mountains stand and south for the Apennines and Haemus. As you continue toward the center of the Moon, you will see where the shore of Mare Serenitatis curves east and the bright ring of Pliny. Continue south along the terminator until you spot the small, bright ring of Dionysius along the edge of Mare Tranquillitatis. Just to the southwest, you may be able to see the rings of Sabine and Ritter. It is near here where the base section of the Apollo 11 landing module—Eagle—lies perhaps forever enshrined in “magnificent desolation.”

For telescope users, the time is now to power up! See if you can spot the small craters Armstrong, Aldrin, and Collins just east. Even if you cannot, the Apollo 11 landing area is about the same distance as Sabine and Ritter are wide to the east-southeast. Even if you don't have the opportunity to see it tonight, take the time during the next couple of days to point it out to your children, grandchildren, or even just a friend. . . . Their Moon is a spectacular world, and we've been there!

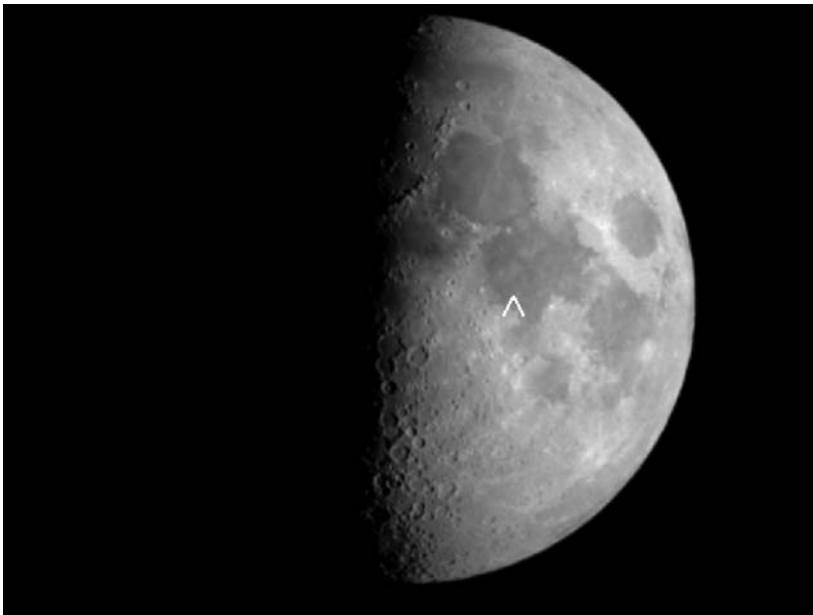


Figure 7.28a. Apollo 11 landing area (credit—Greg Konkel).



Figure 7.28b. Charles Perrine (historical image).

Wednesday, July 29

Long before the Sun sets, look for the Moon to appear in the still blue sky. As it darkens, watch for brilliant blue-white Spica to be around a finger-width north of the Moon. Have you ever wondered if there was any place on the lunar surface that has never seen sunlight? Then let's go exploring for one tonight...

Our first order of business will be to identify crater Albategnius. Directly in the center of the Moon is a dark-floored area known as the Sinus Medii. South of this will be two conspicuously large craters—Hipparchus to the north and ancient Albategnius to the south. Trace along the terminator toward the south until you have almost reached its point (cusp), and you will see a black oval. This normal-looking crater with the brilliant west wall is the equally ancient crater Curtius. Because of its high southern latitude, we will never see the interior of this crater—and neither has the Sun! It is believed that the inner walls are quite steep, and Curtius' interior has never been illuminated since its formation billions of years ago. Because it has remained dark, we can speculate that there may be "lunar ice" pocketed inside its many cracks and Rilles—ice that would date back to the Moon's formation!

Because our Moon has no atmosphere, the entire surface is exposed to the vacuum of space. When sunlit, the surface reaches up to 385 Kelvin, so any exposed "ice" would vaporize and be lost because the Moon's gravity cannot hold it. The only way for "ice" to exist would be in a permanently shadowed area. Near Curtius is the Moon's south pole, and Clementine imaging showed around 15,000 square kilometers of area where such conditions could exist. So where did this "ice" come from? The lunar surface never ceases to be pelted by meteorites, most of which contain water ice. As we know, many craters were formed by just such impacts. If hidden from the sunlight, this "ice" could continue to exist for millions of years!

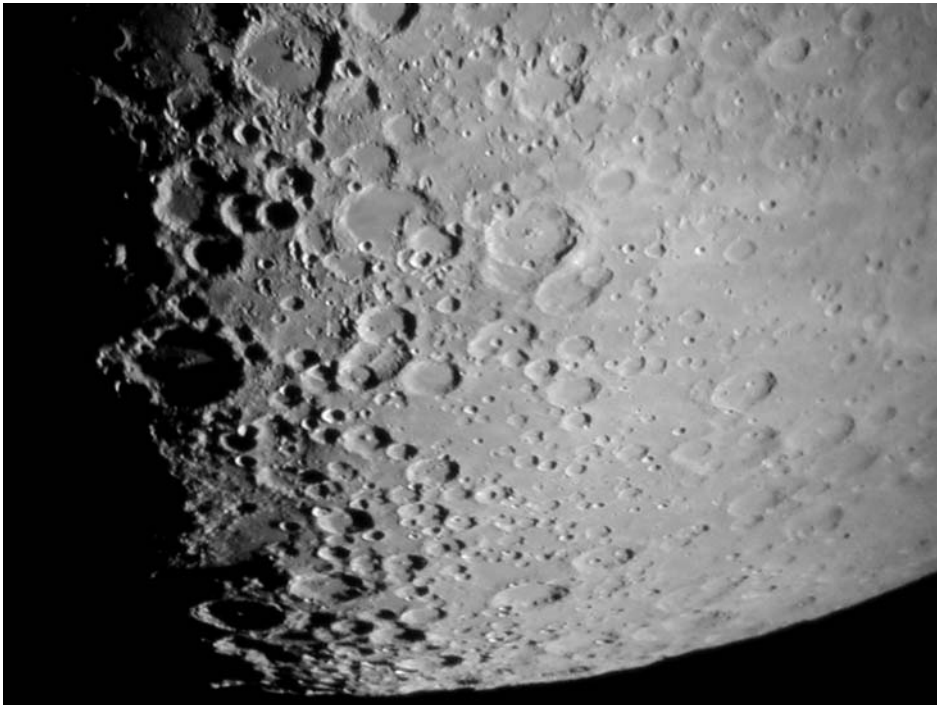


Figure 7.29. Curtius at center bottom (credit—Greg Konkel).

Thursday, July 30

Tonight let's continue our look at the lunar poles by returning to a previous study of crater Plato. North of Plato you will see a long horizontal area of gray floor—Mare Frigoris. North of this you will note a "double crater." This elongated diamond-shape is Goldschmidt, and the crater that cuts across its western border is Anaxagoras. The lunar "north pole" isn't far from Goldschmidt, and since Anaxagoras is just about 1 degree outside of the Moon's theoretical "arctic circle," the lunar Sun will never rise high enough to clear the southernmost rim. As with yesterday's study, this "permanent darkness" must mean there is ice! For that very reason, NASA's Lunar Prospector probe was sent to explore. Did it find what it was looking for? Yes!

The probe discovered vast quantities of cometary ice that has been hidden inside the crater's depths untouched for millions of years. If this sounds rather boring to you, then realize this type of resource will color our plans to eventually establish a manned base on the lunar surface! On March 5, 1998, NASA announced that Lunar Prospector's neutron spectrometer data showed that water ice was discovered at both lunar poles. The first results showed the "ice" mixed in with lunar regolith (soil, rocks, and dust), but long-term data confirmed near pure pockets hidden beneath about 40 centimeters of surface material, with the results being strongest in the northern polar region. It is estimated that there may be as much as 6 trillion kilograms (6.6 billion tons) of this valuable resource! If this still doesn't get your motor running, then realize we would never be able to establish a manned lunar base because of the tremendous expense involved in transporting our most basic human need—water.

The presence of lunar water could also mean a source of oxygen, another vital material we need to survive! And if we wanted to return home or onward, these same deposits could provide hydrogen that could be used as rocket fuel. So, as you view Anaxagoras tonight, realize that you may be viewing one of humankind's future "homes" on a distant world!



Figure 7.30. Lunar north pole (credit—NASA).

Friday, July 31

Now let's take an entirely different view of the Moon as we do some "mountain climbing." Tonight the most outstanding feature on the Moon will be the emerging Copernicus, but since we've delved into the deepest areas of the lunar surface, why not climb to some of its peaks?

Using Copernicus as our guide, to the north and northwest of this ancient crater lies the Carpathian Mountains, ringing the southern edge of Mare Imbrium. As you can see, they begin well east of the terminator, but look into the shadow! Extending some 40 kilometers beyond the line of daylight, you will continue to see bright peaks, some of which reach over 2,000 meters in height! When the area is fully revealed tomorrow, you will see the Carpathian Mountains eventually disappearing into the lava flow that once formed them. Continuing onward to Plato, which sits on the northern shore of Imbrium, we will look for the singular peak of Pico. It is between Plato and Mons Pico that you will find the scattered peaks of the Teneriffe Mountains. These may be the remnants of much taller summits of a once stronger range, but only about 1,890 meters still survives above the surface. Time to power up! To the west of the Teneriffes, and very near the terminator, you will see a narrow series of hills cutting through the region west-southwest of Plato. This is known as the Straight Range—Montes Recti—and some of its peaks reach up to 2,072 meters. Although this doesn't sound particularly impressive, that's over twice as tall as the Vosges Mountains in Central Europe, and on the average very comparable to the Appalachian Mountains in the eastern United States.

Now, take a close look at the Resources section in this book and have an even closer look around the Moon. . . . Antares just might be occulted!

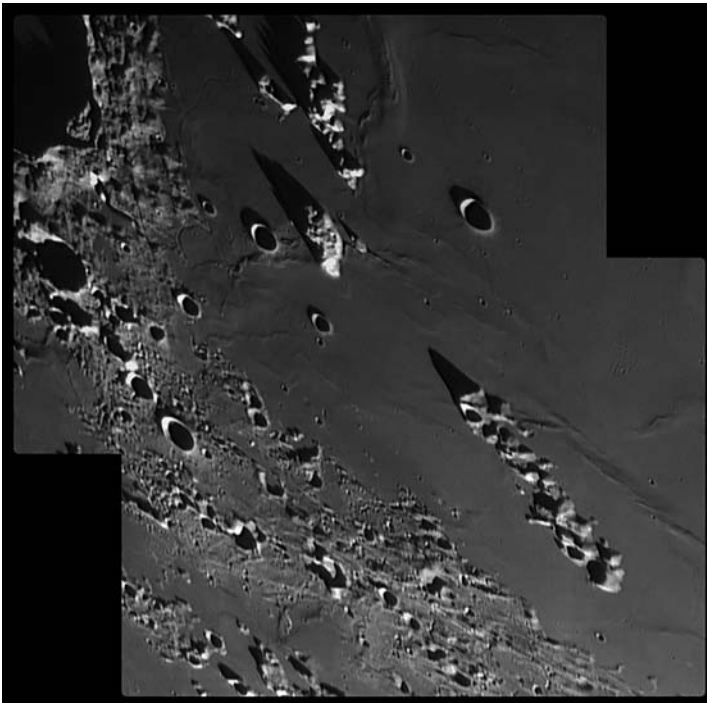


Figure 7.31. Montes Teneriffe and Montes Recti (credit—Wes Higgins).

CHAPTER EIGHT



August, 2009

Saturday, August 1

Let's continue our lunar mountain climbing expedition and look at the "big picture" on the Moon's surface. Tonight all of Mare Imbrium is bathed in sunlight, and we can truly see its shape. Let's identify the mountain ranges again. Starting at Plato and moving east to south to west you will find the Alps, the Caucasus, and the Apennines (where Apollo 15 landed at the western end of Palus Putredinus), respectively. Next come the Carpathian Mountains just north of Copernicus. Look at their form closely. Doesn't it appear that once upon a time an enormous impact created the entire area? The Imbrium impact. . . Compare it to the younger Sinus Iridum. Ringed by the Juras Mountains, it may have also been formed by a much later and very similar impact.

And you thought they were just mountains. . .

Tonight let's honor the 1891 birth on this date of Helen Sawyer Hogg, who cataloged distances to variable stars in globular clusters. Although it's too bright to globular hunt tonight, we can start with our eyes on Delta Ophiuchi (RA 16 14 20 Dec -03 41 39), another undiscovered gem. Known as Yed Prior (the "Hand"), look for its optical double Epsilon to the southeast, handily named Yed Posterior. Now have a look at this area in binoculars or a telescope, using absolutely minimum power. Delta Ophiuchi is 170 light-years from us, while Epsilon is 108. But look at the magnificent field they share. Stars of every spectral type are together in an area of sky that could easily be covered by a small coin held at arm's length. Enjoy this fantastic field, from the hot blue youngsters to the old red giants!



Figure 8.1a. Gibbous Moon (credit—Greg Konkell).



Figure 8.1b. Delta Ophiuchi (credit—Palomar Observatory, courtesy of Caltech).

Sunday, August 2

Today we celebrate the official adoption of Greenwich Mean Time (GMT) in 1880. Tonight take time to head north of Sinus Iridum, across Mare Frigoris and northeast of the punctuation of Harpalus, and revisit the grand crater J. Herschel. Although it looks small because it is seen on the curve, this wonderful old walled plain named for John Herschel contains some very tiny details. Its southeastern rim forms the edge of Mare Frigoris, and the small (24 kilometers) crater Horrebow dots its southwestern edge. The crater walls are so eroded with time that not much remains of the original structure. Look for many very small impact craters dotting J. Herschel's uneven basin and exterior edges. Why return to a previous study? If you can spot the small central crater C, you are resolving a feature only 12 kilometers wide from some 385,000 kilometers away!

While we're out, let's have a look at another astounding system called 36 Ophiuchi, located about a thumb-width southeast of Theta (RA 17 15 20 Dec -26 36 10). Situated in space less than 20 light-years from Earth, even small telescopes can split this pair of 5th magnitude K-type giants—stars very similar to our own Sun. Larger telescopes can pick up the C component as well. Be sure to mark your lists with both of your observations tonight, because J. Herschel is a Lunar Club Challenge, and 36 Ophiuchi is on many doubles' challenge lists.

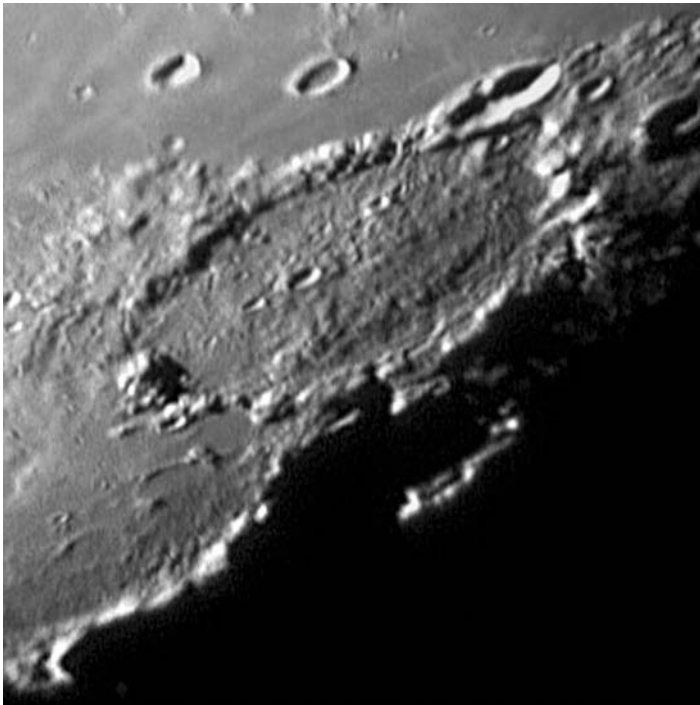


Figure 8.2a. Crater J. Herschel (credit—Alan Chu).



Figure 8.2b. 36 Ophiuchi (credit—Palomar Observatory, courtesy of Caltech).

Monday, August 3

While the gibbous Moon dominates the night sky, why fight it? Let's study it instead, as we head toward some challenging craters. Start by identifying the long narrow ellipse of crater Schiller on the terminator to the south. Head further south along the terminator and look for a line of four prominent craters. Their interiors may be black, but the southwest walls will be brilliantly illuminated. The most striking of this quartet is Zucchius, and depending on libration, it may be very shadowed. To its east is Bettinus, and at high power you will see central peaks in both craters. Further southeast is Kirchner, and to its east is the very old Wilson. Just north of Bettinus and—at an angle to Zucchius—you will see a strange, walled, V-shaped area curving back to Schiller. This odd area is one of the Moon's older surface features. An eon or two ago, this was part of a much larger structure that can be traced here and there amid later forming craters. Since all that is now left is some hills and ridges, no one is certain if the area formed geologically or was caused by an impact.

But this isn't the only mystery in the universe. Why are so many stars in the night sky doubles? Do double stars form together? Are they created separately and are later gravitationally attracted? Or are doubles and multiple stars all that's left of an open cluster after the Milky Way pulls it apart through tidal forces? Who needs theory when these twosomes and threesomes make for such fine views! Let's have a look at another "Herculean pair"—the 3.5-magnitude Mu Herculis (RA 17 46 27 Dec +27 43 14). Keep a sharp eye, and use only enough power to darken the bright Moonlit sky. Look for Mu's dim 9.8-magnitude companion some 30" west-southwest of a golden 3.4-magnitude primary.

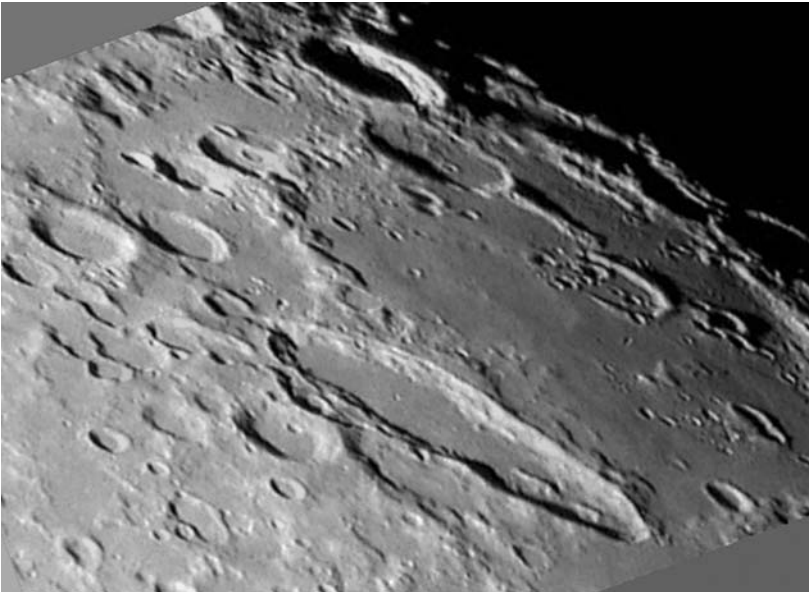


Figure 8.3a. Schiller (credit—Alan Chu).



Figure 8.3b. Mu Herculis (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, August 4

We often overlook the simple beauty of practicing astronomy without a telescope. This evening as the Sun sets and the Moon rises opposite to it, take advantage of some quiet time and really stop to look at the eastern horizon. If you are lucky enough to have clear skies, you will see the Earth's shadow rising—like a dark, sometimes blue band—that stretches 90 degrees north and south. Look just above the horizon for the Rayleigh scattering effect known by some as the “Belt of Venus.” This beautiful pinkish glow is caused by backscattering of sunlight. As the Sun continues to move west, the boundary between Earth's shadow and Venus's Belt rises higher in the sky and gently blends into the coming night. What you are seeing is the shadow of Earth's translucent atmosphere, casting a shadow back on itself. Tonight watch the Moon rise and relax. Perhaps take out a sketchbook and capture the moment . . .

The sky will remain bright all evening—but that won't keep us from challenging ourselves on a fine double now high to the south in Sagittarius at skydark. Tight, disparate double 21 Sagittarii (RA 18 25 21 Dec -20 32 30) is less than 5 degrees due north of Kaus Borealis—Lambda Sagittarii. Because of bright skies, it will take a finderscope to track this 5th magnitude star down. To help single out 21 Sagittarii, look for Mu Sagittarii 3 degrees to 21's west. Resolution of this 1.9" pair is possible in just about any size instrument, but like other pairs we've visited, this one is disparate. Look for the blue 5.1-magnitude “A” star's 7.6-magnitude orange companion leading it across the sky.



Figure 8.4a. Lunar sketch by Deirdre Kelleghan.



Figure 8.4b. 21 Sagittarii (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, August 5

Today we celebrate the 79th birthday of Neil Armstrong, the first human to walk on the Moon. Congratulations! Also on this date in 1864, Giovanni Donati made the very first spectroscopic observations of comet Tempel (1864 II). The three absorption lines he noticed led to what we now know as the Swan bands, arising from a form of molecular carbon (C_2).

With the nearly Full Moon, tonight we'll stay with something bright as we look toward Alpha Lyrae now directly overhead at skydark. Brilliant blue Vega is the fifth brightest star in the night sky. Celebrated in Hollywood's depiction of the Carl Sagan book *Contact*, most folks know that Vega lies some 26 light-years away. Due to its proximity to Earth, Vega isn't as brilliant as it appears, though it is significantly brighter than our own Sun. If Sol were as distant, it would appear as a star of the 4th magnitude—some 58 times fainter. As a marker star, Vega has two other very significant roles—it is within a few degrees of the apex of the Sun's Way as we move through the Milky Way Galaxy, and in 12,000 years, it will be found within a few degrees of the celestial North Pole! For those with telescopes, look for a faint 10th magnitude companion about $1'$ south of Vega.

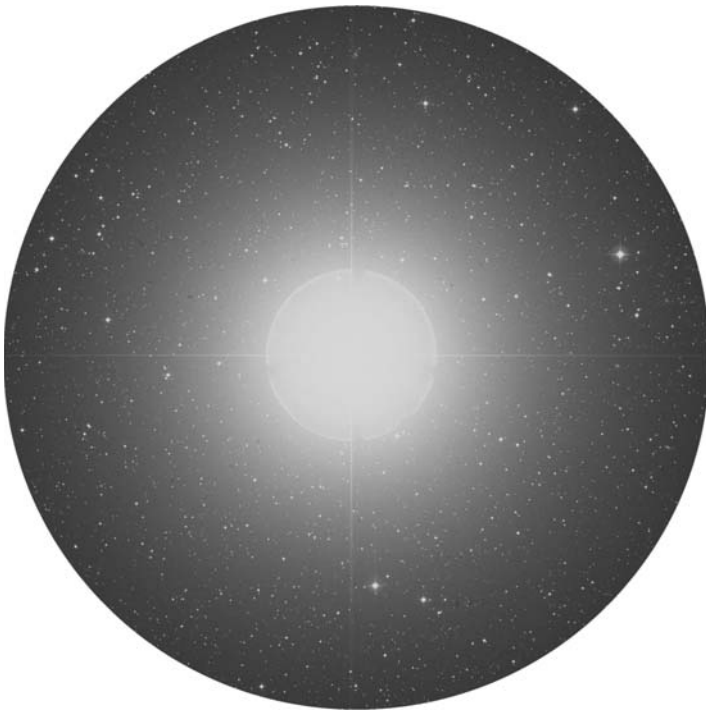


Figure 8.5a. Alpha Lyrae: Vega (credit—Palomar Observatory, courtesy of Caltech).



Figure 8.5b. Neil Armstrong (credit—NASA).

Thursday, August 6

Tonight is officially the Full Moon, and a shallow penumbral eclipse will be visible from southeastern North America, South America, Europe, Africa, and west Asia. This Moon is also known as the "Fruit" or "Barley" Moon, perhaps because it is sometimes slightly colored? The shading will be very subtle, but perhaps it will dim the sky enough to catch asteroid 16 Psyche nearly brushing the northern limb at a distance of about 0.2 degrees. At well over 200 kilometers in diameter and no brighter than magnitude 9, it's going to be a tough call, but it will be fun to catch this nickel-iron giant!

While you're out, have a look at 52 Cygni. Located due south of Epsilon (RA 20 45 39 Dec +30 43 11), this foreground star to the Western Veil Nebula is also a pretty double whose 8.7-magnitude disparate companion lies some 6" east-northeast of the 4.2-magnitude primary. As a challenge for small scopes during the lunacy, try different eyepieces to strike a balance between darkening the sky and condensing the light of the faint companion.



Figure 8.6a. Asteroid Psyche (credit—NASA).



Figure 8.6b. 52 Cygni (credit—Palomar Observatory, courtesy of Caltech).

Friday, August 7

Today marks the 1726 birth of James Bowdoin, astronomer and friend of Benjamin Franklin. What do you think he would have thought if he could be with us tonight as we return to our studies with the globular M14, one of the clusters nearer to the galactic center? Located about 16 degrees (less than a handspan) south of Alpha Ophiuchi (RA 17 37 36 Dec -03 14 45), this 9th magnitude, Class VIII cluster can be spotted with larger binoculars, but only fully appreciated with the telescope.

When studied spectroscopically, globular clusters are found to be much lower in heavy element abundance than stars such as our Sun. These earlier generation stars (Population II) began their formation during the birth of our galaxy, making globular clusters the oldest formations we can study. In comparison, the disk stars have evolved many times, going through cycles of starbirth and supernova, which in turn enriched the heavy element concentration in star-forming clouds. Of course, as you may have guessed, M14 breaks the rules. M14 contains an unusually high number of variable stars—in excess of 70—with many of them known to be the W Virginis type. In 1938, a nova appeared in M14, but it was undiscovered until 1964, when Amelia Wehlau of the University of Ontario was surveying the photographic plates taken by Helen Sawyer Hogg. The nova was revealed on eight of these plates taken on consecutive nights and showed itself as a 16th magnitude star—and was believed to be at one time almost five times brighter than the cluster members. Unlike 80 years earlier with T Scorpii in M80, actual photographic evidence of the event existed. In 1991, the eyes of the Hubble were turned its way, but neither the suspect star nor traces of a nebulous remnant were discovered. Then, 6 years later, a carbon star was discovered in M14. To a small telescope, M14 will offer little to no resolution and will appear almost like an elliptical galaxy, lacking in any central condensation. Larger scopes will show hints of resolution, with a gradual fading toward the cluster's slightly oblate edges. A true beauty!



Figure 8.7a. M14 (credit—NOAO/AURA/NSF).

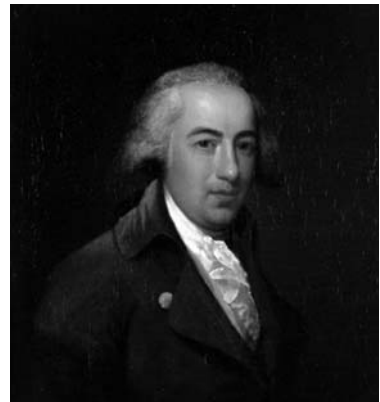


Figure 8.7b. James Bowdoin (historical image).

Saturday, August 8

On this date in 2001, the Genesis Solar Particle Sample Return mission was launched on its way toward the Sun. On September 8, 2004, it returned with its sample of solar wind particles. Unfortunately, a parachute failed to deploy, causing the sample capsule to plunge unchecked into the Utah soil. Although some of the specimens were contaminated, many did survive the mishap. So what is “star stuff?” Mostly highly charged particles generated from a star’s upper atmosphere flowing out in a state of matter known as plasma.

Before moonrise, let’s study one of the grandest of all solar winds as we seek out an area about three finger-widths above the Sagittarius teapot’s spout as we have a look at the magnificent M8 (RA 18 03 37 Dec $-24\ 23\ 12$). Visible to the unaided eye as a hazy spot in the Milky Way, fantastic in binoculars, and an area truly worth study in any size scope, this 5,200-light-year-diameter area of emission, reflection, and dark nebulae has a rich history. Its involved star cluster—NGC 6530—was discovered by Flamsteed around 1680 and the nebula by Le Gentil in 1747. Cataloged by Lacaille as III.14 about 12 years before Messier listed it as number 8, its brightest region was recorded by John Herschel, and dark nebulae were discovered within it by Barnard.

Tremendous areas of starbirth are found in this region, while young, hot stars excite the gas in a region known as the “Hourglass” around the stars Herschel 36 and 9 Sagittarii. Look closely around cluster NGC 6530 for Barnard Dark Nebulae B 89 and B 296 at the nebula’s southern edge...and try again on a darker night. No matter how long you choose to swim in the “Lagoon,” you will surely find more and more things to delight both the mind and the eye!



Figure 8.8a. M8: the Lagoon Nebula (credit—NOAO/AURA/NSF).



Figure 8.8b. Genesis Spacecraft (credit—NASA).

Sunday, August 9

On this date in 1976, the Luna 24 mission was launched on a return mission of its own, not to retrieve solar winds' samples but lunar soil! Remember this mission as we take a look at its landing site in the weeks ahead. Tonight we'll return to the nebula hunt as we head about a finger-width north and just slightly west of M8 for the "Trifid" (RA 18 02 23 Dec -23 01 48). M20 was discovered by Messier on June 5, 1764, and much to his credit, he described it as a cluster of stars encased in nebulosity. This is truly a wonderful observation, since the Trifid could not have been easy to spot, given his equipment. Some 20 years later William Herschel (although he usually avoided repeating Messier objects) found M20 of enough interest to assign separate designations to parts of this nebula—IV.41, V.10, V.11, V.12. The word "Trifid" was used to describe its beauty by John Herschel.

Although M20 is a very tough call in binoculars, it is not impossible with good conditions to see the light of an area that left its home nearly a millennium ago. Even smaller scopes will pick up this round, hazy patch of both emission and reflection, but you will need aversion to see the dark nebula that divides it. This was cataloged by Barnard as B 85. Larger telescopes will find the Trifid as one of the very few objects that actually appears much in the eyepiece as it does in photographs—with each lobe containing beautiful details, rifts, and folds best seen at lower powers. Look for its cruciform star cluster and its fueling multiple system while you enjoy this triple treat tonight!



Figure 8.9a. Luna 24 launch (press release photo).

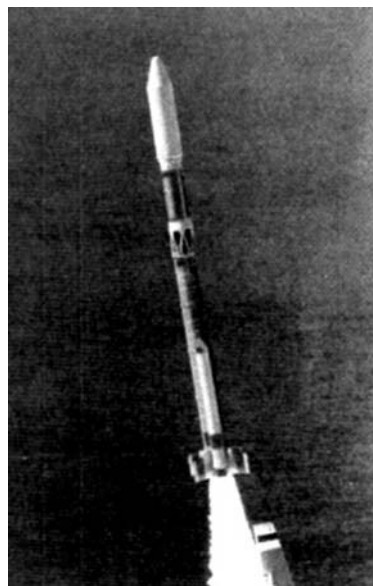


Figure 8.9b. M20: the Trifid nebula (credit—Palomar Observatory, courtesy of Caltech).

Monday, August 10

On this date in 1966, Lunar Orbiter 1 was successfully launched on its mission to survey the Moon. Tonight we'll survey another star-forming region as we head about a palm-width north of the lid star (λ) in the Sagittarius teapot as we seek out "Omega" (RA 18 20 26 Dec - 16 10 36). Easily viewed in binoculars of any size, and outstanding in every telescope, the 5,000-light-year-distant Omega Nebula was discovered by Philippe Loys de Chéseaux in 1745-1746 and later (1764) cataloged by Messier as object 17. This beautiful emission nebula is the product of hot gases excited by the radiation of newborn stars. As part of a vast region of interstellar matter, many of its embedded stars don't show in photographs but reveal themselves beautifully to the eye at the telescope. As you look at its unique shape, you realize that many of these areas are obscured by dark dust, but this same dust is often illuminated by the stars themselves.

Often known as the "Swan," M17 will appear as a huge, glowing check mark or ghostly "2" in the sky, but power up if you use a larger telescope and look for a long, bright streak across its northern edge, with extensions to both the east and north. Although the illuminating stars are truly hidden, you will see many glittering points in the structure itself, and at least 35 of them are true members of this region, spanning about 40 light-years that could contain up to 800 solar masses. It is an awesome sight!



Figure 8.10a. M17 (credit—Palomar Observatory, courtesy of Caltech).



Figure 8.10b. Lunar Orbiter 1 (credit—NASA).

Tuesday, August 11

On this date in 1877, Asaph Hall of the US Naval Observatory was very busy. This night would be the first time he would see Mars's outer satellite Deimos! Six nights later, he observed Phobos, giving Mars its grand total of two moons. Tonight is the peak of the Perseid meteor shower, and this year the early evening has no Moon! Now let's sit back and talk about the Perseids while we watch.

The Perseids are undoubtedly the most famous of all meteor showers and never fail to provide an impressive display. Their activity appears in Chinese records as far back as 36 AD. In 1839, Eduard Heis was the first observer to give an hourly count and discovered that their maximum rate was around 160 per hour at that time. He, and other observers, continued their studies in subsequent years to find that this number varied. Giovanni Schiaparelli was the first to relate the orbit of the Perseids to periodic comet Swift-Tuttle (1862 III). The fall rates have both risen and fallen over the years as the Perseid stream was studied more deeply, and many complex variations were discovered. There are actually four individual streams derived from the comet's 120-year orbital period, which peaks on slightly different nights, but tonight through tomorrow morning at dawn is our accepted peak.

Meteors from this shower enter Earth's atmosphere at a speed of 60 kilometers per second (134,000 miles per hour), from the general direction of the border between the constellations of Perseus and Cassiopeia. Although they can be seen anywhere in the sky, if you extend their paths backward, all the true members of the stream will point back to this region of the sky. For best success, position yourself so you are generally facing northeast and get comfortable. The radiant will continue to climb higher in the sky as dawn approaches and the Moon officially becomes new. If you are clouded out, don't worry. The Perseids will be around for a few more days yet, so continue to keep watch!

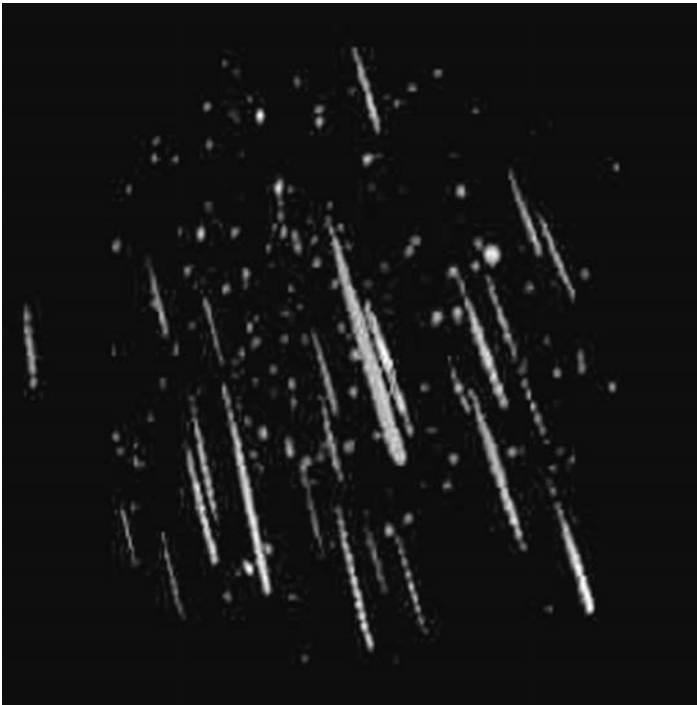


Figure 8.11. Perseids (credit—Sirko Molau, IMO, Archenhold-Sternwarte/NASA).

Wednesday, August 12

Did you mark your calendar to be up before dawn to view the Perseid meteor shower despite the Moon? Good! Tonight, while darkest skies are on our side, we'll fly with the "Eagle" as we hop another finger-width north of M17 (RA 18 18 48 Dec -13 49 00) and head for one of the most famous areas of starbirth—IC 4703.

Although the open cluster NGC 6611 was discovered by Chéseaux in 1745–1746, it was Charles Messier who cataloged the object as M16, and he was the first to note the nebula IC 4703, more commonly known as the "Eagle." At 7,000 light-years-distant, this roughly 7th magnitude cluster and nebula can be spotted in binoculars, but at best it is a hint. As part of the same giant cloud of gas and dust as neighboring M17, the Eagle is also a place of starbirth illuminated by these hot, high energy, stellar youngsters that are only about 5.5 million years old. In small- to mid-sized telescopes, the cluster of around 20 brighter stars comes alive with a faint nebulosity that tends to be brighter in three areas. For larger telescopes, low power is essential. With good conditions, it is very possible to see areas of dark obscuration and the wonderful "notch" where the Pillars of Creation reside. Immortalized by the Hubble Space Telescope (HST), they won't seem them as grand or colorful as HST did, but what a thrill to know they are there!



Figure 8.12. M16 and the Eagle Nebula (credit—Bill Schoening/NOAO/AURA/NSF).

Thursday, August 13

Tonight, begin with just your eyes as you gaze about four finger-widths (RA 18 18 24 Dec –18 26 00) above the top of the Sagittarius “teapot dome” for an open window on the stars and the magnificent M24.

This huge, hazy patch of stars is in reality an area of space known as “Baade’s Window”—an area free of obscuring gas and dust. Cataloged by Messier in 1764 as object 24, even small binoculars will reveal the incredible vista of the “Sagittarius Star Cloud.” Although it’s actually not a cluster, but rather a clean view of an area of our own galaxy’s spiral arm, that will not lessen the impact when viewed through a telescope. Spanning a degree and a half of sky, it is one of the few areas in which even a novice can easily perceive areas of dark dust.

For larger telescopes, look for the dim, open cluster NGC 6603 in the northeastern position of the Window. There are two very notable dark nebulae, B92 and B93, located in the northern segment as well. Near teardrop-shaped B92 and its single central star, you should spot open cluster Collinder 469 and also Markarian 38 south of B93. You’ll find B 86 near Gamma Sagittarii. At the southern edge of the star cloud, look for emission nebulae IC 1283–1284, along with the reflection nebulae NGC 6589 and NGC 6590 and open cluster NGC 6595. Still up for more? Then head west to see if you can find 12th magnitude planetary nebula NGC 6567. Even if you don’t accept these challenges, you can still enjoy looking at a 560-light-year swatch of stars from one of the Milky Way’s loving arms!



Figure 8.13. M24: the Sagittarius Star Cloud (credit—Vanessa Harvey/REU Program/NOAO/AURA/NSF).

Friday, August 14

If you're up well before dawn this morning, look for the Pleiades brushing by the Moon. This could be an occultation event, so be sure to check the Resources section of this book and International Occultation and Timing Association (IOTA) for times and locations.

Tonight let's venture about three finger-widths northeast of Lambda Sagittarii to visit a well known but little visited galactic cluster—M25 (RA 18 31 42 Dec -19 07 00). Discovered by Chéseaux and then cataloged by Messier, it was observed and recorded by William Herschel, Johann Elert Bode, Admiral Smythe, and T.W. Webb but never added to the NGC catalog of John Herschel! Thanks to J.L.E. Dreyer, it did make the second Index Catalog as IC 4725.

M25 is seen even with the slightest optical aid, and this 5th magnitude cluster contains two G-type giants as well as a Delta Cephei-type variable with the designation of U, which changes about 1 magnitude in a period of less than a week. It's very old for an open cluster, perhaps near 90 million years, and the light you see tonight left the cluster over 2,000 years ago. Although binoculars will see about a double handful of bright stars overlying fainter members, telescopes will reveal more and more as aperture increases. At one time it was believed to have only about 30 members, but this was later revised to 86. But recent studies by Archinal and Hynes indicate it may have as many as 601 member stars!



Figure 8.14. M25 (credit—Palomar Observatory, courtesy of Caltech).

Saturday, August 15

On this date in 2006, Voyager 1, the most distant manmade object, reached 100 astronomical units (AUs) from the Sun—meaning 100 times more distant from the Sun than Earth—about 15,000 million kilometers (9,300 million miles). Voyager 1 continues traveling at a rate of about a million miles per day and could cross into interstellar space within 10 years. What fantastic sights do you think it is seeing?

Tonight we'll head toward the riches of Scorpius to have a look at three pristine open clusters. Begin your starhop at the colorful southern Zeta pair and head north less than 1 degree for NGC 6231 (RA 16 54 08 Dec -41 49 36). Wonderfully bright in binoculars and well resolved in the telescope, this tight-open cluster was discovered by Hodierna before 1654. De Chéseaux cataloged it as object 9, Lacaille as II.13, Dunlop as 499, Melotte as 153, and Collinder as 315. No matter what catalog number you choose to put in your notes, you'll find the 3.2-million-year young cluster shining as the "Northern Jewelbox!" For high power fans, look for the brightest star in this group, called van den Bos 1833, a splendid binary.

About another degree north is the loose open cluster Collinder 316, with its stars scattered widely across the sky. Caught on its eastern edge is another cluster known as Trumpler 24, a site where new variables might be found. This entire region is encased in a faint emission nebula called IC 4628, making this low-power journey through southern Scorpius a red-hot summer treat!



Figure 8.15a. NGC 6231 (credit—Palomar Observatory, courtesy of Caltech).

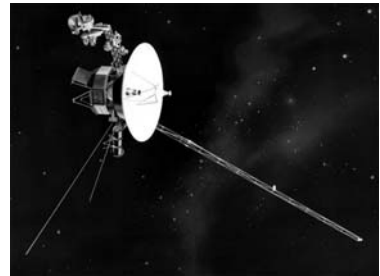


Figure 8.15b. Voyager 1 (credit—NASA).

Sunday, August 16

Before dawn, look for the close pair of Mars and the Moon celebrating the 1744 birth on this date of Pierre Méchain! We know Méchain as Charles Messier's assistant, but Méchain was himself a fine astronomer and mathematical prodigy. He discovered 11 comets, and provided 26 entries to Messier's catalog. If he were alive today, Pierre would be eager to join us tonight for our studies. Begin about a degree and a half south of twin Nu Scorpii for NGC 6242 (RA 16 55 36 Dec -39 28 00). Discovered by Lacaille and cataloged as I.4, this object is also known as Dunlop 520, Melotte 155, and Collinder 317. At roughly magnitude 6, this open cluster is within binocular range but truly needs a telescope to appreciate its fainter stars. Although NGC 6242 might seem like nothing more than a pretty little cluster with a bright double star, it contains an X-ray binary that is a "runaway" black hole, surmised to have formed near the galactic center and vaulted into an eccentric orbit when the progenitor star exploded. Its kinetic energy is much like that of a neutron star or a millisecond pulsar, and it was the first black hole confirmed to be in motion.

Now head a little more than a degree east-southeast for NGC 6268 (RA 17 02 40 Dec -39 44 18). At a rough magnitude of 9, this small open cluster can be easily observed in smaller scopes and resolved in larger ones. NGC 6268 itself is somewhat lopsided, with more of its members clustered near its western border. Although it, too, might not seem particularly interesting, this young cluster is highly evolved and contains some magnetic, chemically peculiar stars; it has some Be-class, or metal-weak, members as well.



Figure 8.16a. NGC 6242 (credit—Palomar Observatory, courtesy of Caltech).



Figure 8.16b. NGC 6268 (credit—Palomar Observatory, courtesy of Caltech).

Monday, August 17

Photographic opportunity knocks! Before dawn, brilliant Venus and the crescent Moon will adorn the sky. Even if you don't take a picture, the view should be an inspiration to your day! If you'd like to catch another pair, look for Saturn tonight at twilight. Joining it about 3 degrees south is elusive Mercury. Use binoculars, and you should be able to see both in the same field of view!

Let's salute the 1966 Pioneer 7 launch on this date. It was the second in a series of satellites sent to monitor the solar wind, as well as to study cosmic rays, interplanetary space, and magnetic fields. Tonight we'll launch our own studies as we locate Lambda Scorpii and hop three finger-widths northeast (RA 17 40 18 Dec -32 12 00). We're hunting the "Butterfly!"

Easily seen in binoculars and tremendous in the telescope, this brilliant magnitude 4 open cluster was discovered by Hodierna before 1654 and independently found by de Chéseaux as his object 1, before being cataloged by Messier as M6. Containing about 80 stars, the light you see tonight left its home in space around the year 473 AD. It is believed to be around 95 million years old and contains a single yellow supergiant, the variable BM Scorpii. Although most of M6's stars are hot, blue, and on the main sequence, the unique shape of this cluster gives it not only visual appeal but wonderful color contrast as well!



Figure 8.17. M6: the Butterfly Cluster (credit—Nigel Sharp and Mark Hannah/NOAO/AURA/NSF).

Tuesday, August 18

Before sunrise, go out with binoculars and look at the Moon. If you haven't had a chance to catch an asteroid, then you'll get two for the bargain! Both bright Vesta and Hygeia are less than half a degree from the southern limb, and the pair is separated from each other by just a fraction of a degree. Given Vesta's magnitude, you can rest assured that it will be the brightest "star" near the limb!

On this date in 1868, Norman Lockyer was very busy, becoming the first person to see helium absorption lines in the Sun's spectrum. Tonight we'll take a walk from helium-rich Lambda Scorpii about three finger-widths east-northeast to an even more prominent area of stars, dating back to Ptolemy in 130 AD. Astronomers throughout the ages have spent time with this cluster: Hodierna knew it as Ha II.2, Halley in 1678 as number 29, Denham in 1733 as number 16, De Chéseaux as number 10, Lacaille as II.14, Bode as 41, John Herschel as h 3710, and Dreyer as NGC 6475. . . But we know it best as Messier object 7 (RA 17 53 48 Dec -34 47 00). (William Herschel noted it but didn't give it a number, as was his practice with Messier objects.)

Set against the backdrop of the Milky Way, even the smallest of binoculars will enjoy this bright open cluster, while telescopes can resolve all of its 80 members. Roughly 800 light-years away, it contains many different spectral types in various stages of evolution, giving the cluster an approximate age of 260 million years. Full of binaries and close doubles, an extreme test of tonight's soon-to-be moonlit conditions would be to see if you can spot the 11th magnitude globular cluster NGC 6543 to the northwest!



Figure 8.18. M7: Ptolemy's Cluster (credit—Nigel Sharp, REU program/NOAO/AURA/NSF).

Wednesday, August 19

Born on this date in 1646 was John Flamsteed, an English astronomer with a passion for what he did. Despite a rather difficult childhood and no formal education, Flamsteed went on to become the First Observer at the Royal Observatory, and his catalog of 3,000 stars was perhaps the most accurate published up to his time. Flamsteed's star numbers are still in use.

Let's honor Flamsteed with tonight's studies at the far eastern edge of Sagittarius. NGC 6818 (RA 19 43 57 Dec -14 09 11) is known as the "Little Gem" nebula for its distinctive green color. This 9th magnitude object looks nearly stellar in binoculars, and shows as annular magnified with a telescope. Small, but bright, 6,000-light-year-distant NGC 6818 was a prime target of the HST. Research showed two distinct regions, the round shell-like outer layer and an elongated interior "bubble." Scientists believe the central star is responsible for this characteristic. Fast winds from this fueling core may have elongated the inner region and ruptured the outer shell!

Less than a degree south is the summer's most curious galaxy—NGC 6822 (RA 19 44 57 Dec -14 48 11), which is a telescopic challenge even for skilled observers but not an impossible one. Why bother? Because this distant dwarf galaxy is bound to our own Milky Way by gravitational attraction. Named after its discoverer (E.E. Barnard, 1884), Barnard's Galaxy is a not-so-nearby member of our local galaxy group. Discovered with a 6" refractor, the 1.7-million-light-year NGC 6822 can be seen with very dark sky conditions at the lowest possible power due to its large apparent size and low surface brightness. Large telescopes will see faint regions of glowing gas (HII regions) and unresolved concentrations of bright stars. To distinguish them, try a nebula filter to enhance the HII and downplay the star fields. Barnard's Galaxy appears like a very faint open cluster overlain with a sheen of nebulosity, but using the above technique, the practiced eye will clearly see that the "shine" behind the stars is extragalactic in nature!



Figure 8.19a. NGC 6818: The Little Gem (credit—Palomar Observatory, courtesy of Caltech).



Figure 8.19b. NGC 6822: Barnard's Galaxy (credit—Palomar Observatory, courtesy of Caltech).

Thursday, August 20

Tonight go south of Sagittarius to look for the delicate crescent of stars called the Southern Crown, Corona Australis. Its hidden jewel is the 7.3-magnitude, 28,000-light-year-distant globular cluster NGC 6723 (RA 18 59 33 Dec $-36\ 37\ 53$). Discovered on June 3, 1826, by James Dunlop of New South Wales, Australia, NGC 6723 can be best found by heading less than 7 degrees due south of Zeta Sagittarii. This mid-sized cluster gives a surprising view, but if you're in a more northerly location, best catch it at its highest.

But if you're in the south? Then drop just a bit further southeast and have a look at the reflection-emission nebulae NGC 6726/27/29 (RA 19 01 39 Dec $-36\ 53\ 28$). The three nebulae were discovered by Johann Schmidt during his observations at Athens Observatory in 1861 and were independently recovered by Marth, 3 years later in Malta. Even with a small scope, the brighter portions are visible as a faint haze and come to life with aperture. Be sure to note the easily split double BSO 14 in the same field!

Now, relax. . . Tonight is the peak of the Kappa Cygnid meteor shower. Tonight is also the New Moon and a great time to just kick back and watch the area near Deneb. Discovered in the late 1800s, the Kappa Cygnids are often overlooked because the grander, more prolific Perseids get more attention. Although the stream has been verified, peak dates and fall rates vary from year to year. The average rate is usually no more than 5 per hour, but it is not uncommon to see 12 or more per hour, with many fireballs. The stream's duration is about 15 days. Clear skies!



Figure 8.20a. NGC 6723 (credit—Palomar Observatory, courtesy of Caltech).



Figure 8.20b. NGC 6726 (credit—Stephen Boyd).

Friday, August 21

On this date in 1993, the Mars Observer was lost. . . But you can't miss Mars at its peak just before dawn!

Tonight it's time for us to fly with the "Swan" as the graceful arch of the Milky Way turns overhead. We'll start by taking a look at a bright star cluster that's equally great in either binoculars or telescope, M39. Located about a fist-width northeast of Deneb (Alpha Cygni), you will easily see a couple of dozen stars in a triangular pattern. M39 (RA 21 31 48 Dec +48 27 00) is particularly beautiful because it will seem almost three-dimensional against its backdrop of fainter stars. Younger than the Coma Berenices cluster, and older than the Pleiades, the estimated age of M39 is at least 230 million years. This loose, bright, galactic cluster is around 800 light-years away. Its members are all main sequence stars, and the brightest of them are beginning to evolve into giants.

For more of a challenge, try dropping about a degree south-southwest (RA 21 29 00 Dec +47 08 00) for NGC 7082, also known as H VII.52. Although it is a less rich, less bright, and far less studied open cluster, at magnitude 7.5 NGC is within range of binoculars and is on many open cluster observing lists. With only a handful of bright stars to NGC 7082's credit, larger telescopes are needed to resolve out many of the fainter members. Be sure to mark your notes for both objects!



Figure 8.21a. M39 (credit—Palomar Observatory, courtesy of Caltech).



Figure 8.21b. NGC 7082 (credit—Palomar Observatory, courtesy of Caltech).

Saturday, August 22

Born this date in 1833 was Samuel Pierpont Langley, who investigated the relationship between solar phenomena and meteorology. Is that why we always have clouds when solar activity is at its best?

Tonight we'll hunt with the "Fox" as we head to Vulpecula to try two more open star cluster studies. The first can be done easily with large binoculars or a low power scope. It's a rich beauty in the constellation of Vulpecula but is more easily found by moving around 3 degrees southeast of Beta Cygni (RA 19 35 48 Dec +25 13 00). Known as Stock 1, this stellar swarm contains 50 or so members of varying magnitudes, which you will return to often. With a visual magnitude of near 5, loose associations of stars—like Stock clusters—are the subject of recent research. The latest information indicates that the members of this cluster are truly associated with one another.

A little more than a degree to the northeast is NGC 6815 (RA 19 40 44 Dec +26 45 32). Although NGC 6815 is a slightly more compressed open cluster, it has no real status among deep-sky objects, but it is another one to add to your collection of things to do and see!



Figure 8.22a. Stock 1 (credit—Palomar Observatory, courtesy of Caltech).



Figure 8.22b. NGC 6815 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, August 23

On this date in 1609, Galileo demonstrated the telescope for the first time. Tonight we'll aim our own optics at an asterism known as the "Coat Hanger," which is also known as Brocchi's Cluster, or Collinder 399. Let the colorful double star Beta Cygni—Albireo—be your guide as you move about 4 degrees to its south-southwest (RA 19 25 24 Dec +20 11 00). You will know this cluster when you see it, because it really does look like a coat hanger! Enjoy its red stars. Discovered by Al Sufi in 964 AD, this 3.5-magnitude collection of stars was again recorded by Hodierna. Thanks to its extended size of more than 60', it escaped the catalogs of both Messier and Herschel. Only around a half dozen stars share the same proper motion, which may make it a cluster much like the Pleiades, but studies suggest it is merely an asterism—but one with two binary stars at its heart.

And for larger scopes? Fade east to the last prominent star in the cluster (RA 19 30 36 Dec +20 16 00) and power up. NGC 6802 awaits you! At near magnitude 9, Herschel VI.14 is a well-compressed open cluster of faint members. The subject of ongoing research in stellar evolution, this 100,000-year-old cluster is on many observing challenge lists!

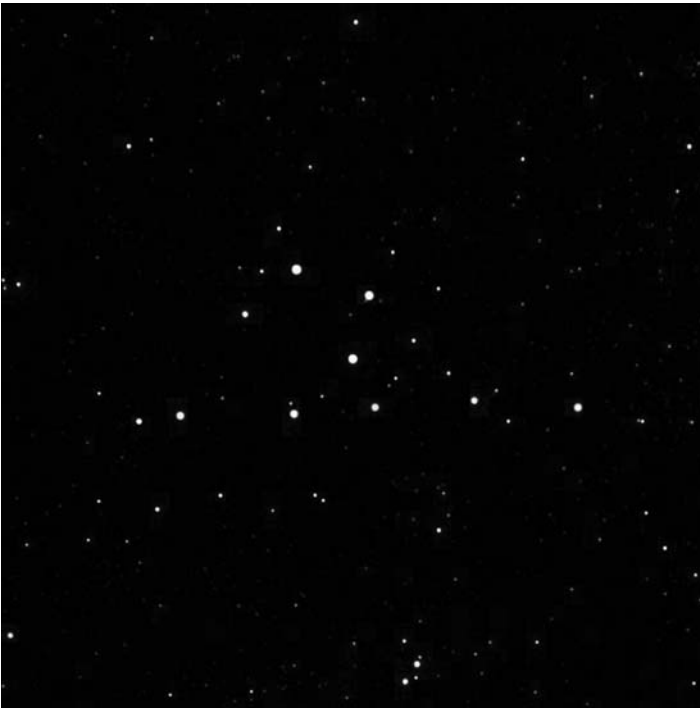


Figure 8.23a. Collinder 399 (credit—Gil Estel).



Figure 8.23b. NGC 6802 (credit—Palomar Observatory, courtesy of Caltech).

Monday, August 24

Tonight it's going to be very hard to ignore the Moon, so why don't we start by returning to a previously studied Lunar Club Challenge? Your mission is to locate crater Petavius along the south-east shore of Mare Fecunditatis and have a look at the Petavius Wall. While you're admiring Petavius and its rima, keep in mind that this 80-kilometer-long crack is a buckle in the lava flow across the crater floor. Now, look along the terminator for the long, dark rannel, which is often called the Petavius Wall but is actually the fascinating crater Palitzsch. This 41-kilometer-wide crater is confluent with a 110-kilometer-long valley that is outstanding at this phase!

Our study continues tonight as we move away from the galactic center in search of a remote globular cluster that can be viewed by most telescopes. As we have learned, radial velocity measurements show us that the majority of globulars are involved in highly eccentric elliptical orbits that take them far outside the plane of the Milky Way. These orbits form a sort of spherical "halo," which is more concentrated toward our galactic center. This halo is actually larger than the disk of our own galaxy. Since globular clusters don't take part in our galaxy's disk rotation, they can possess very high relative velocities. Tonight let's head toward the constellation of Aquila and look at one such globular—NGC 7006 (RA 21 02 29 Dec +16 11 14). Located about half a fist-width east of Gamma Aquilae, NGC 7006 is speeding toward us at a velocity of around 350 kilometers per second. At 150,000 light-years from the center of our galaxy, this particular globular could very well be an extragalactic object, like our earlier study M54. At magnitude 11.5, it's not for the faint of heart but can be spotted in scopes as small as 150 millimeters; it requires larger aperture to look like anything more than a suggestion. Given its distance from the galactic center, it's not hard to realize this is a Class I (the most concentrated), even though it is quite faint. Even the largest of amateur scopes will find it unresolvable!

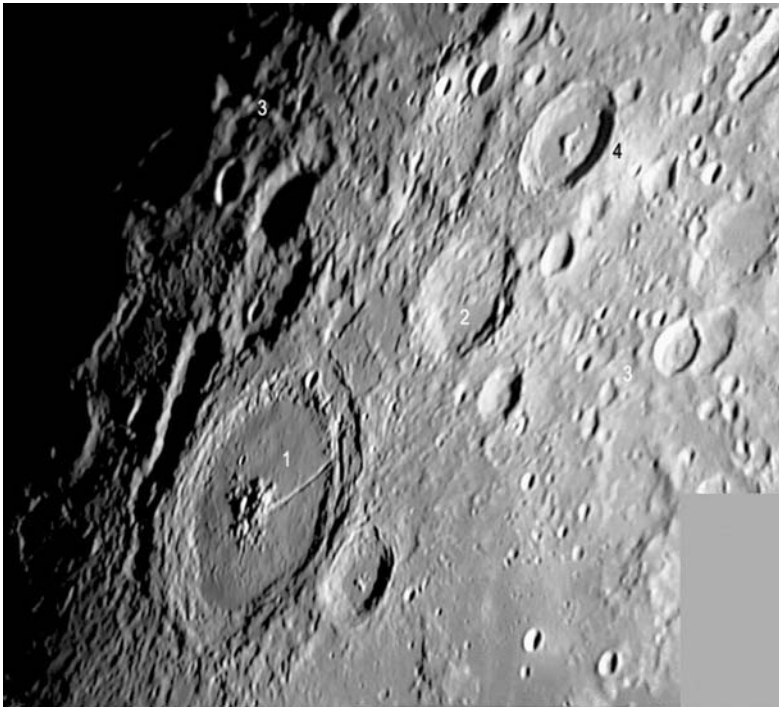


Figure 8.24a. Petavius (credit—Alan Chu).



Figure 8.24b. NGC 7006 (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, August 25

Tonight Spica appears to commemorate the 1822 death on this date of Sir William Herschel as it glides by the north limb of the Moon.

Tonight's venture to the lunar surface reveals the Serpentine Ridge located near Posidonius. Properly named Dorsa Smirnov, it runs for 130 kilometers north to south across Mare Serenitatis. Can you spot the very tiny crater Very in its center?

Now let's continue our globular cluster studies with structure. As a rule, most contain a large number of RR Lyrae-type stars once known as "cluster variables." Globulars can also contain a large number of white dwarfs, and some have neutron stars detectable as pulsars. However, out of our galaxy's 151 known globular clusters, only four harbor an unusual object. . . a planetary nebula.

Head to Pegasus to locate magnitude 6.5, Class IV M15. Viewable in small binoculars about one field of view northwest of Enif (RA 21 29 58 Dec +12 10 00), this magnificent globular cluster turns into a true delight in a telescope. Compared to its peers, M15 ranks third in variable star population, with 112 identified. The central core is one of the densest known, and almost half of M15's mass is contained within it. Studies by the HST are unclear, and we still don't know if this density is caused by the mutual gravity of the core's stars or if it disguises a super-massive object similar to those found in galactic nuclei. M15's collapsing core is also home to nine known pulsars, which are neutron stars left behind from previous supernovae occurring during the cluster's evolution. One is even a double neutron star! Although we cannot totally resolve M15, it was the first globular cluster in which a viewable planetary nebula, known as Pease 1, was identified—and it awaits your investigation tonight!



Figure 8.25a. The Serpentine Ridge (credit—sketch by Deirdre Kelleghan).



Figure 8.25b. M15 (credit—NOAO/AURA/NSF).

Wednesday, August 26

Are you ready for a lunar walk? Then look to the northwest shore of Mare Serenitatis for Aristoteles and Eudoxus. Mark your notes and then look for other features!

When the Moon has set, let's finish our globular cluster studies. Look for the major distribution centers on our galaxy's core region in the Ophiuchus/Sagittarius area. Orbiting the galactic center for billions of years, globular clusters have endured a wide range of disturbances. Their component stars escape when accelerated by mutual encounters, and the tidal force at the center of our own Milky Way pulls them apart at periastris. Close encounters with clusters and nebulae can also act upon them! As their stellar members evolve, gas loss results in mass loss. Although it happens slowly compared to open clusters, our observable globular friends are the last survivors of a once larger population, whose stars have been spread throughout the halo. This process of destruction is never-ending, and globular clusters may cease to exist in 10 billion years.

Now look for M75 about 8 degrees southwest of Beta Capricorni (RA 20 06 04 Dec -21 55 16.) Residing around 67,500 light-years away, M75 is one of the most remote Messiers. Possibly 100,000 light-years from the galactic center, M75 has survived billions of years to remain one of the few Class I globulars.

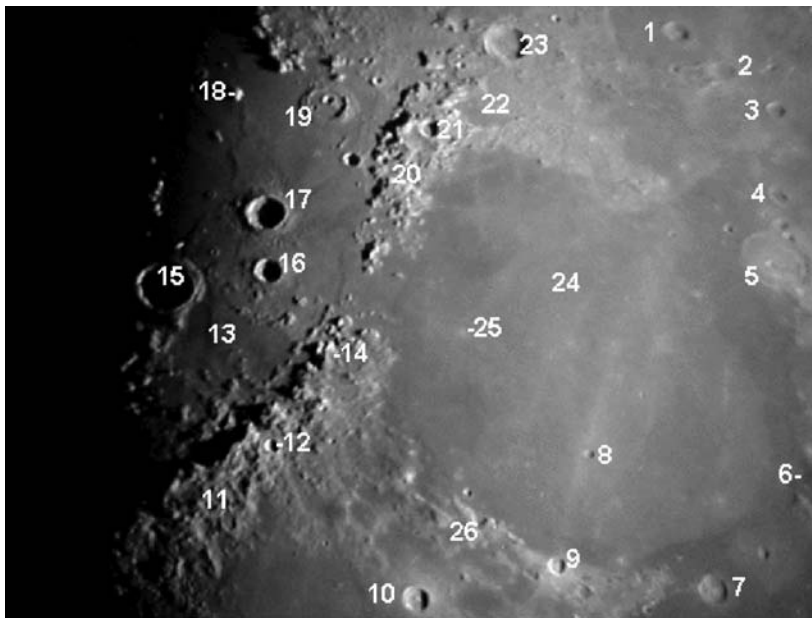


Figure 8.26a. Eudoxus area (credit—Greg Konkel). (1) Burg, (2) Barrow, (3) Grove, (4) Daniel, (5) Posidonius, (6) Apollo 17 Landing Area, (7) Plinius, (8) Bessel, (9) Menelaus, (10) Manilius, (11) Apennine Mountains, (12) Conon, (13) Palus Putredinus, (14) Mons Hadley, (15) Archimedes, (16) Autolycus, (17) Aristillus, (18) Mons Piton, (19) Cassini, (20) Caucasus Mountains, (21) Calippus, (22) Alexander, (23) Eudoxus, (24) Mare Serenitatis, (25) Linné, and (26) Haemus Mountains.



Figure 8.26b. M75 (credit—Palomar Observatory, courtesy of Caltech).

Thursday, August 27

Our first order of business for the evening will be to pick up a Lunar Club Challenge we haven't noted yet—Hipparchus. Located just slightly south of the central point of the Moon, and very near tonight's terminator, this is not truly a crater but a hexagonal mountain-walled plain. Spanning about 150 kilometers in diameter with walls around 3,320 meters high, it is bordered just inside its northern wall by crater Horrocks. This deep appearing "well" is 30 kilometers in diameter, and its rugged interior drops down an additional 2,980 meters below the floor. To the south and just outside the edge of the plain is crater Halley. Slightly larger at 36 kilometers in diameter, this crater (named for Sir Edmund) is a little shallower at 2,510 meters, but it has a very smooth floor. To the east, you'll see a series of three small craters, the largest of which is Hind.

Now let's go have a look at a star buried in one of the spiral arms of our own galaxy—W Sagittarii (RA 18 05 01 Dec -29 34 38).

Located less than a finger-width north of Gamma, the tip of the "teapot spout," W is a Cepheid variable that's worth keeping an eye on. Although its brightness varies by less than a magnitude, it does so in less than 8 days! Normally holding close to magnitude 4, nearby field stars will help you correctly assess when minimum and maximum occur. Although it's difficult for a beginner to see such changes, watch it over a period of time. At maximum, it will be only slightly fainter than Gamma to the south. At minimum, W will be only slightly brighter than the stars to its northeast and southwest. While you watch W go through its changes, think on this: not only is W a Cepheid variable (a standard for distance measurements), but it is also one that periodically changes its shape. Not enough? Then think twice. . . Because W is also a Cepheid binary. Still not enough? Then you might like to know that recent research points toward W having a third companion as well!

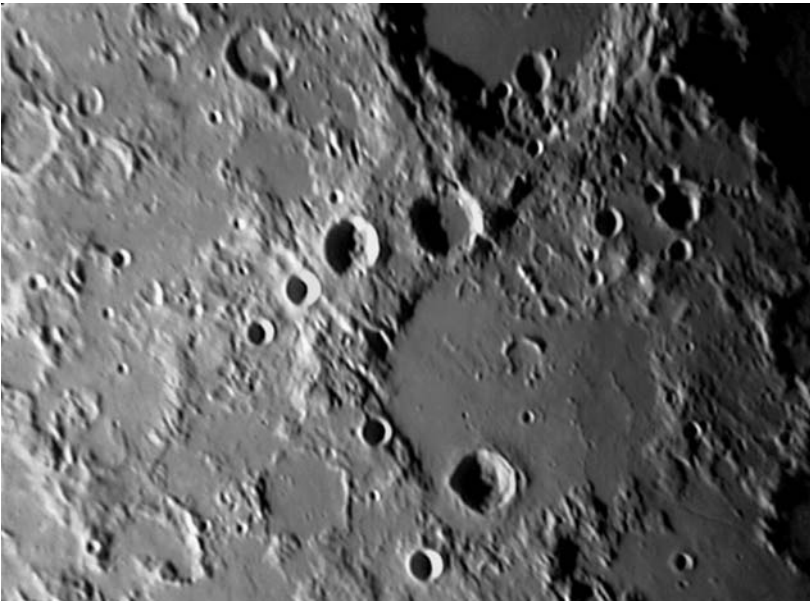


Figure 8.27a. Hipparchus (credit—Alan Chu).

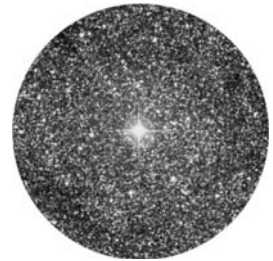


Figure 8.27b. W Sagittarii (credit—Palomar Observatory, courtesy of Caltech).

Friday, August 28

When we begin our observations tonight, we'll start by having a look at another great binocular or telescope study crater, Archimedes. You'll find it located in the Imbrium plain north of the Apennine Mountains and west of Autolycus. Under this lighting, the bright ring of this Class V walled plain extends 83 kilometers in diameter. Even though it looks to be quite shallow, it still has impressive 2,150-meter-high walls. To its south is a feature not often recognized, the Montes Archimedes. Although this relatively short range is heavily eroded, it is still visible across 140 km of lunar topography. Look for a shallow rima that extends southeast across Palus Putredinus toward the Apennines. Mark your challenge notes!

Keep those binoculars handy, as we look toward the Northern Cross, otherwise known as Cygnus the Swan. Start at the Swan's beak—Albireo—and hold the binoculars very steady. Can you make out two stars where you thought there was one? If so, then you are seeing 3.2-magnitude Albireo's distant companion. But don't stop with binoculars; bring out the scope and have another look at Beta Cygni (RA 19 30 45 Dec +27 57 55). Albireo's brighter star is a warm golden yellow and the fainter is a pristine aqua blue. Many astronomers agree this is the premier pair of colors in the heavens!

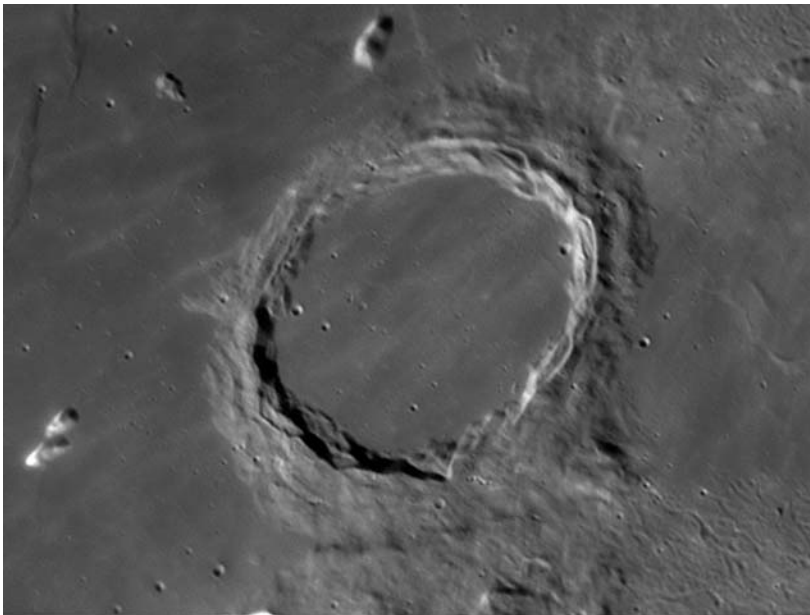


Figure 8.28a. Archimedes (credit—Wes Higgins).

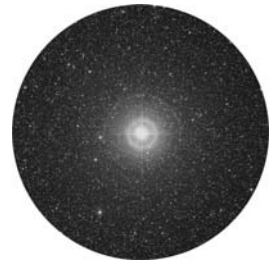


Figure 8.28b. Beta Cygni (credit—Palomar Observatory, courtesy of Caltech).

Saturday, August 29

Our lunar mission for tonight is to move south, past the crater rings of Ptolemaeus, Alphonsus, Arzachel, and Purbach, until we end up at the spectacular crater Walter. Named for Dutch astronomer Bernhard Walter, this 132- by 140-kilometer-wide lunar feature offers up amazing details at high power. It is worthwhile to take the time to study the differing levels, which drop to a maximum of 4,130 meters below the surface. Multiple interior strikes abound, but the most fascinating of all is the wall crater Nonius. Spanning 70 kilometers, Nonius would also appear to have a double strike of its own—one that's 2,990 meters deep!

Although it will be tough to locate with the unaided eye thanks to the Moon, let's take a closer look at one of the most unsung stars in this region of sky—Eta Sagittarii (RA 18 17 37 Dec -36 45 42). This M-class giant star will display a wonderful color contrast in binoculars or scopes, showing up as slightly more orange than stars in the surrounding field. Located 149 light-years away, this irregular variable is a source of infrared radiation and is a little larger than our own Sun, yet is 585 times brighter. At around 3 billion years old, Eta has either expended its helium core or just began to fuse carbon and oxygen, creating an unstable star capable of changing its luminosity by about 4%. But have a closer look, for Eta is also a binary system with an 8th magnitude companion!

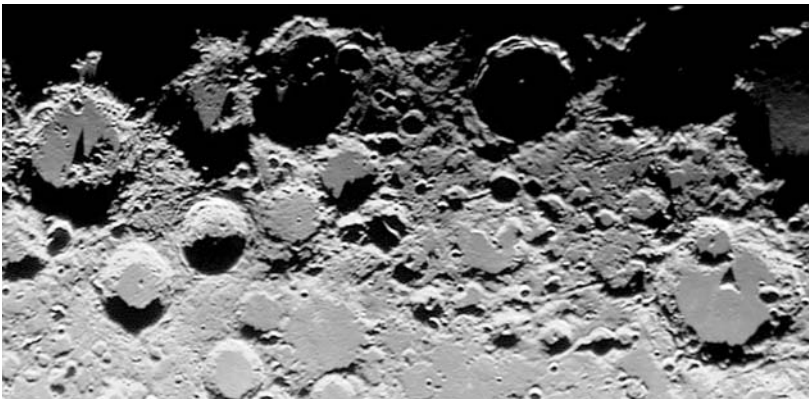


Figure 8.29a. Albategnius to Walter (credit—Alan Chu).



Figure 8.29b. Eta Sagittarii (credit—Palomar Observatory, courtesy of Caltech).

Sunday, August 30

Tonight let's do a little Moon-discovering of our own as we head to the western shore of Mare Cognitum and look along the terminator for the Montes Rhiphaeus—the “Mountains in the Middle of Nowhere.” But are they really mountains? Let's take a look. . . At its widest, this unusual range spans about 38 kilometers and runs for a distance of about 177 kilometers. Less impressive than most lunar mountain ranges, some peaks reach up to 1,250 meters high, making these summits about the same height as our Earthly volcanoes Mounts St. Augustine and Kilauea. While we are considering volcanic activity, consider that these peaks are the only things left of Mare Cognitum's walls after the lava filled them in. At one time, this area may have included some of the tallest lunar features!

Tonight let's have a look at the second brightest star of the Summer Triangle—Altair (RA 19 50 47 Dec +08 52 06). Like Vega, 16-light-year-distant Alpha Aquilae is a Sirius-type star, which is several times the size and mass of our Sun. Such stars burn hotter at the surface (approaching 10,000 Kelvin) and appear much whiter to the eye as a result. An unusual feature of Altair is its exceedingly high speed of rotation, requiring just 6 hours to complete an “Altairian day” at the equator. Because of this, its girth is significantly greater than its height, and gases on the equator move along at the surprising rate of 150 kilometers per second! As you observe Altair telescopically, look for a 10th magnitude companion roughly 3' to the northwest.



Figure 8.30a. Montes Rhiphaeus (credit—Greg Konkell).



Figure 8.30b. Alpha Aquilae: Altair (credit—Palomar Observatory, courtesy of Caltech).

Monday, August 31

Today we celebrate two births—Sir Bernard Lovell (1913) and Robert Hanbury Brown (1916). Sir Bernard established the Jodrell Bank radio telescope, and Brown used it to map stellar radio sources!

Tonight's lunar studies can be seen with binoculars or telescopes. Just slightly north of center, along the terminator, look for the bright point of Kepler and equally bright Aristarchus. Each will develop a bright ray system in the coming days! West of Aristarchus is telescopic crater Herodotus and a fine white thread known as Vallis Schroteri, or Schroter's Valley, to the north. Winding its way across the Aristarchus plain for 160 kilometers, it is from 3 to 8 kilometers wide and is about 1 kilometer deep. But what is it? Schroter's Valley is a prime example of a collapsed lava tube—perhaps created from early volcanic activity—or by a major meteor strike, like the one that formed the Aristarchus. This long, narrow cave on the surface only shows well when the lighting is perfect. Like many sinuous Rilles on the surface, Schroter's Valley has collapsed. If any intact lava tubes can be found on the Moon, they could conceivably provide shelter for future settlers!

Now have a look at the brightest star in the "Archer," Epsilon Sagittarii (RA 18 24 10 Dec –34 23 04). Known as Kaus Australis, or the "Southern Bow," 120-light-year-distant blue-white Epsilon is 250 times brighter than our own Sun. Although a major challenge would be to spot Epsilon's 14th magnitude companion located about 32" away, even the smallest telescope or binoculars can spot the 7th magnitude visual companion to the north-northwest!

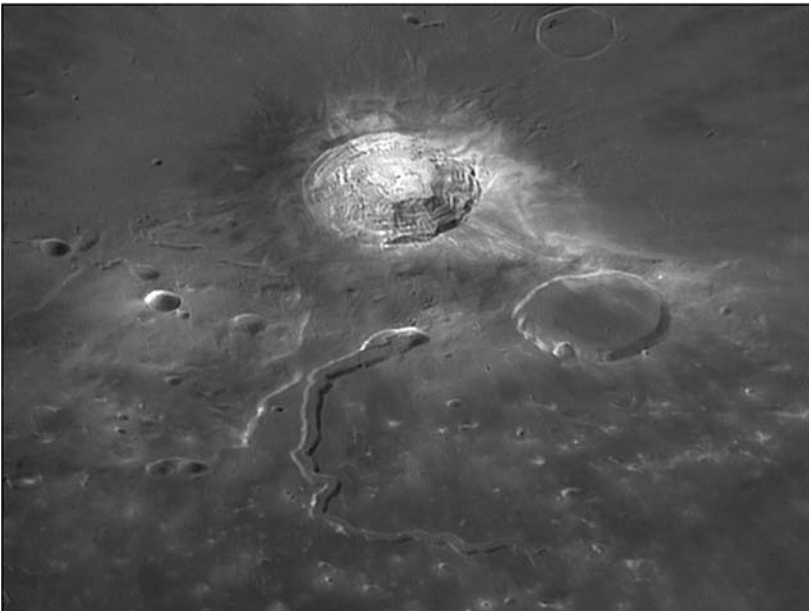


Figure 8.31a. Schroter's Valley (credit—Wes Higgins).



Figure 8.31b. Epsilon Sagittarii: Kaus Australis (credit—Palomar Observatory, courtesy of Caltech).

CHAPTER NINE



September, 2009

Tuesday, September 1

On this date in 1859 solar physicist Richard Carrington (who first assigned sunspot rotation numbers) observed the first recorded solar flare. Naturally enough, an intense aurora followed the next day. One hundred and twenty years later, in 1979, Pioneer 11 made history as it flew by Saturn. And where is Saturn now? Fading west. Fast. . . catch it before it's gone!

Tonight we'll start our observations in the lunar southwest as we look along the terminator to identify the challenge crater Schickard. Look for an elongated gray oval that's more than just another cool crater. Named for Dutch mathematician and astronomer Wilhelm Schickard, this 227-kilometer-diameter feature is a ringed plain and is very old. At high power you'll see a variegated floor and dark areas near the walls, yet the center is creased by a lighter coloration. It is believed Schickard was formed by an early impact before Mare Nectaris formed. Its floor may have contained vents that allowed it to fill with lava during the Imbrium period. As it cooled and matured, another impact formed the Orientale basin and splashed material Schickard's way. But Schickard wasn't done evolving yet. . . Lava continued to flow, and left even more dark evidence for us to observe. How do we know this is so? If you're able to resolve Schickard's tiny interior impacts, you'll see that far fewer occur over the newer material. Older formations bear the scars of time and impact, while younger features are fresh and unmarked!

For observers of the southern skies, it's your turn to take a look at a specific star! Your mission? Gamma Arae (RA 17 25 23 Dec -56 33 39). Visually, this 680-light-year-distant, 3rd magnitude, B-type star has a nearby visual companion. But have you looked telescopically? A well-separated 10th magnitude companion to Gamma Arae was discovered by John Herschel in 1835. Discover it for yourself tonight!

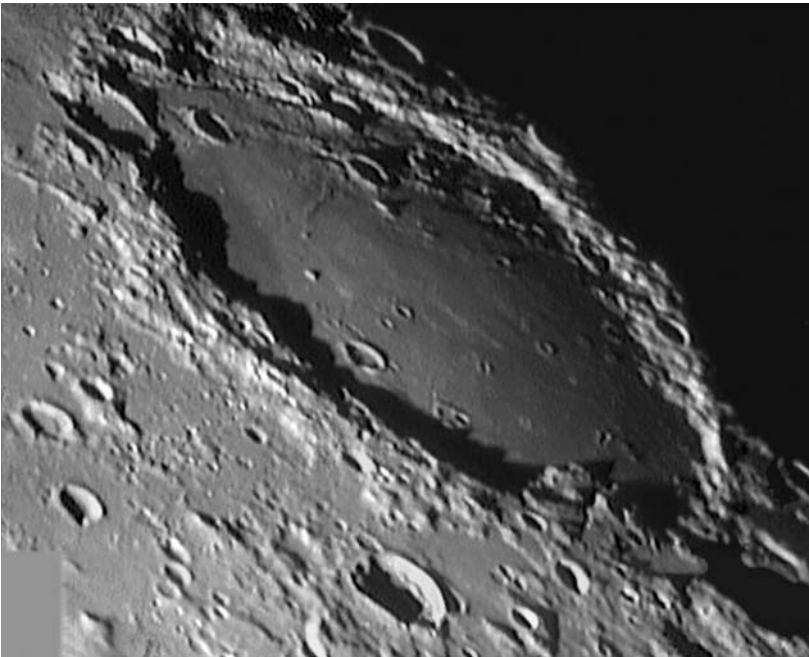


Figure 9.1a. Schickard (credit—Alan Chu).



Figure 9.1b. Gamma Arae (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, September 2

Today we celebrate the 1908 birth of Nikolai Aleksandrovich Kozyrev on this date. Are you familiar with this Russian astronomer? He was the first to photograph lunar outgassing and conclude that the Moon isn't a dead world after all. Crater Alphonsus is now much too overlit to enjoy, so let's continue our study of lunar evolution as we have a look at another walled plain just south of Grimaldi. Named for English naturalist Charles Darwin, this old feature also bears the scars of the impact that created the Orientale Basin. Look carefully at the slopes in the northeast, for this may very well be material that was thrown there and left to slide back down to the crater floor. Spanning about 130 kilometers in diameter, Darwin's actual size is only diminished by the fact that we view it on a curve. Its northern and southern shores have almost completely eroded, yet some evidence remains of its eastern margin, broken in places by the Rima Darwin, which stretches for 280 kilometers. Was there lava here as well? Yes. Evidence of this still exists in the form of a dome along Darwin's battered western edge.

Mirror, mirror on the wall. Who's the brightest Cepheid of them all? Let's find out as we head way down south again for a look at another unusual star, Kappa Pavonis (RA 18 56 57 Dec -67 14 00). This normal-appearing G-type star is actually a Cepheid variable in disguise. Watch for Kappa to change by almost a full magnitude in a period of just about 9 days!

Now, look around the Moon... Jupiter is dancing nearby!

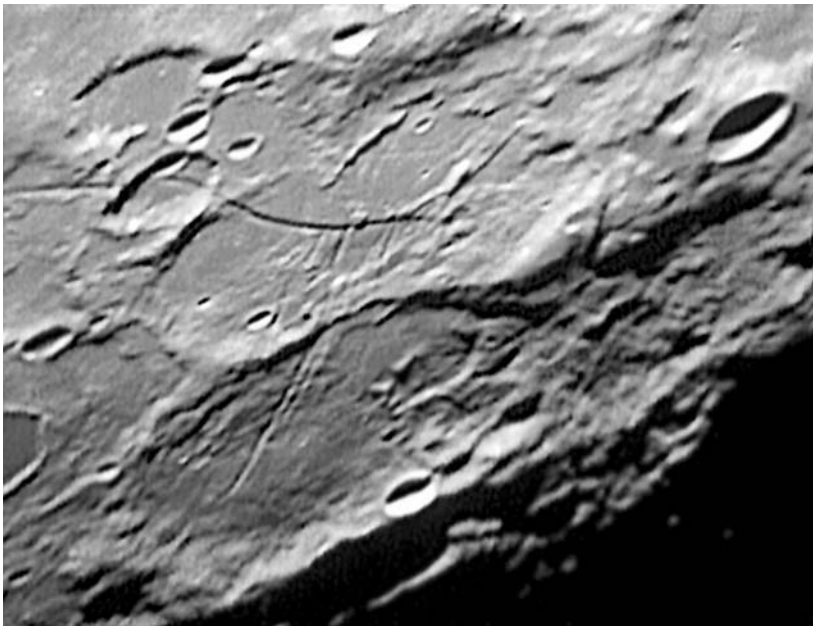


Figure 9.2a. Crater Darwin (credit—Alan Chu).



Figure 9.2b. Kappa Pavonis (credit—Palomar Observatory, courtesy of Caltech).

Thursday, September 3

It's a great day for landings! On this date in 1976, Viking 2 landed on Mars, and in 2006, SMART 1 went into the history books as it impacted the lunar surface in Lacus Excellentiae. Launched on September 27, 2003, by European Space Agency (ESA), it entered lunar orbit over a year later on November 13, 2004. After operating 5,000 hours through 483 starts and stops, the xenon-ion engines ran out of fuel in September 2005, but not before the mission successfully completed its mapping studies. Although the craft caused a brief flash on the surface as it ended its life, it left an indelible mark on history—one almost as important as that left in 1959 by the first craft to impact the Moon, Luna 2.

Think having all this Moon around is the pits? Then let's venture to Zeta Sagittarii (RA 19 02 36 Dec -29 52 48) and have a look at Ascella—the "Armpit of the Centaur." Although you'll find Zeta easily as the southern star in the handle of the teapot formation, what you won't find is an easy double. With almost identical magnitudes, Ascella is one of the most difficult of all binaries. Discovered by W.C. Winlock in 1867, the components of this pair orbit each other very quickly—in little more than 21 years. Although they are about 140 light-years away, this gravitationally bound pair waltz no further apart than do our own Sun and Uranus!

Too difficult? Then have a look at Nu Sagittarii (Ain al Rami), or the "Eye of the Archer" (RA 18 54 10 Dec -22 44 41). It's one of the earliest known double stars, and was recorded by Ptolemy. While Nu 1 and Nu 2 are not physically related to one another, they are an easy split in binoculars. Eastern Nu 2 is a K-type giant that is about 270 light-years from our Solar System, but take a very close look at the western Nu 1. Although it appears almost as bright, this one is 1,850 light-years away! As a bonus, power up the telescope, because this is one very tight triple star system.



Figure 9.3a. Zeta Sagittarii (credit—Palomar Observatory, courtesy of Caltech).



Figure 9.3b. Nu Sagittarii (credit—Palomar Observatory, courtesy of Caltech).

Friday, September 4

It's a Full Moon tonight. Many cultures refer to this one in particular as the "Corn Moon," because at this time of year most corn crops are ready for harvest. Tonight let's harvest some bright lunar features as we trace the ray system of Tycho in the lunar south. Look for the bright points of Kepler and Aristarchus in the northwest quadrant. In the east, dazzling crater Proclus will light up the western shore of Mare Crisium. Just north of central, look for the two bright rings of Manlius and Menelaus.

Although the Moon will dominate tonight's sky, we can still take a very unusual and beautiful journey to a bright and very colorful pair of stars known as Omicron 1 Cygni. Easily located about halfway between Alpha (Deneb) and Delta on the western side (RA 20 13 28 Dec + 46 46 40), this is a pure delight in binoculars or any size telescope. The striking gold color of 3.7-magnitude Omi 1 A is easily highlighted against the blue of its same-field companion, 5th magnitude Omi 1 B. Although this wide pairing is only an optical one, the K-type giant (A) is indeed a double star—an eclipsing variable about 150 times larger than our own Sun—and is surrounded by a gaseous corona more than double the size of the star itself. If you are using a scope, you can easily spot its blue tinted, 7th magnitude companion star about one-third the distance between the two giants. Although our true pair is some 2 billion kilometers apart, they are oriented nearly edge-on from our point of view, allowing the smaller star to be totally eclipsed during each revolution. This total eclipse lasts for 63 days and happens about every 10.4 years, but don't stay up too late. . . We still have years to wait!

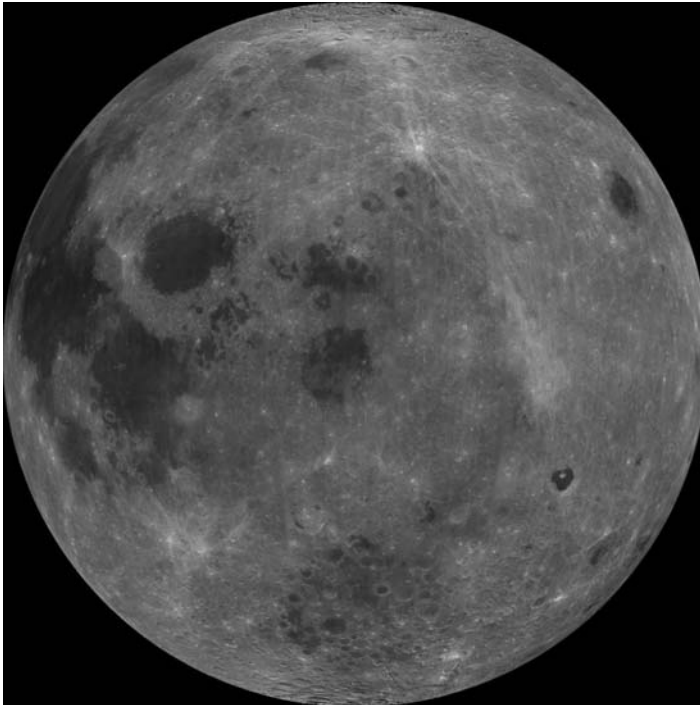


Figure 9.4a. Full Moon (credit—NASA).



Figure 9.4b. Omicron 1 Cygni (credit—Palomar Observatory, courtesy of Caltech).

Saturday, September 5

Tonight before the Moon commands the sky, let's start with the brightest star in Vulpecula—Alpha. Although it is not a true binary star, it is quite attractive in the telescope, and an easy split for binoculars. Alpha itself is a 4.4-magnitude red giant, which makes a nice color contrast with the unrelated yellow field star that is 2 magnitudes dimmer.

Now head around a half degree northwest of Alpha (RA 20 19 29 Dec -70 51 36) for open cluster NGC 6800. Also known as Herschel VIII.21, this cluster is suitable for even smaller scopes but requires aperture to resolve completely. Discovered by Sir William in this month (10th) in 1784, you'll like this ring-like arrangement of stars!

Now drop 2.7 degrees southwest of Alpha (RA 19 23 12 Dec +22 08 00) for yet another open cluster, NGC 6793. Discovered by Herschel in 1789 and logged as catalog object VIII.81, you'll find a few more bright stars here. The challenge in this cluster is not so much being able to see it in a smaller telescope—but being able to discern a cluster from a star field!



Figure 9.5a. NGC 6800 (credit—Palomar Observatory, courtesy of Caltech).



Figure 9.5b. NGC 6793 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, September 6

Today we celebrate many births. In 1891, it's Yrjö Väisälä who produced telescope optics and discovered asteroids. In 1830, John Henry Dallmeyer, who was a master at making telescopes and eyepieces, was born. Last, in 1811, was James Melville Gilliss who founded the United States Naval Observatory.

Tonight we'll return again to Vulpecula, but with a different goal in mind. What we're after requires dark skies yet can be seen in either binoculars or a small telescope. Once you've found Alpha, begin about two finger-widths southeast, and right on the galactic equator you'll find NGC 6823 (RA 19 43 10 Dec +23 17 54.). The first thing you will note is a fairly large, somewhat concentrated magnitude 7 open cluster. Resolved in larger telescopes, the viewer may note these stars are the hot, blue-white variety. For good reason. NGC 6823 only formed about 2 billion years ago. Although it is some 6,000 light-years away and occupies around 50 light-years of space, it's sharing the field with something more—a very large emission/reflection nebula, NGC 6820 (RA 19 42 27 Dec +23 05 14).

In the outer reaches of star cluster NGC 6823, new stars are being formed in masses of gas and dust as hot radiation is shed from the brightest of the stellar members of this pair. Fueled by emission, NGC 6820 isn't always an easy visual object; it is faint and covers almost four times as much area as NGC 6823. But trace the edges very carefully, since the borders are much more illuminated than the central cluster region. Take the time to really observe this one! The processes going on here are very much like those in the "Trapezium" area of the Orion nebula. Be sure to mark your siting in your observing notes. NGC 6823 is Herschel VII.18 and NGC 6820 is also known as Marth 401!



Figure 9.6. NGCs 6823 (central) and 6820 (credit—Palomar Observatory, courtesy of Caltech).

Monday, September 7

Tonight look for the primary stars of Sagitta just to the west of bright Albireo. Make note of the distance between the two brightest, and look exactly that distance north of the “tip of the arrow” to find M27 (RA 19 59 36 Dec + 22 43 16). Discovered in 1764 by Messier in a 3.5-foot focal length telescope, this 48,000-year-old planetary nebula can be seen in a 4 \times telescope. Here you will see a glowing green “apple core,” which has an unusual quality about it that is not easy to identify. It somehow moves. . . It pulsates. It appears “living.”

For many years this author quested to understand the 850-light-year-distant M27, but no one could answer my questions. I eventually learned that it was composed of doubly ionized oxygen. Perhaps there was a spectral reason for what could be seen year after year? Like all amateurs, I became the victim of “aperture fever,” and I continued to study M27 with a 12 \times telescope, never realizing the answer was right there—I just hadn’t powered up enough. Several years later, while studying at the Warren Rupp Observatory, I was viewing through a friend’s identical 12 \times telescope and, as chance would have it, he was using about twice the magnification that I normally used on the “Dumbbell.” Imagine my total astonishment as I realized for the very first time that the faint central star had an even fainter companion that made it seem to wink! At smaller apertures or low power, this was not revealed. Still, the eye could “see” a movement within the nebula—the central radiating star and its companion.

Do not sell the Dumbbell short. It can be seen as a small, unresolved area in common binoculars, easily picked out with larger binoculars as an irregular planetary nebula, and turns astounding with even the smallest of telescopes. In the words of Burnham:

“The observer who spends a few moments in quiet contemplation of this nebula will be made aware of direct contact with cosmic things; even the radiation reaching us from the celestial depths is of a type unknown on Earth. . .”



Figure 9.7. M27: the Dumbbell Nebula (credit—R. Jay GaBany).

Tuesday, September 8

When skies are dark, it's time for us to head directly between the two southernmost stars in the constellation of Lyra (RA 18 53 35 Dec +33 01 45) and grab the "Ring." What summer would be complete without it?

Discovered by French astronomer Antoine Darquier in 1779, the Ring Nebula was cataloged later that year by Charles Messier as M57. In binoculars, the Ring will appear slightly larger than a star, yet it cannot be focused to a sharp point. To a modest telescope at even low power, M57 turns into a glowing doughnut against a wonderful stellar backdrop. The accepted distance to this unusual structure is 1,400 light-years, and how well you see the Ring on any given night is mostly attributable to conditions. As aperture and power increase, so do details, and it is not impossible to see braiding in the nebula's structure with scopes as small as 8" on a fine night, or to pick up the star caught on the edge in even smaller apertures.

Like with all planetary nebulae, seeing the central star is considered the ultimate in viewing. The central itself is a peculiar bluish dwarf that gives off a continuous spectrum and might very well be a variable. At times, this shy, near 15th magnitude star can be seen with ease with a 12" telescope, yet be elusive to 31" in aperture weeks later. No matter what details you may see, reach for the Ring tonight. You'll be glad you did.

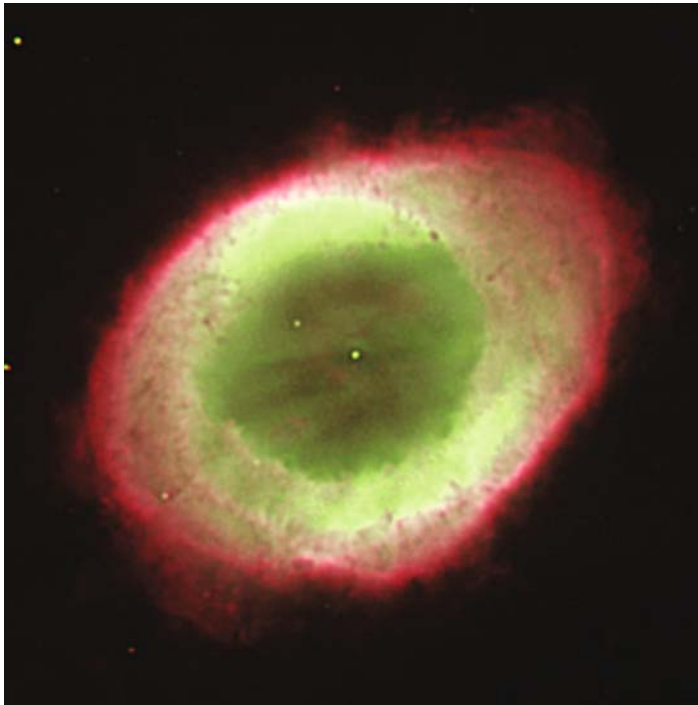


Figure 9.8. M57: The Ring Nebula (credit—C.F. Claver/WIYN/NOAO/AURA/NS).

Wednesday, September 9

On the night before this date in 1966, a legend was born when the television program *Star Trek* premiered. Created by Gene Roddenberry, the show was instrumental in inspiring several generations' interest in space, astronomy, and technology. The short-running series still airs in repeats, along with many movie and series sequels. May it continue to "live long and prosper."

As your starry mission this evening, we'll continue our studies in Vulpecula with a spectacular open cluster—NGC 6940. At close to magnitude 6, you'll find this unsung symphony of stars around three finger-widths southwest of Epsilon Cygni (RA 20 34 24 Dec + 28 17 00).

Discovered by Sir William Herschel on October 15, 1784, and logged as H VIII.23, this intermediate aged galactic cluster will blow your mind in larger aperture. Visible in binoculars, as size increases the field explodes into about 100 stars in a highly compressed, rich cloud. Although it is a little-visited cluster, it is on many observing challenge lists. Use low power to get the full effect of this stunning star field.

If you see a shooting star while you're out, it may belong to the Piscid meteor stream, which will reach its peak tonight with an expected maximum of around 5 meteors per hour. This particular shower favors the Southern Hemisphere. Although this branch of the Piscids is rather unstudied, it is an unusual and diffuse stream that is active all month.



Figure 9.9a. NGC 6940 (credit—Palomar Observatory, courtesy of Caltech).



Figure 9.9b. Gene Roddenberry (public image).

Thursday, September 10

Stay on alert tonight as the Moon and Pleiades are very near—an occultation event! Check the Resources section of this book and International Occultation and Timing Association (IOTA) for times and locations. While we wait, let's talk. . . Have you ever wondered if Sir William Herschel ever had a bad night or made an error? Considering how much the technology of astronomy has changed in over 200 years since he did his work, you'd be surprised at the uncanny knack Herschel had for making correct calls.

Tonight take the journey to Vulpecula in an area roughly between M27 and NGC 6940. We're looking for a small grouping of brighter stars. Focus your attention (and telescope) on star 20. This is the region for a magnitude 6 open cluster within an open cluster known as NGC 6882 (RA 20 11 48 Dec + 26 49 00) and NGC 6885 (RA 20 12 00 Dec + 26 29 00). Check out the date, because they were discovered on September 9 and 10, 1784, by Sir William and logged as H VIII.20 and H VIII.22, respectively. Herschel's notes indicate the clusters to be north and south of each other, yet according to research, his descriptions don't really precisely match the star field.

For many years, this was widely debated as an error, the assumption being that the only true cluster, NGC 6885, was the one around star 20. Yet another, larger, grouping does exist—NGC 6882. Scientific research has proved that two distinct physical clusters of stars are paired together in this region. Although errors and disagreements followed later over correctly listing both objects in the different catalogs, one fact remains. On this night 223 years ago, Herschel was right!



Figure 9.10. NGCs 6882 and 6885 (credit—Palomar Observatory, courtesy of Caltech).

Friday, September 11

Today we celebrate the birthday of Sir James Jeans. Born in 1877 on this date, English-born Jeans was an astronomical theoretician. At the beginning of the twentieth century, Jeans worked out the fundamentals of the process of gravitational collapse. This was an important contribution to the understanding of the formation of solar systems, stars, and galaxies.

While we are studying some of the summer's finest objects, we'd be remiss if we didn't look at another cosmic curiosity—the "Blinking Planetary." Located a couple of degrees east of visible star Theta Cygni, and in the same lower power field as 16 Cygni (RA 19 44 48 Dec + 50 31 30), it is formally known as NGC 6826.

Viewable in even small telescopes at mid-to-high power, you'll learn very quickly how its name came about. When you look directly at it, you can only see the central 9th magnitude star. Now, look away. Focus your attention on visual double 16 Cygni. See that? When you avert, the nebula itself is visible. This is actually a trick of the eye. The central portion of our vision is more sensitive to detail and will only see the central star. At the edge of our vision, we are more likely to see dim light, and the planetary nebula appears. Located around 2,000 light-years from our Solar System, it doesn't matter if the Blinking Planetary is a trick of the eye or not. . . because it's cool! Also known as Herschel IV.73 and Caldwell object 16, this tiny planetary shows an abundance of carbon and dust pockets in its structure. It skyrocketed to fame when viewed by the Hubble Space Telescope (HST), which revealed the mysterious red "FLIERS," whose bow shocks point toward this planetary nebula instead of away from it!



Figure 9.11a. NGC 6826: the Blinking Planetary (credit—Hubble Space Telescope/NASA).



Figure 9.11b. Sir James Jeans (widely used public image).

Saturday, September 12

Today we note two births: Arthur von Auwers (1838), who calculated stellar distances, and Guillaume Le Gentil (1725), who was a frustrated Venus transit observer! Tonight, do your best not to be frustrated as we encourage those with larger binoculars and telescopes to head for a dark sky location. We are going on a quest...the quest for the holy "Veil."

By no means is the Veil Nebula Complex an easy one. The brightest portion, NGC 6992 (RA 20 56 20 Dec + 31 41 48), can be spotted in large binoculars, and you can find it just slightly south of a central point between Epsilon and Zeta Cygni. NGC 6992 is much better in a 6" scope, however, and low power is essential to see the long ghostly filaments that span more than a degree of sky. About 2.5 degrees west-southwest, and incorporating star 52, is another long narrow ribbon of what may be classified as a supernova remnant. When aperture reaches the 12" range, so does the true breadth of this fascinating complex. It is possible to trace these long filaments across several fields of view. They sometimes dim and at other times widen, but like watching a surreal solar flare, you will not be able to tear your eyes away from this area. Another undesignated area lies between the two NGCs, and the whole 1,500-light-year-distant area spans over 2.5 degrees. Sometimes known as the Cygnus Loop, it's definitely one of late summer's finest objects.



Figure 9.12. The Veil Nebula (credit—NOAO/AURA/NSF).

Sunday, September 13

Your first challenge for this morning is to check out the last quarter Moon and look for Mars nearly touching it.

On this date in 1922, the highest air temperature ever recorded at the surface of Earth occurred. The measurement was taken in Libya and burned in at a blistering 136°F (58°C), but did you know that the temperatures in the sunlight on the Moon are double that? If you think the surface of the Moon is a bit too warm for comfort, then know surface temperatures on Mars average only about 80°F (27°C) during the day!

Tonight, let's take the time to hunt down an often overlooked globular cluster—M56. Located roughly midway between Beta Cygni and Gamma Lyrae (RA 19 15 35.50 Dec +30 11 04.2), this Class X globular was discovered by Charles Messier in 1779 on the same night he discovered a comet and was later resolved by Herschel. At magnitude 8 and small in size, it's a tough call for a beginner with binoculars but is a very fine telescopic object. With a general distance of 33,000 light-years, this globular resolves well with larger scopes but doesn't show as much more than a faint, round area with small aperture. However, the beauty of the chains of stars in the field makes it quite worth the visit!

While you're there, look carefully: M56 is one of the very few objects for which the photometry of its variable stars was studied strictly with amateur telescopes. Although one bright variable had been known previously, up to a dozen more have recently been discovered. Of those, six had their variability periods determined using CCD photography and telescopes just like yours!



Figure 9.13a. Mars (credit—NASA).

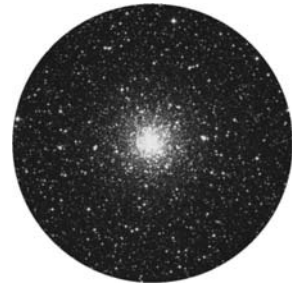


Figure 9.13b. M56 (credit—Palomar Observatory, courtesy of Caltech).

Monday, September 14

On this date in 1959, the Soviet Luna 2 became the first probe to impact the Moon when it crashed east of the Sea of Serenity. Arriving only 36 hours after launch, it was the first manmade object to reach a celestial body!

Tonight we'll move onto Aquila to look at the hot central star of an interesting planetary nebula—NGC 6804. You'll find it almost 4 degrees due west of Altair (RA 19 31 35 Dec +09 13 32). Discovered by Herschel and classed as open cluster H VI.38, it wasn't until Pease took a closer look that its planetary nature was discovered. Interacting with clouds of interstellar dust and gas, NGC 6804 is a planetary in decline, with its outer shell around magnitude 12 and the central star at about magnitude 13. Although only larger telescopes will get a glimpse of the central, it's one of the hottest objects in space, with temperatures of around 30,000 K!



Figure 9.14a. NGC 6804 (credit—Palomar Observatory, courtesy of Caltech).

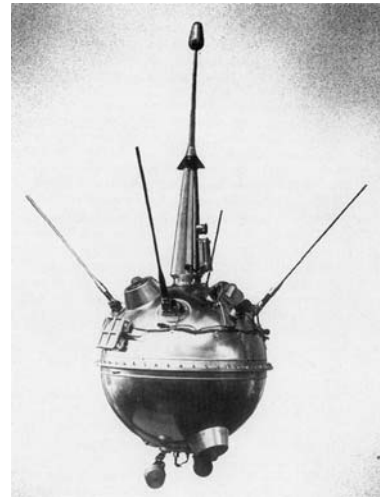


Figure 9.14b. Luna 2 (credit—NASA).

Tuesday, September 15

Today is the anniversary of the 1735 birth of French astronomer Jean-Sylvain Bailly. Bailly was best noted for computing Comet Halley's orbit and studying Jupiter's moons. If you're out before dawn, take a look at our own Moon in binoculars. Bright asteroid Vesta is just slightly more than a degree north!

Now have a look at one of the prettiest clusters in the night—M11 (RA 18 51 00 Dec -06 16 00). Discovered in 1681 by German astronomer Gottfried Kirch at the Berlin Observatory, M11 was cataloged by Charles Messier in 1764 and first dubbed the "Wild Duck" by Admiral Smyth. To our modern telescopes and binoculars, there is little doubt as to how this rich galactic cluster earned its name, for it has a distinctive wedge-shaped pattern that closely resembles a flight of ducks. This fantastic open cluster of several thousand stars (about 500 of them are magnitude 14 or brighter) is approximately 250 million years old.

M11 is easily located by identifying Altair, the brightest star in Aquila. By counting two stars down the "body" of Aquila and stopping on Lambda, you will find your starhop guide. Near Lambda you will see three stars, the centermost being Eta Scuti. Now just aim! Even small binoculars will have no problem finding M11, but a telescope is required to start resolving individual stars. The larger the telescope's aperture the more stars will be revealed in this most concentrated of all open clusters!



Figure 9.15. M11: the Wild Duck Cluster (credit—Nigel Sharp/REU Program/NOAO/AURA/NSF).

Wednesday, September 16

On this date in 1662, the first Astronomer Royal, John Flamsteed, made the first recorded astronomical observation. Sixteen-year-old Flamsteed had just witnessed a solar eclipse. How many youths do you know who would spend time corresponding with other astronomers and studying an event such as that? Flamsteed even tried to make his own measuring instruments. Do you think he could have told us just how close Venus and the Moon are this morning?

Return tonight to M56, then move off to tiny Sagitta and identify its faint stars Delta and Gamma. Almost precisely between them (RA 19 53 46 Dec +18 46 42), binoculars or finder scopes will reveal 8th magnitude M71. Aside from brightness, size, and beauty of stellar field, these two globulars have very little in common. M71 is roughly one-third as distant as M56, and its brightest stars approach the 11th magnitude. Most smaller telescopes can resolve a string of stars (reminiscent of M4) across its core. Very loosely structured, it would be more fitting as an “uncertain class,” but its stellar chemistry of high metal content stars means M71 has a dual identity as both dense open cluster and a globular!

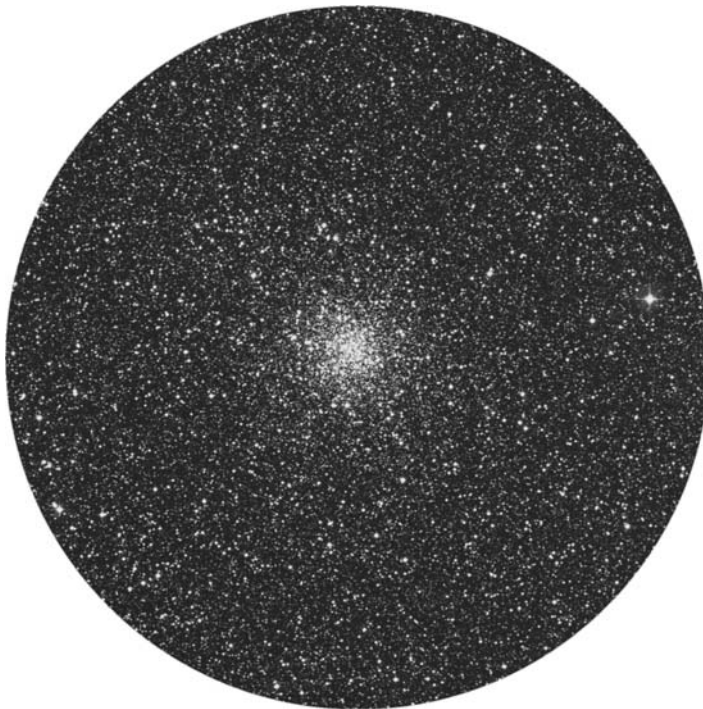


Figure 9.16a. M71 (credit—Palomar Observatory, courtesy of Caltech).



Figure 9.16b. Flamsteed and instruments (historical image).

Thursday, September 17

Today in 1789, Sir William Herschel discovered Saturn's moon Mimas. Tonight we'll look at another kind of "Saturn" he also discovered, as we locate the centermost bright star in the northern half of the constellation of Aquarius—Theta.

Three finger-widths north of Theta you will see dimmer Nu, and one finger-width west of Nu is NGC 7009 (RA 21 04 10 Dec -11 21 48). Nicknamed the "Saturn Nebula," this wonderful blue planetary is about 8th magnitude and is easily achievable in small scopes and large binoculars. At moderate magnification, you will see the elliptical shape giving rise to its moniker. With larger scopes, those "ring-like" projections become even clearer!

Discovered by Herschel in 1782, NGC 7009's central star is a bluish dwarf with a temperature of about 55,000 K. A shell of glowing gas surrounds the nebula, which formed when the blue dwarf ejected as much as 10% of its mass. This process may have taken millions of years. Spanning a half light-year in diameter and located about 3,900 light-years away, this very cool nebula will likely become a favorite!



Figure 9.17. NGC 7009 (credit—Brad Ehrhorn/Adam Block/NOAO/AURA/NSF).

Friday, September 18

One of the most interesting features of the autumn sky is how slowly the stars and constellations seem to proceed across the heavens. This is only an illusion, since skydark arrives earlier each night (after summer solstice in the Northern Hemisphere), making the progress of the constellations across the sky seem to “freeze.” Tonight, Capella can be seen rising to the northeast just as Antares settles southwest. Four planets—Jupiter, Pluto, Neptune, and Uranus—are still above the horizon, with Jupiter now very low to the west-southwest. Descending to the northwest is Ursa Major, the “Big Dipper.” Across the sky is Piscis Austrinus, and lonely but bright Fomalhaut is beginning its rise. Seven stars of the first magnitude now grace the heavens. Against this backdrop, one of the darkest skies of the month is now upon us. It’s the New Moon. . .

Let’s have a look at another fine planetary nebula—NGC 7662. At 9 magnitude, this one is more commonly known as the “Blue Snowball” and can be found about three finger-widths east of Omicron Andromedae, or a little less than a handspan northwest of Alpha Pegasi (RA 23 25 54 Dec + 42 32 06). Similar in size to M57, even low power with a small scope easily reveals the planetary nature of this very fine study. Power up and you’ll discover that the annulus of this roughly circular planetary is definitely brighter inside than out. Large telescopes will highlight NGC 7662’s blue coloration and reveal a bright inner globe surrounded by a faint outer ring.



Figure 9.18. NGC 7662 (credit—Adam Block/NOAO/AURA/NSF).

Saturday, September 19

On this date in 1848, William Boyd was observing Saturn and discovered the planet's eighth moon, Hyperion. If you're out before sunset, some lucky stargazers are going to discover that the slender crescent Moon is about to occult Mercury! Check the Resources in this book and IOTA for locations and dates. Then check them both out in binoculars!

Would you like to try for another pair? Then wait until the skies are fully dark and head north for a galaxy and cluster pairing—NGC 6946 (RA 20 34 51 Dec + 60 09 18) and NGC 6939 (RA 20 31 30 Dec + 60 39 42). Located in western Cepheus, you'll find them about a finger-width southwest of Eta.

Discovered by William Herschel on September 9, 1798, 10 million-light-year-distant face-on spiral NGC 6946 spreads itself pretty thin in modest instruments. Lacking a bright core, this oval mist orients southwest to northeast. Larger telescopes will reveal traces of rotating spiral arms, especially in the southwest. This galaxy would appear extraordinary if we weren't looking through Milky Way obscuration to view it! Through smaller scopes, northwestern open cluster NGC 6939 appears like a tight little formation of 11th and 12th magnitude stars similar in pattern to a very small M11. It resolves well in larger scopes.



Figure 9.19a. NGC 6946 (credit—Palomar Observatory, courtesy of Caltech).



Figure 9.19b. NGC 6939 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, September 20

Today we recognize the passing of cosmonaut Gherman S. Titov in 2000; Titov was not only the second human in space but also the youngest! Perhaps when he was orbiting Earth in Vostok 2 he had a chance to see the Moon. Why don't we join him? Tonight, your lunar mission is to journey to the edge of the east limb and slightly south of central to identify crater Humboldt. Seen on the curve, this roughly 200-kilometer-wide crater holds a wealth of geographical details. Its flat, cracked floor has central peaks and a small mountain range, as well as a radial Rille structure. If libration and steadiness of skies are in your favor, power up and look for dark pyroclastic areas and a concentric inner crater.

Now, let's have a look at Beta and Gamma Lyrae, the lower two stars in the "Harp." Beta is actually a quick-changing variable, which drops to less than half the brightness of Gamma in about 12 days. For a few days, the pair will seem of almost equal brightness, and then you will notice the star closest to Vega fade away. Beta is one of the most unusual spectroscopic stars in the sky, and it is possible that its eclipsing binary companion may be the prototype of a "collapsar" (yep, a black hole!), rather than a true luminous body.

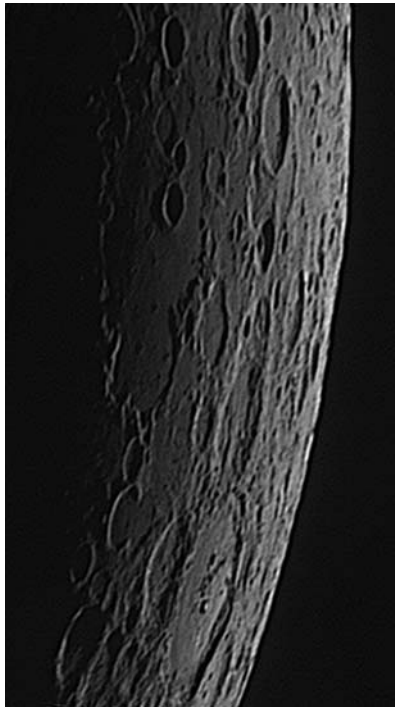


Figure 9.20a. Crater Humboldt (credit—Ricardo Borba).



Figure 9.20b. Beta Lyrae (credit—Palomar Observatory, courtesy of Caltech).

Monday, September 21

If you were unable to identify Humboldt last night, try again tonight with Petavius as your guide. Although we have studied Petavius before, here is another opportunity to note down your studies of the Petavius Wall. Look for unusual features, such as 57-kilometer-diameter Wrottesley on Petavius' northwest wall, or 83-kilometer-wide Hase to the south, with its deep interior impact. Or how about long, shallow Legendre and Phillips on Humboldt's west wall? If libration is favorable, you might even spot the edge of Barnard on Humboldt's southeast edge!

Tonight we commemorate the 2003 demise of the NASA Galileo space probe, which ended its 8-year mission to Jupiter, as planned. The Jet Propulsion Laboratory in Pasadena, California, directed the craft into Jupiter's atmosphere so it would burn up, totally vaporizing its structure and eliminating any chance of contaminating Jupiter's satellites. Why not take a look at the Jovian system yourself? Jupiter is well placed tonight for observation!

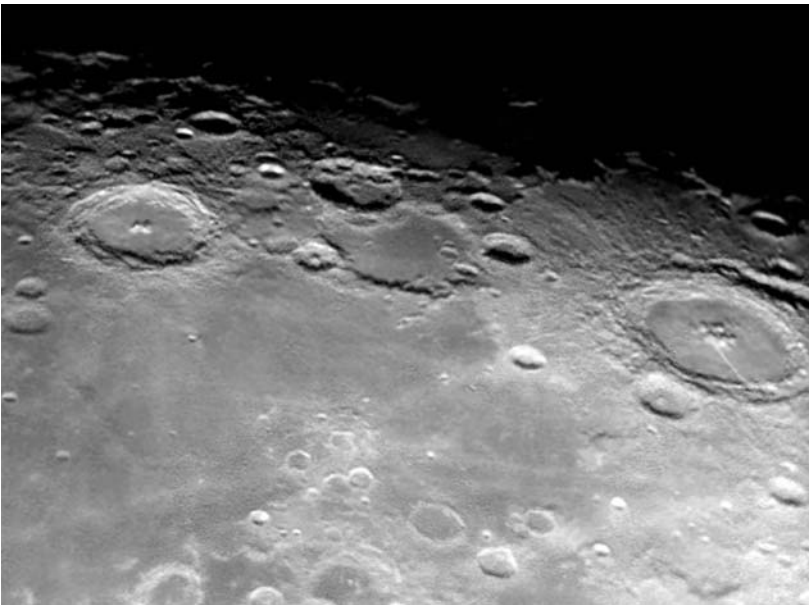


Figure 9.21a. Petavius (credit—Alan Chu).



Figure 9.21b. A Galileo view of Io and Jupiter (credit—NASA).

Tuesday, September 22

Today is the autumnal equinox. This marks the first day of the fall season for the Northern Hemisphere, and we astronomers welcome back earlier dark skies!

Tonight we'll discover our own Moon as we have a look at one of the last lunar challenges that occur during the first few days of the Moon's appearance—Piccolomini. You'll find it to the southwest of the shallow ring of Fracastorius on Mare Nectaris' southern shore. Piccolomini is a standout lunar feature, mainly because it is a fairly fresh impact crater. Its walls have not yet been destroyed by later impacts, and the interior is nicely terraced. Power up and look carefully at the northern interior wall, where perhaps a rockslide has slipped toward the crater floor. Although the floor itself is fairly featureless, the central peak is awesome. Rising up a minimum of 2 kilometers above the floor, it's even higher than the White Mountains in New Hampshire!

Now let's take a look at a double that has a close separation—Epsilon Lyrae. Known to most of us as the "Double Double," look about a finger-width northeast of Vega. Even the slightest optical aid will reveal this tiny star as a pair, but the real treat is with a telescope, for each component is a double star! Both sets of stars appear as primarily white, and both are very close to each other in magnitude. What is the lowest power that you can use to split them?

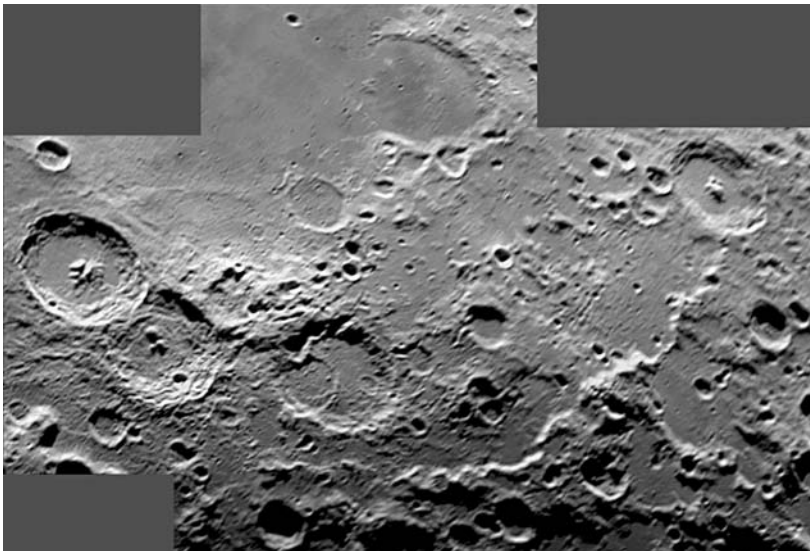


Figure 9.22a. Piccolomini (credit—Alan Chu).



Figure 9.22b. Epsilon 1 and 2 Lyrae (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, September 23

On this date in 1846, Johann Galle of the Berlin Observatory made a visual discovery. While at the telescope, Galle saw Neptune and identified it as a planet for the first time. Also on this date in 1962, the prime time cartoon “The Jetsons” premiered. Think of all the technology it inspired!

Tonight we’ll use a well-known lunar feature to help guide us to another challenge that is a little less easy to identify—crater Plinius. Starting with the grand visage of Posidonius, trace your way south past the ruined walls of Le Monnier and look for the long north–south wrinkle of Dorsa Smirnov running parallel to the terminator. Where it ends in the Promontorium Archerusia, look for the bright circle of Plinius.

Spanning approximately 43 kilometers, Plinius is far from a prominent crater, yet it will remain a very bright ring as the Moon grows full. Formed by an impact, its walls are bright and sharp, but it has an irregular floor and jagged central peaks that will appear at times like two small impact craters.

If you have not had a chance to view the Plinius area, take a look around. . . Surveyor 5 did! It was the third spacecraft in the Surveyor series to achieve a successful soft lunar landing and obtain touchdown dynamics data. On this night in 1967, it was about to shut down for 3 weeks of lunar night, but not before its miniature chemical analysis lab had determined that the regolith consisted of basaltic rock. While televising images, a small bar magnet attached to one footpad was busy looking for the presence of magnetic material in the lunar soil!



Figure 9.23a. Posidonius, Le Monnier, the Serpentine Ridge, and Crater Plinius (credit—Greg Konkel).



Figure 9.23b. Surveyor 5: a foot on the moon (credit—NASA).

Thursday, September 24

Tonight as the skies darken, look for the beautiful red Antares less than a degree north of the Moon. Such a close union might mean an occultation, so be sure to check the Resources section of this book and IOTA! In 1970, the first automated return of lunar material to Earth occurred on this date when the Soviets' Luna 16 returned with 85 grams of the Moon. Tonight let's dig up our own lunar history samples!

For binoculars and telescopes, the Moon will provide a piece of scenic history, as we take an in-depth look at crater Albategnius. This huge, hexagonal, mountain-walled plain will appear near the terminator about one-third of the way north from the south limb. This 136-kilometer-wide crater is approximately 4,390 meters deep, and the west wall casts a black shadow on the dark floor. Albategnius is a very ancient formation, which partially filled with lava at one point in its development; and it is home to several wall craters such as Klein (which will appear telescopically on its southwest wall). Albategnius holds more than just the distinction of being a prominent crater tonight; it holds a place in history. On May 9, 1962, Louis Smullin and Giorgio Fiocco of the Massachusetts Institute of Technology aimed a red laser beam toward the lunar surface, and Albategnius became the first lunar object to be illuminated and detected by a laser from Earth!

On March 24, 1965, Ranger 9 took this snapshot of Albategnius from an altitude of approximately 2,500 kilometers. Companion craters in the image are Ptolemaeus and Alphonsus, which will be revealed tomorrow night. Ranger 9 was designed by NASA for one purpose—to achieve a lunar impact trajectory and to send back high-resolution photographs and high-quality video images of the lunar surface. It carried no other scientific experiments, and its only destiny was to take pictures right up to the moment of final impact. It is interesting to note that Ranger 9 slammed into Alphonsus approximately 18.5 minutes after the photo shown in Figure 9.24a was taken. They called that... a "hard landing."



Figure 9.24a. Ranger 9 image of lunar surface (credit—NASA).

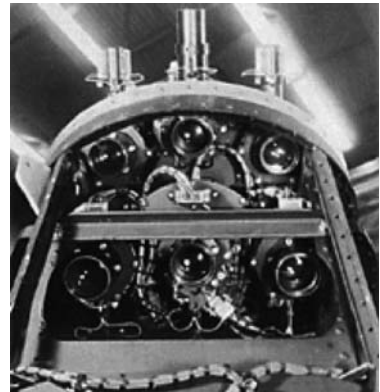


Figure 9.24b. Ranger 9's Vidicon cameras (credit—NASA).

Friday, September 25

Today we celebrate the 1625 birth on this date of Ole (Christensen) Rømer. Rømer, by timing Jupiter's moons being eclipsed, was the first to prove that light had a finite speed. Let's walk upon our own Moon this evening as we take a look at sunrise over one of the most often studied and mysterious of all craters, Plato. Located on the northern edge of Mare Imbrium, and spanning 95 kilometers in diameter, Class IV Plato is simply a feature that all lunar observers check because of the many reports of unusual happenings. Over the years mists, flashes of light, areas of brightness and darkness, and the appearance of small craters have become a part of Plato's lore.

On October 9, 1945, an observer sketched and reported "a minute but brilliant flash of light" inside the western rim. Lunar Orbiter 4 photos later showed where a new impact may have occurred. Although Plato's interior craterlets average between less than 1 and up to slightly more than 2 kilometers in diameter, many times they can be observed, and sometimes they cannot be seen at all under almost identical lighting conditions. No matter how many times you observe this crater, it is ever-changing and very worthy of your attention!



Figure 9.25. Plato area (credit—Sketch by Deirdre Kelleghan).

Saturday, September 26

Tonight's featured lunar crater will be located on the south shore of Mare Imbrium right where the Apennine mountain range meets the terminator. Eratosthenes is unmistakable at 58 kilometers in diameter and 375 meters deep. Named after the ancient mathematician, geographer, and astronomer Eratosthenes, this splendid Class I crater will display a bright west wall and a deep interior, which contains its massive crater-capped central mountain reaching up to 3,570 meters high! Extending like a tail, an 80-kilometer-long mountain ridge angles away to the southwest. As beautiful as Eratosthenes appears tonight, it will fade away to total obscurity as the Moon becomes more nearly full. See if you can spot it in 5 days!

Now let's journey to a very pretty star field as we head toward the western wingtip of Cygnus, to have a look at Theta, also known as 13 Cygni (RA 19 36 26 Dec + 50 13 15). Theta is a beautiful main sequence star that is also considered by modern catalogs to be a double. For large telescopes, look for a faint (13th magnitude) companion to the west. But it's also a wonderful optical triple! In the field with Theta to the southeast is the Mira-type variable R Cygni, which ranges in magnitude from around 7–14 in slightly less than 430 days. This pulsating red star has a really interesting history that can be found at American Association of Variable Star Observers (AAVSO) and is circumpolar for far northern observers. Check it out!

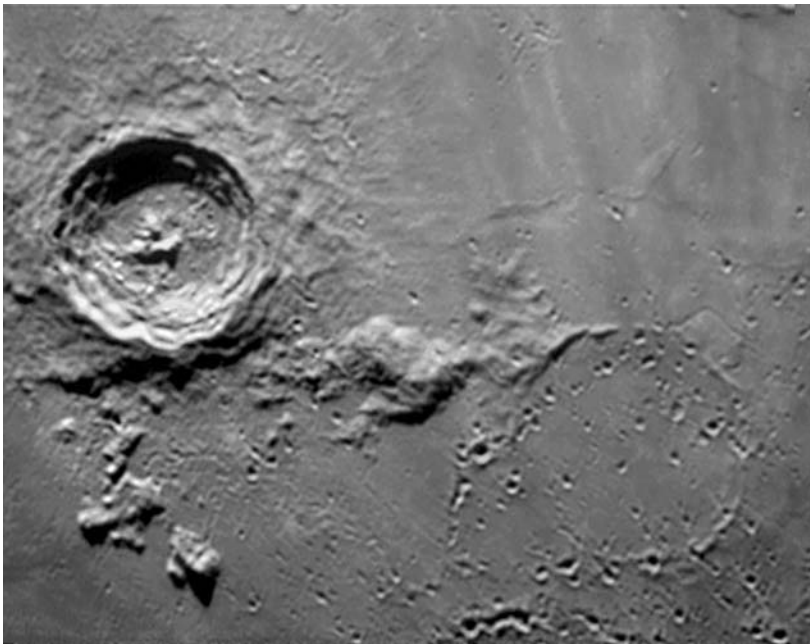


Figure 9.26a. Eratosthenes (credit—Alan Chu).



Figure 9.26b. Theta Cygni (credit—Palomar Observatory, courtesy of Caltech).

Sunday, September 27

Today we celebrate the 1814 birth on this date of Daniel Kirkwood. In 1866, this American astronomer was the first to publish his discovery of gaps in the distances of asteroids from the Sun, the “Kirkwood Gaps.” Not only did he study the orbits of asteroids, but he was also the first to suggest that meteor showers were caused by orbiting debris from comets. Known as “the American Kepler,” Kirkwood went on to author 129 publications, including three books.

Tonight on the Moon, let’s take an in-depth look at one of the most impressive of the southern lunar features—Clavius. Although you cannot help being drawn visually to this crater, let’s start at the southern limb near the terminator and work our way up. Your first sighting will be the large and shallow dual rings of Casatus, with its central crater, and Klaproth adjoining it. Further north is Blancanus, with its series of very small interior craters, but wait until you see Clavius. Caught on the southeast wall is Rutherford, with its central peak, and crater Porter on the northeast wall. Look between them for the deep depression labeled D. West of D you will also see three outstanding impacts: C, N, and J; CB resides between D and Porter. The southern and southwest walls are also home to many impacts, and look carefully at the floor for many, many more! Clavius has been often used as a test of a telescope’s resolving power to see just how many more craters you can find inside it. Power up and enjoy!

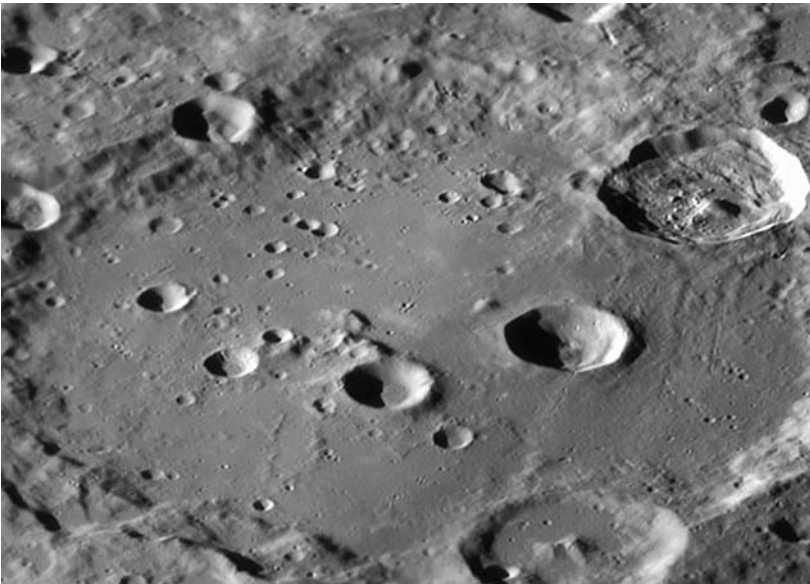


Figure 9.27a. Clavius (credit—Wes Higgins).

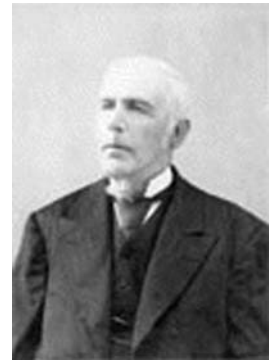


Figure 9.27b. Daniel Kirkwood (widely used public image).

Monday, September 28

Tonight, exploring the Moon will be in order, since one of the most graceful and recognizable lunar features will be prominent—Gassendi. As an ancient mountain-walled plain that sits proudly at the northern edge of Mare Humorum, Gassendi sports a bright ring and a triple central mountain peak that are within the range of binoculars. Let's go visit it again. . .

Telescopic viewers will appreciate Gassendi most at high power, in order to better see how its southern border has been eroded by lava flow. Also of note are the many Rilles and ridges that exist inside the crater, as well as the presence of the younger Gassendi A on the north wall. While viewing the Mare Humorum area, keep in mind that we are looking at an area about the size of the state of Arkansas. It is believed that the impact of a planetoid formed Mare Humorum. The incredible collision crushed the surface layers of the Moon, resulting in a concentric "anticline" that can be traced out to twice the size of the original impact area. The floor of this huge crater then filled in with lava and was once thought to have a greenish appearance, which in recent years has more accurately been described as reddish. Take your time to appreciate the view. . . The scenery is worthy of a sketch!



Figure 9.28. Gassendi (credit—sketch by Deirdre Kelleghan).

Tuesday, September 29

Tonight our primary lunar study is crater Kepler. Look for it as a bright point, slightly to the lunar north of center and near the terminator. Kepler's home is the Oceanus Procellarum—a sprawling dark mare composed primarily of dark minerals of low reflectivity (albedo) such as iron and magnesium. Bright, young Kepler will display a wonderfully developed ray system. The crater rim is very bright, consisting mostly of a pale rock called anorthosite. The "lines" extending from Kepler are fragments that were splashed out and flung across the lunar surface when the impact occurred. The region is also home to features known as "domes"—seen between the crater and the Carpathian Mountains. So unique is Kepler's geological formation that it became the first crater mapped by the U.S. Geological Survey in 1962.

Now use your eyes and take a close look around the Moon for Jupiter! If you'd like to visit another object that only requires eyes, then look no further than Eta Aquilae one fist-width due south of Altair (RA 19 52 28 Dec +01 00 20). Discovered by Pigot in 1784, this Cepheid-class variable has a precision rate of change of over a magnitude in a period of 7.17644 days. During this time, it will reach a maximum magnitude of 3.7 and decline slowly over 5 days to a minimum of 4.5. Yet it only takes 2 days to brighten again! This period of expansion and contraction makes Eta unique. To help gauge these changes, compare Eta to Beta on Altair's same southeast side. When Eta is at maximum, they will be about equal in brightness.

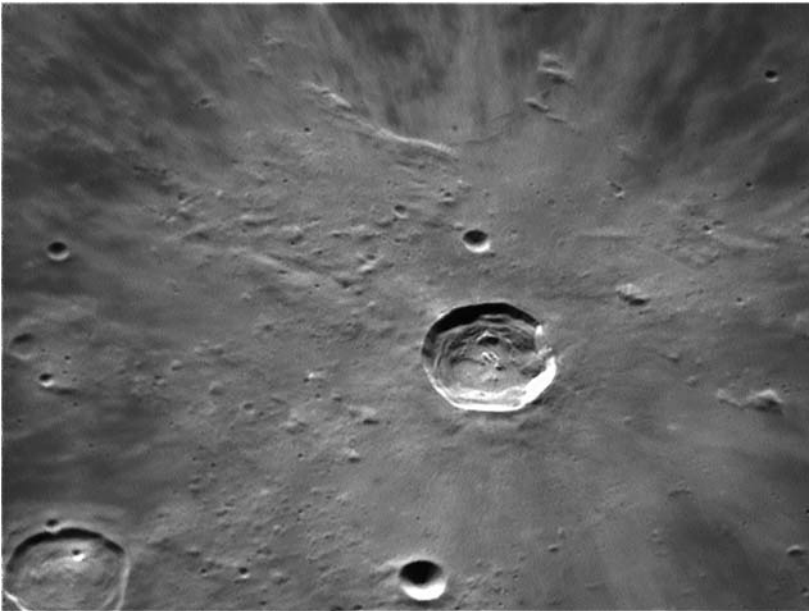


Figure 9.29a. Kepler (credit—Wes Higgins).



Figure 9.29b. Eta Aquilae (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, September 30

On this date in 1880, Henry Draper must have been up very early to take the first photo of the Great Orion Nebula (M42). If you're up before dawn, use binoculars to spot this awesome nebula!

Tonight Uranus will be less than 2 degrees south of the Moon, but let's look at a lunar feature that goes beyond simply incredible—to downright weird. Start by identifying Kepler and head due west across Oceanus Procellarum until you encounter the bright ring of crater Reiner. Spanning 30 kilometers, Reiner isn't anything in particular, just shallow-looking walls with a little hummock in the center. But look further west and a little more north for an anomaly—Reiner Gamma. Well, it's bright and slightly eye-shaped. But what exactly is it? Possessing no depth or elevation, Reiner Gamma could be an extremely young feature caused by a comet. Only three other such features exist—two on the lunar far side and one on Mercury. These are high albedo surface deposits with magnetic properties. Unlike the ejected material of lunar rays, Reiner Gamma can be seen during daylight—when ray systems disappear—and it never casts a shadow. Reiner Gamma causes a magnetic deviation on a barren world with no magnetic field. Its proposed origins could be solar storms, volcanic activity, or even seismic waves. Yet, the best explanation for its presence is a cometary strike. It is believed that a split-nucleus comet, or cometary fragments, once impacted the area, and the swirl of gases from the high-velocity debris may have somehow changed the regolith. However, ejecta from an impact could have formed around a magnetic “hot spot,” much like a magnet attracts iron filings. No matter which theory is correct, the simple act of viewing Reiner Gamma and realizing it's different from all other nearside lunar features makes this journey worth the time!



Figure 9.30a. Reiner and Reiner Gamma (credit—Alan Chu).



Figure 9.30b. Henry Draper (historical image).

CHAPTER TEN



October, 2009

Thursday, October 1

Tonight Venus and Uranus will be 2 degrees apart and near the Moon's south limb. Would you like to have some fun tonight? Invite someone along, and let's look at how differently people perceive stellar color!

First, Alpha Canes Venaticorum (RA 12 56 01 Dec +38 19 06), better known as Cor Caroli. The "Heart of Charles" is an easy binary located 130 light-years away. Many noteworthy observers fail to see color in this pair, but many others can! Do you think the primary star is tinged orange and the secondary is faintly blue? Now, Beta Cygni (RA 19 30 43 Dec +27 57 34)—Albireo—is also an easy, colorful binary. Or is it? Well noted for its yellow/blue color contrast, many people see it differently. They may perceive them as orange and almost purple or radically different colors—or no color at all! Alpha Herculis (RA 17 14 38 Dec +14 23 25)—Ras Algethi—is a more difficult binary. Suggesting that the M-type primary should be red and the companion green (a color sensed well by the dark-adapted human eye) isn't always correct. It would seem the answers aren't quite black and white!

What do these stars have in common? None of them is "normal." The Cor Caroli system is enveloped in an intense magnetic field, where the magnetic/spectroscopic variable primary is bluer at minimum. Albireo's primary star is a composite spectroscopic binary, with a companion that displays strong hydrogen absorption lines. Ras Algethi's red giant primary is a variable star that is shedding a huge envelope of gas, engulfing its composite spectroscopic binary B companion! Take a look at two of these stars in black and white, before we "color" your opinion of what you can see!

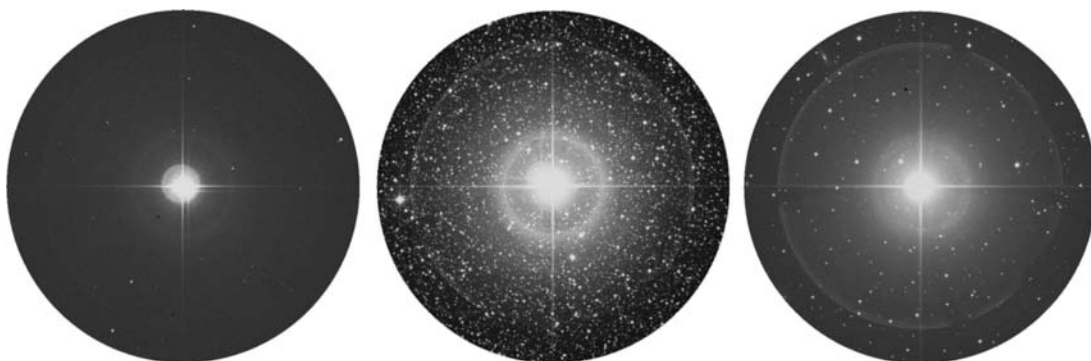


Figure 10.1. *Left:* Cor Caroli, *center:* Albireo, *right:* Ras Algethi (credit—Palomar Observatory, courtesy of Caltech).

Friday, October 2

It's that time of year! Time to be able to see all the planets in 24 hours! If you're able to get up before sunrise, it's a good time to watch celestial mechanics in action as Mercury, Venus, and Saturn are beginning to draw together just before dawn. Be on the lookout for Mars nearly overhead. Now is a good time to see details.

If you haven't spotted Uranus yet, let the Moon be your guide tonight for finding it about 5 degrees south. Even with bright skies, you should be able to distinguish its faint greenish disk from surrounding stars. What of Neptune? The blue world is a bit further from the Moon tonight on the ecliptic, and you'll find it around 21:45 in right ascension. The last is the mighty Jove. For binoculars and telescopes, Jupiter is definitely the king of the observable planets for detail. Not only can you spot its different zones and equatorial belts, but refractor users can also regularly distinguish the faded Great Red Spot and other fine features, such as white ovals. For all larger apertures, be on the lookout for the moons! It's very exciting to watch a shadow transit or to catch a Galilean as it reappears from behind the limb. In just a matter of a few hours, Jupiter's details can change greatly!

For those who still cheer for Pluto's status as a planet? The tiny god of the underworld still holds its place in our Solar System. . .and the sky! You can find it during the early evening around 18:02 in right ascension. Good luck on your planet quest!!



Figure 10.2. Solar System Montage (credit—NASA).

Saturday, October 3

When the Universal Date changes tonight, the Moon will become full, and this will be the one closest to the autumnal equinox. Because the Moon's orbit is more nearly parallel to the eastern horizon, it will rise near dusk for the next several nights in a row. On the average, the Moon rises about 50 minutes later each night, but at this time of year it's around 20 minutes later for mid-northern latitudes and even later further north. Because of this added light, the name "Harvest Moon" was coined; it allowed farmers more time to work in the fields.

Often times we perceive the Harvest Moon as being more orange than at any other time of the year. The coloration is caused by the scattering of the light by particles in our atmosphere. When the Moon is low, like now, we get more of that scattering effect, and it truly does appear more orange. The very act of harvesting itself produces more dust, and often times that coloration will last the whole night through. And we all know the size is only an "illusion"...

So, instead of cursing the Moon for hiding the deep-sky gems tonight, enjoy it for what it is, a wonderful natural phenomenon that doesn't even require a telescope!



Figure 10.3. Saguaro Moon (credit and copyright—Stefan Seip (NASA/APOD)).

Sunday, October 4

This date in 1957, the USSR's Sputnik 1 made space history, as it became the first manmade object to orbit Earth. Earth's first artificial satellite was tiny, roughly the size of a basketball, and weighed no more than the average man. Every 98 minutes it swung around Earth in its elliptical orbit...and changed everything. It was the beginning of the "Space Age." Take the time with your children or grandchildren to check www.heavens-above.com for visible passes of the International Space Station (ISS), and think about how much our world has changed in just over half a century!

Tonight we'll begin with an easy double star and make our way toward a more difficult one. Beautiful, bright, and colorful, Beta Cygni is an excellent example of an easily split double star. As the second brightest star in the constellation of Cygnus, Albireo lies roughly in the center of the "Summer Triangle," making it a relatively simple target for even urban telescopes. Albireo's primary (or brightest) star is around magnitude 4 and has a striking orangish color. Its secondary (or B) star is slightly fainter at a bit less than magnitude 5, and often appears to most as blue, almost violet. The pair's wide separation of 34" makes Beta Cygni an easy split for all telescopes at modest power, and even for larger binoculars. At approximately 410 light-years away, this colorful pair has a separation of about 4,400 Astronomical Unit (AU). As Burnham noted:

"It is worth contemplating, in any case, the fact that at least 55 Solar Systems could be lined up, edge-to-edge, across the space that separates the components of this famous double!"

Now let's have a look at Delta (RA 19 44 58 Dec +45 07 50). Located around 270 light-years away, Delta is a more difficult binary star. Its duplicity was discovered by F. Struve in 1830, and it is a very tough test for smaller optics. Located no more than 220 AU away from the magnitude 3 parent star, the companion takes anywhere from 300 to 540 years to orbit its star and is often rated as dim as 8th magnitude. If skies aren't steady enough to split it tonight, try again! Both Beta and Delta are on many challenge lists.



Figure 10.4a. Beta Cygni: Albireo (credit—University of Nebraska-Lincoln).



Figure 10.4b. Delta Cygni (credit—Palomar Observatory, courtesy of Caltech).

Monday, October 5

Today marks the birthdate of Robert Goddard. Born in 1882, Goddard is known as the father of modern rocketry—and with good reason. In 1907, Goddard came into the public eye when a cloud of smoke erupted from the basement of the physics building at Worcester Polytechnic Institute, from which he had just fired a powder rocket. By 1914, he had patented the use of liquid rocket fuel and the design of two- or three-stage solid fuel rockets. His work continued as he sought methods of lofting equipment ever higher, and by 1920, he had envisioned his rockets reaching the Moon. Among his many achievements, he proved that a rocket could work in a vacuum. By 1926 the first scientific equipment went along for the ride; by 1932, Goddard was guiding those flights; and by 1937 his motors were pivoting on gimbals and being controlled gyroscopically. His lifetime of work went pretty much unnoticed until the dawn of the Space Age, but in 1959 (14 years after his death) he received acclaim at last as NASA's Goddard Space Flight Center was established in his memory.

Tonight let's head about a finger-width south of Gamma Cygni to have a look at an open cluster well suited for all optics—M29 (RA 20 23 56 Dec +38 31 23). Discovered in 1764 by Charles Messier, this type D cluster has an overall brightness of about magnitude 7 but isn't exactly rich in stars. Hanging out anywhere from 6,000 to 7,200 light-years away, one would assume this to be a very rich cluster—and it may very well have hundreds of stars—but the light is blocked by a dust cloud a thousand times denser than average. Approaching us at around 28 kilometers per second, the loose grouping of M29 could be as old as 10 million years and appears much like a miniature of the constellation of Ursa Major at low power. Even though it isn't the most spectacular in star-rich Cygnus, it is another Messier object to add to your list!

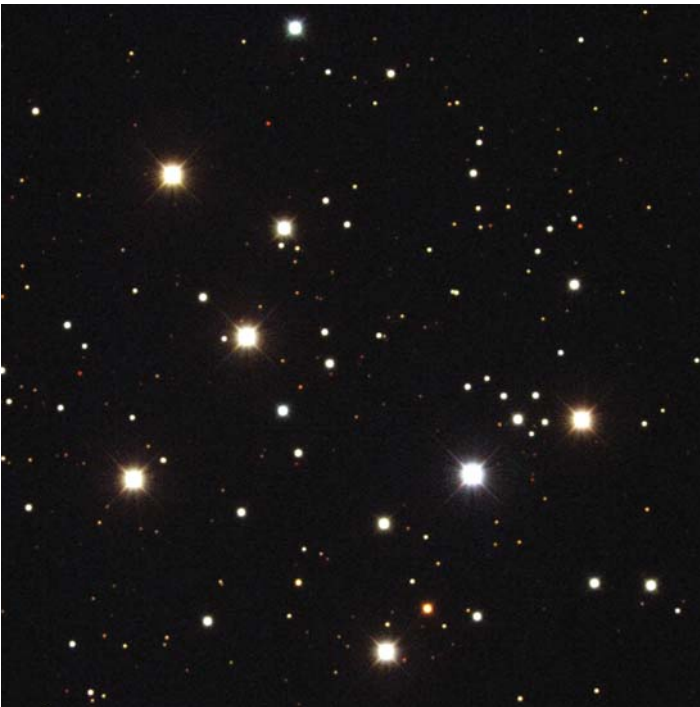


Figure 10.5a. M29 (credit—Hilary Mathis/NOAO/AURA/NSF).



Figure 10.5b. Robert Goddard (credit—NASA).

Tuesday, October 6

Today we celebrate the 1735 birth of Jesse Ramsden. Does that name sound somehow familiar? It should. His telescope eyepiece designs are still commonly in use today!

Tonight we'll have a look at the central star of the "Northern Cross"—Gamma Cygni (RA 20 22 13 Dec +40 15 24). Also known as Sadr, this beautiful main sequence star lies at the northern edge of the "Great Rift." Surrounded by a field of nebulosity known as IC 1310, 2nd magnitude Gamma is very slowly approaching us, from a distance of about 750 light-years. It is here in the rich, starry fields that the great dust cloud begins its stretch toward southern Centaurus, dividing the Milky Way into two streams. The dark region extending north of Gamma toward Deneb is often referred to as the "Northern Coalsack," but its true designation is Lynds 906.

If you take a very close look at Sadr, you will find it has a well-separated 10th magnitude companion star, which is probably not related; yet in 1876, S.W. Burnham found that the object itself is a very close double. Just to its north is NGC 6910, a roughly 6th magnitude open cluster that displays a nice concentration in a small telescope. To the west is Collinder 419, another bright gathering that is nicely concentrated. South is Dolidze 43, a widely spaced group with two brighter stars on its southern perimeter. East is Dolidze 10, which is far richer in stars of various magnitudes and contains at least three binary systems. Whether you use binoculars or telescopes, chances are you won't see much nebulosity in this region, but the sheer population of stars and objects in this area makes a visit with Sadr worthy of your time!



Figure 10.7a. Gamma Cygni region (credit—Teresa Hawes, Phillip Darling, and Adam Block/NOAO/AURA/NSF).

Wednesday, October 7

Get up, get up! There's a major celestial scenery alert!! Before dawn, Mercury, Venus, and Saturn will make a lovely triangle in the morning sky. . . But watch as the Moon and the Pleiades waltz along! This is a (grazing) occultation event for many observers, so be sure to check the Resources section of this book and International Occultation and Timing Association (IOTA) for times and locations!

Tonight before the Moon rises and we leave Cygnus for the year, try your luck with IC 5070, also known as the "Pelican Nebula." You'll find it just about a degree southeast of Deneb and surrounding the binary star 56 Cygni (RA 20 51 00 Dec +44 22 00).

Located around 2,000 light-years away, the Pelican is an extension of the elusive North American Nebula, NGC 7000. Given its great expanse and faintness, catching the Pelican does require clean skies, but it can be spotted best with large binoculars. As part of this huge star-forming region, look for the obscuring dark dust cloud Lynds 935 to help you distinguish the nebula's edges. Although it is every bit as close as the Orion Nebula, this star hatchery isn't quite as easy to spot!

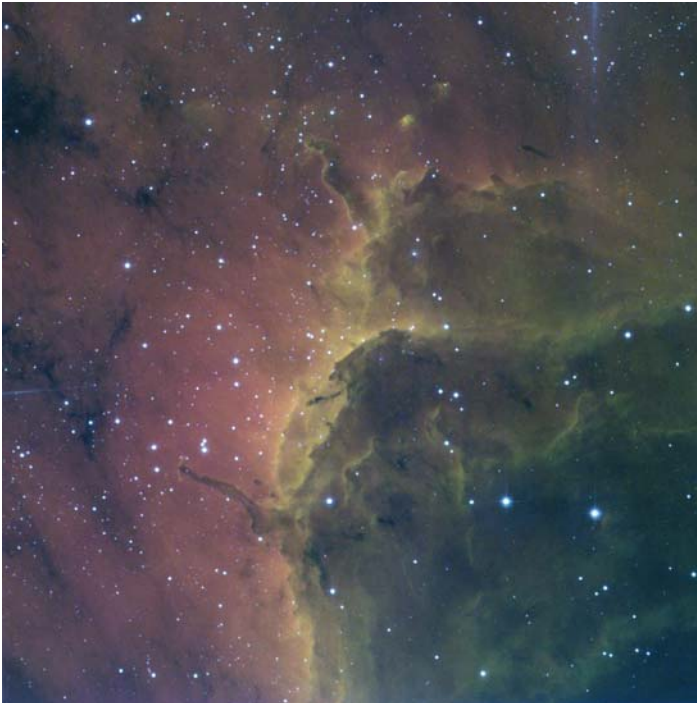


Figure 10.7. IC 5070: the Pelican Nebula (credit—John Bally, U. Colorado/NOAO/AURA/NSF).

Thursday, October 8

If you haven't seen the morning planetary conjunction...do it now! Before dawn, Mercury will be just 0.3 degrees away from Saturn!

Tonight's destination starts out easy but gets tougher. Head for Eta Pegasi and slightly more than 4 degrees north-northeast for NGC 7331 (RA 22 37 04 Dec +34 24 58). This beautiful, 10th magnitude, tilted spiral galaxy is how our Milky Way would appear to us if we could travel 50 million light-years away and look back. Very similar in structure both to ourselves and the "Great Andromeda," NGC 7331 gains more interest as scope size increases, yet can be spotted with larger binoculars. At 8" in aperture, a bright core appears and the beginnings of wispy arms. In the 10"-12" range, spiral patterns emerge, and with good seeing conditions, you'll see "patchiness" in structure as nebulous areas are revealed and the western half is deeply outlined with a dark dust lane. But hang on...because the best is yet to come! Shift the scope a half degree south-southwest and behold one of the most famous galaxy clusters in the night. In 1877, the French astronomer Edouard Stephan discovered something a bit more with NGC 7331...a group of galaxies! This faint gathering of five is better known as "Stephan's Quintet," and its members are no further apart than the diameter of our own galaxy.

To a large telescope, NGCs 7317, 7318A, 7318B, 7319 and the largest, 7320, are all rather faint, like ghostly grains of rice on a dinner plate. So why bother? Their proximity—and the more than 100-star clusters and dwarf galaxies we cannot see—makes them a curiosity. About 100 million years ago, two-member galaxies collided, their streamers of material creating new star-forming regions while tidal pull kept them connected. Most of the stars within the galaxies are nearly a billion years old, but they share common younger ones. See if you can make out the soft sheen of the galactic nuclei of the interacting group and enjoy their faint mystery!



Figure 10.8. Stephan's Quintet (credit—Nigel Sharp/NOAO/AURA/NSF).

Friday, October 9

Tonight is the peak of the Draconid meteor shower, whose radiant is near the westerling constellation of Hercules. This particular shower can be quite impressive when comet Giacobini-Zinner passes near Earth. When this happens, the fall rate jumps to 200 per hour and has even been known to reach 1,000. Comet Giacobini-Zinner reached perihelion on July 2, 2005, passing within 8 million kilometers of Earth but has now greatly distanced itself from our region of the Solar System. Chances are the Draconids will produce only about 3–5 meteors per hour, but this number can vary.

Tonight's skies remain dark into the early hours, so let's take this opportunity to have a look at two objects from one of the more obscure catalogs. Set your sights on Alpha Pegasi, and drop due south less than 5 degrees to pick up NGC 7479 (RA 23 04 56 Dec +12 19 23). Discovered by William Herschel in 1784, this 11-magnitude barred spiral galaxy experienced a supernova as recently as 1990. Although the 16th magnitude event near its nucleus is no longer visible, modest telescopes will easily pick out the bright core and elongation of the central bar. Larger aperture will find this one a real treat, as the spiral arms curl over and under the central structure, resembling a ballet dancer *en pointe*. Congratulations! If you've found it, you've just observed Caldwell 44.

NGC 7814 is easy enough to find. Start at Gamma Pegasi and use the finderscope to center on a star around 3 degrees northwest (RA 00 03 14 Dec +16 08 43). In the scope, look southeast to see NGC 7814 as a scratch of light in the low power field. Magnify and enjoy! This galaxy has a deeply concentrated nucleus and a very prominent dissecting dark dust lane. This one is also known by another name, Caldwell 43.



Figure 10.9a. NGC 7479 (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.9b. NGC 7814 (credit—Palomar Observatory, courtesy of Caltech).

Saturday, October 10

On this date in 1846, William Lassell was busy at his scope as he made a new discovery, Neptune's moon Triton. Although our everyday equipment can't "see" Triton, we can still have a look at Neptune! You'll find it on the ecliptic around 21:45 in right ascension. On this date 140 years later (1986), a tiny asteroid, Asteroid 3753, was found orbiting Earth. Named Cruithne, the little body will orbit our Earth for at least another 5,000 years from a minimum distance of 15 million kilometers.

While time and the stars appear to stand still, and astronomical twilight begins earlier each night, let's take one last look at the exiting constellation of Sagittarius. Our return study for this evening is a telescopic challenge for skilled observers only. Set your sights about 2 degrees northeast of easy double 54 Sagittarii and around 7 degrees west of Beta Capricorni (RA 19 44 58 Dec -14 48 11), and let's have a look at NGC 6822. Often referred to as "Barnard's Galaxy" for its discoverer (E.E. Barnard, 1884), this unusual customer is actually a member of our local galaxy group. For the 4"-6" telescope, this 11th magnitude, 1.7-million-light-year-distant object will not be easy to see, but it can be achieved with good conditions. Lower power is essential in even larger scopes, and those into the 12"-16" range will see NGC 6822 burst into stunning resolution. Barnard's Galaxy almost appears like an open cluster overlaid with nebulosity, but the experienced eye will clearly see that the "shine" behind the stars is galactic in nature. It's a very clumpy and unusual galaxy, one that you will very much enjoy. Be sure to look for the small, pale blue, 10th magnitude planetary nebula NGC 6818 in the same field to the north-northwest. This pair rocks!

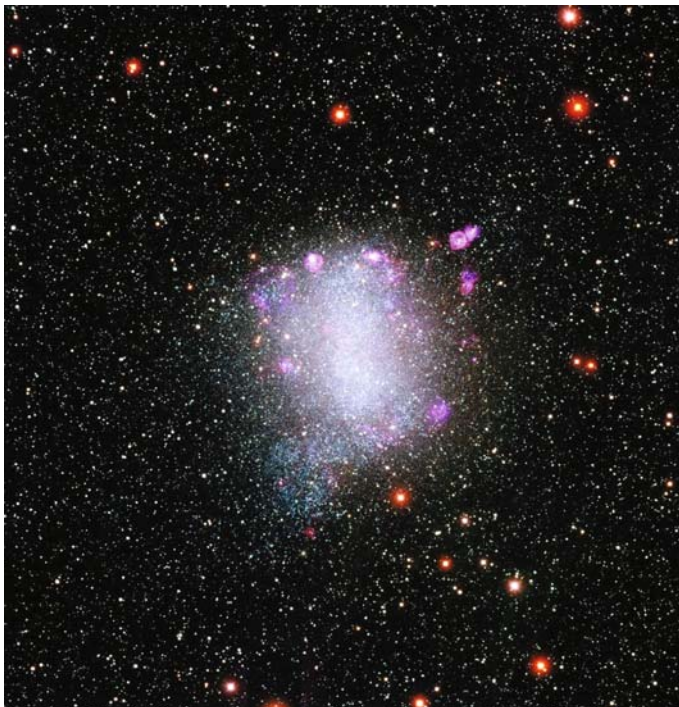


Figure 10.10. NGC 6822 (credit—Local Group Galaxies Survey Team/NOAO/AURA/NSF).

Sunday, October 11

Today we begin with the 1758 birth on this day of Heinrich Olbers, a German astronomer who calculated the orbit of the 1779 comet, discovered the minor planets (asteroids) Pallas (1802) and Vesta (1807), and discovered five comets during his career.

Tonight we'll have a look at a collection of stars as we ponder the age-old mystery of M73. Located about three finger-widths north-northwest of Theta Capricorni (RA 20 59 00 Dec -12 38 00), this 9th magnitude open cluster consisting of four stars was discovered by Charles Messier on October 4, 1780. Messier described it as a "cluster of three or four small stars, which resembles a nebula at first glance. . . ." Hotly debated as to whether or not the grouping is a genuine cluster or simply an asterism, it was also included in J. Herschel's catalog (GC 4617) and given the NGC 6994 designation by Dreyer. In 1931, Collinder cataloged M73 as Cr 426, with an estimated distance of 12,000 light-years. Still, the debate about its authenticity as a physically related group continues.

At least two stars show the same proper motion, leading scientists to believe that M73 may be the remnant of a much older and now dispersed cluster—or simply two related stars. Of the 140 stars investigated in the region, 24 may be real members, including those in Messier's original observation. Thanks to the work of Hertzsprung and Russell, these candidates fall within the color-magnitude diagram of a 2–3-billion-year-old cluster with Messier's suspect four being evolved giants. Although more recent data indicate that M73 may simply be an asterism—sharing no common proper motion—you can still enjoy this unusual Messier in even a small telescope!



Figure 10.11a. M73 (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.11b. Heinrich Olbers (historical image).

Monday, October 12

On this date in 1891, the Astronomical Society of France was established. Exactly 1 year later, in 1892, astronomy great E.E. Barnard was hard at work using the new tool of photography to become the first to discover a comet—1892 V—in this way! But Barnard's main photographic interest was in capturing the details of the Milky Way. Tonight let us take out binoculars or a telescope using the widest possible field of view and have a look at Barnard's passion as we view two regions in the westering Aquila, the "Double Dark Nebula."

Just northeast of Altair is bright star Gamma Aquilae, and about a finger-width west, is a pair of Barnard discoveries: B 142 and B 143—two glorious absences of stars known as interstellar dust clouds. B 143 (RA 19 40 42 Dec +10 57 00) is no more than a half degree in size and will simply look like a blank area shaped like a horseshoe, with its extensions pointing toward the west. Just south is B 142 (RA 19 39 41 Dec +10 31 00), an elongated comma shape, which seems to underscore its companion. Located anywhere from 1,000 to 3,000 light-years away, these non-luminous clouds of gas and dust are a fine example of Barnard's obsession. Do not be upset if you don't see them on your first attempt, for the chances are, if you are seeing nothing, you are looking in the right place!



Figure 10.12a. Barnard 142 (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.12b. Barnard 143 (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, October 13

Ready for some early morning action? Then get up before dawn to view asteroid Hygeia 0.7 degrees north of the Moon at perigee. Vesta is only 3 degrees further north! How about spotting Mercury? You'll find asteroid Pallas 0.3 degrees north. But check out the real show! Venus and Saturn will only be 0.5 degrees apart! This will make an awesome spectacle in the eyepiece and a not-to-be-missed photo opportunity! Today also marks the founding of the British Interplanetary Society (BIS) in 1933. "From imagination to reality," the BIS is the world's oldest established organization devoted solely to supporting and promoting astronautics and the exploration of space. Tonight we'll do them proud as we have a look at the mighty M2. You'll find it located about three finger-widths north-northeast of Beta Aquarii (RA 21 33 27 Dec -00 49 24).

At slightly dimmer than 6th magnitude, this outstanding globular cluster is just inside that region where it can't quite be viewed unaided, but even the smallest of binoculars will pick it out of a relatively starless field with ease. Holding a Class II designation, it was discovered by Maraldi on September 11, 1746, and rediscovered independently by Messier exactly 14 years later. At a distance of roughly 37,500 light-years, M2 is estimated to contain in the neighborhood of 150,000 stars. Even a small telescope will reveal M2's rich and concentrated core region and slight ellipticity. Not bad for a 13-billion-year-old group of stars! As aperture increases, some of the brightest stars will begin to resolve, and in larger telescopes it will approach total resolution. You might well note a dark area in the northeastern section and several more located throughout the splendid field. Feast your eyes on one of the finest views in the skies!



Figure 10.13. M2 (credit—Doug Williams/REU Program/NOAO/AURA/NSF).

Wednesday, October 14

Today we celebrate the 1788 birth of Sir Edward Sabine, an astronomer and adventurer who studied sunspots and helped determine Earth's magnetic fields. His passion? Aurora!

Tonight the large, bright, and scattered open cluster M39 is in favor just after skydark. Located between Deneb and Lacerta (RA 21 31 48 Dec +48 27 00), this 4-magnitude cluster can be seen as a faint haze unaided and easily resolves into over a dozen stars through binoculars. Discovered by Charles Messier in 1764, M39 resides about 800 light-years away and could be as much as 300 million years old. The brightest of these main sequence stars have almost reached the red giant phase!

A degree and a half south of M39 is its "echo"—the large, faint, 7.2-magnitude open cluster NGC 7082 (RA 21 29 00 Dec +47 08 00). Easily overlooked within a V-shaped array of brighter stars, the NGC 7082 cluster takes some concentration, along with a larger scope, to perceive it as a physical system based on its two dozen or so faint component stars.



Figure 10.14a. M39 (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.14b. NGC 7082 (credit—Palomar Observatory, courtesy of Caltech).

Thursday, October 15

This date in 1963 marks the first detection of an interstellar molecule. This discovery was made by Sander Weinreb (with Barrett, Meeks, and Henry) on the Massachusetts Institute of Technology (MIT) Millstone Hill 84-foot dish. The discovery was made possible by new correlation receiver technology and picked up a hydroxyl molecule in an absorption band. By using the radio galaxy Cas A as a background continuum source, the detection occurred at 1667.46 MHz and again at 1665.34 MHz. By the dawn of 2000, nearly 200 different interstellar molecules had been identified, and many of these are classified as organic.

Tonight, let's see what's up there in the region of Cas A using visible light. The nearest bright star to Cas A is Beta Cassiopeiae—the bright star westward of the “W.” To locate the region of Cas A, go about three finger-widths due west of Beta and follow the subtle curve of three 5th magnitude stars. Cas A lies less than a degree south-southwest of the second star in the sequence of three. This star is a complex 5th magnitude multiple-star system associated with variable star AR Cassiopeia System (RA 23 30 01 Dec +58 32 56).

Through binoculars, two stars of the AR system are easily resolved; the 4.9-magnitude primary is led across the sky by a 7.1-magnitude secondary (component C), which is a very tight double itself. Its 8.9-magnitude partner is resolvable in mid-sized scopes. Large aperture scopes may also be able to distinguish a 9.3-magnitude, second (B) component from the primary. Smaller scopes are back in the running again when attempting three 11th magnitude stars, none of which are close to the primary. Intermediate scopes can also hope to pick out a 12.9-magnitude H component northwest of C. An 8.9-magnitude F also has a 9.1-magnitude near twin to the east-northeast. If you can see them all you should probably wrap an observatory building around your telescope—if one isn't there already! If you like to follow brightness changes in variables, AR Cas is not a good choice. This eclipsing type variable only fluctuates by a tenth of a magnitude over a period of 6 Earth days.



Figure 10.15a. AR Cassiopeiae (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.15b. MIT Millstone Hill Dish (credit—MIT).

Friday, October 16

Celestial scenery alert! Be up and outside this morning before dawn. The incredible duo of Venus and Saturn will be joined by the Moon! In 1982, the 30th return of Halley's Comet was observed with the 5-meter (200") Hale Telescope at the Mount Palomar Observatory. The comet was beyond the orbit of Saturn!

Tonight let's return to the region of Cas A and see what else we can find. Although Cas A is itself not visible in amateur equipment, it is known to be associated with a 10,000-light-year-distant supernova remnant related to an unnoticed event occurring more than 300 years ago. The remnant itself has now expanded to a region filling some 10 light-years of space and has been imaged using orbiting X-ray observatories. The closest deep-sky study to Cas A is the dense and compact open cluster NGC 7510 (RA 23 11 00 Dec +60 34 00). This diminutive, magnitude 7.9 study can just be glimpsed as a hazy patch in large binoculars and small scopes, with a few of its brightest 10th magnitude members resolvable at higher magnifications. Doubling the aperture brings out a dozen or so of NGC 7510's 12th magnitude stars against the teeming glow of numerous fainter members. Double the aperture again, and 60 stars to magnitude 14 are possible. Many amateurs have discovered that the combination of a small rich field refractor, a 6" apochromatic refractor, and a 12" Newtonian makes for the ultimate in observing equipment. But don't forget those binoculars!



Figure 10.16. NGC 7510 (credit—Palomar Observatory, courtesy of Caltech).

Saturday, October 17

Today we mark the birth of Dr. Mae C. Jemison, the first black woman to go into space!

Tonight let's revisit M39 and use it as our touchstone to seek out other deep-sky gems. Starting with M39, head less than two finger-widths east-southeast (RA 21 53 32 Dec +47 16 06) to a 7.2-magnitude open cluster, one associated with the 12th magnitude "Cocoon Nebula." Collectively known as IC 5146, this cluster with nebulosity consists largely of 12th magnitude stars and is just about mid-sized. Barely detectable in a small scope, this 4,000-light-year-distant cluster needs aperture to come out and play. Large scopes may make seeing the nebula possible, although an appropriate filter may be necessary from most observing sites. To assist in finding the Cocoon, look for the stream of the dark obscuration nebula B168 touching its eastern frontier.

Returning again to M39, head two finger-widths southwest in the direction of Deneb to seek 6.8-magnitude IC 1369 (RA 21 12 06 Dec +47 44 00). Mid-sized instruments will show a dozen or so 12th and 13th magnitude members within a misty haze of those waiting to be resolved. Also known as alternative catalog study Pechüe (AN 3259), IC 1369 has been studied for luminosity features.



Figure 10.17a. IC 5146 (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.17b. IC 1369 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, October 18

Tonight it's a New Moon! Time to break out the muscle and challenge big telescope users to hone their skills. It's galaxy-hunting time, and our destination for tonight is the Hickson Compact Group 87 (RA 20 48 11 Dec -19 50 24). Several billion years ago, on the ecliptic plane about 4 degrees west-southwest of Theta Capricorni, and around 400 million light-years from our Solar System, a galactic association decided to form its own "Local Group." Orbiting around a common center every 100 million years, their mutual gravity is pulling each of them apart, creating starbursts and feeding their active galactic nuclei. Small wonder they're shredding each other. They're only 170,000 light-years apart! One day HCG 87 may even form a single elliptical galaxy bright enough for the average telescope to see, but as they are now, this group isn't going to be seen with anything less than 20" in aperture.

So, shall we try something a little more within the realm of reality? Then go ahead and drop about 8 degrees south of Theta, and try picking up on the NGC 7016/17/18 group (RA 21 07 20 Dec -25 29 15). Are they faint? Of course! It wouldn't be a challenge if they were easy, would it? With an average magnitude of 14, this tight trio known as Leavenworth 1 is around 600 million light-years away. They're very small and not very easy to locate, but for those who like something a bit different, give it a try!



Figure 10.18a. Hickson Compact Group 87 (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.18b. NGC 7016/17/18 (credit—Palomar Observatory, courtesy of Caltech).

Monday, October 19

As your starry mission this evening, you'll continue your studies in Vulpecula with a spectacular open cluster—NGC 6940 (RA 20 34 24 Dec +28 17 00). At close to magnitude 6, you'll find this unsung symphony of stars around three finger-widths southwest of Epsilon Cygni. Discovered by Sir William Herschel in 1784 and logged as H VIII.23, this intermediate-aged galactic cluster will blow your mind in large aperture. Although NGC 6940 is visible in binoculars, as aperture increases the field explodes into about 100 stars in a highly compressed, rich cloud. Although not visited often, NGC 6940 is on many observing challenge lists. Use low power to get the full effect of this stunning star field!

Now, move onto Aquila and look at the hot central star of an interesting planetary nebula—NGC 6804 (RA 19 31 35 Dec +09 13 32). You'll find it almost 4 degrees due west of Altair. Discovered by Herschel and classed as open cluster H VI.38, it wasn't until Pease took a closer look that its planetary nature was discovered. Interacting with clouds of interstellar dust and gases, NGC 6804 is a planetary in decline, with its outer shell about magnitude 12 and the central star near magnitude 13. Although only larger telescopes will get a glimpse of the central star, it's one of the hottest objects in space, with a temperature of about 30,000 K!



Figure 10.19a. NGC 6940 (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.19b. NGC 6804 (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, October 20

On this day we celebrate the 1632 birth of Sir Christopher Wren. In astronomy, Wren's skills were constructing working models, making diagrams, and charting—professions highly esteemed by Sir Isaac Newton!

We are now slipping into the stream of Comet Halley and one of the finest meteor showers of the year. If skies are clear tonight, this would be the perfect chance to begin observations of the Orionid meteor shower. But get to bed early and rise well before dawn!

Have a large scope and want a challenge tonight? Try the 10th magnitude, "bright" reflecting nebula NGC 7023. To locate this difficult study, start at 3-magnitude Beta Cephei and head southwest less than two finger-widths to 5.2-magnitude T Cephei (RA 21 01 36 Dec +68 09 48). What? No T Cephei? Don't worry! This one is a Mira-type variable capable of going "deep," to magnitude 11.3! Instead, center on a solitary 7th magnitude star (SAO 19158) and avert your vision to scan around. Look to the south for a patch of nebulosity shaped like an Oriental fan. This is the brightest portion of the nebula itself. Very large amateur scopes will also begin to reveal the very faint cluster now condensing out of this nebulous cloud of gas and dust.



Figure 10.20a. NGC 7023 (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.20b. Sir Christopher Wren (historical image).

Wednesday, October 21

Be sure to be outdoors before dawn to enjoy one of the year's most reliable meteor showers. The offspring of Comet Halley grace the early morning hours with their return as the Orionid meteor shower. This dependable shower produces an average of 10–20 meteors per hour maximum; best activity begins before local midnight on October 20 and reaches its peak when Orion stands high to the south about 2 hours before local dawn on October 21. This looks to be the year's premier meteor shower! Although Comet Halley has long departed the inner Solar System, its debris trail remains well organized, allowing us to predict when this meteor shower will occur. Earth first enters the stream at the beginning of October and does not leave until the beginning of November. This makes your chances of "catching a falling star" above average! These meteors are very fast, and although faint, occasional fireballs do leave persistent trails.

For best success, get away from city lights. Face south-southeast, relax, and enjoy the stars of the winter Milky Way. The radiant is near Betelgeuse, but they may occur from any part of the sky. The meteor-watching experience is much more comfortable if you include a lawn chair, blanket, and thermos of your favorite beverage. Clouded out? Don't despair. You don't always need eyes or perfect weather to keep the watch. Tune an FM radio to the lowest frequency that doesn't receive a clear signal. An outdoor FM antenna pointed to the zenith increases your chances, but isn't essential. Simply turn up the static and listen. Those hums, whistles, beeps, bongs, and occasional snatches of signals are distant transmissions being reflected off a meteor's ion trail!

Tonight it's a true stargazer's evening. Watch for the slender "Da Vinci" moon to appear after sunset. It's about to occult Antares! Check the Resources section of this book and IOTA for locations and times. Enjoy the Earthshine, and clear skies to you!



A 26-day old Moon Right: Crescent portion Left: Earthshine portion 2004.07.13 20:42–20:57 UT. FS102 + PL25 + CP990 (2 images)

Figure 10.21. Earthshine Moon (credit—Alan Chu). *Left:* Earthshine portion, *right:* crescent portion.

Thursday, October 22

Today we celebrate the 1905 birthday of Karl Jansky, physicist and electrical engineer. His pioneer discovery was non-Earth-based radio waves at 20.5 MHz—our galaxy's own Milky Way radio source! In 1975 on this date, Soviet probe Venera 9 was busy sending Earth the very first look at Venus's surface. Before dawn, you can also see Venus. Can you tell its phase? At dusk, have a look at the Moon. If the lunar terminator has not advanced too far at your viewing time, scan the southeast shoreline of Mare Crisium for Agarum Promontorium progressing northward across the dark plain before it disappears beneath the once-molten lava. There were times in the past when great lunar observers noted a mist-like appearance in this area—another transient lunar phenomenon.

Now it's time for a telescopic challenge, a compact galaxy group. You'll find it less than half a degree southeast of the stellar pair 4 and 5 Aquarii (RA 20 52 26 Dec -05 46 19). Known as Hickson 88, this grouping of four faint spiral galaxies is estimated to be about 240 million light-years away and is by no means an easy object; yet the galactic cores can just be glimpsed using mid-sized scopes from a very dark site. Requiring around 12.5'' of aperture to study, you'll find the brightest are northernmost NGC 6978 and NGC 6977. Although little detail can be seen in the average large backyard scope, NGC 6978 appears barred, while NGC 6977 shows as face-on. Further south is smaller, fainter NGC 6976, usually caught while averting and studying the neighborhood. The southernmost galaxy is NGC 6975, whose slender, edge-on appearance makes it much harder to glimpse. Although these four galaxies seem to be in close proximity to one another, no current data suggest any interaction between them.



Figure 10.22a. Hickson 88 (credit—Palomar Observatory, courtesy of Caltech).



Figure 10.22b. Carl Jansky at the antennae used to detect the Milky Way (historical image).

Friday, October 23

Today marks the 1893 birth of Ernest Julius Öpik, whose forte was meteors and meteorites. But that's not all! Among his very noted achievements, Öpik was the first to measure the distance to an extragalactic object!

Tonight we'll begin on the lunar surface and go out on a limb—the southeastern limb—to have a look at an unusual crater. Named for the French agrochemist and botanist Jean-Baptiste Boussingault, this elliptical-appearing crater actually spans a handsome 71 kilometers. What makes Boussingault so unusual is that it is home to its own large interior crater, called A. This double-ring formation gives it a unique stepped, concentric look that's worth your time!

Now wait for the Moon to wester a bit, and we'll return to Pegasus and the incredible M15. Although skies are a bit bright, you can still have a very satisfactory look at M15 through any size binoculars or telescope. You can find it easily just about two finger-widths northwest of red Epsilon Pegasi—Enif (RA 21 29 58 Dec +12 10 00). Shining brightly at magnitude 6.4, low power users will find it a delightfully tight ball of stars, but scope users will realize it is unique. As resolution begins, sharp-eyed observers will note the presence of a planetary nebula, Pease 1. The famous X-ray source you have just seen with your own eyes may have a supernova remnant buried deep inside!

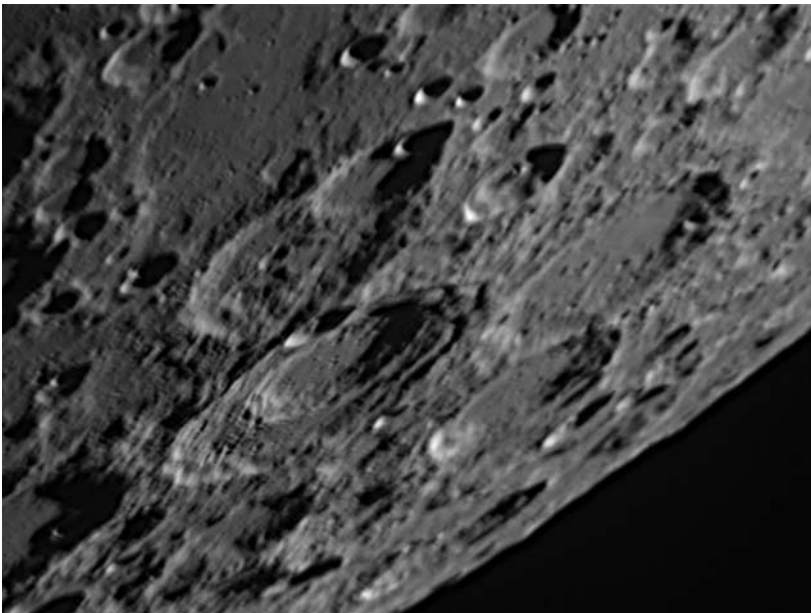


Figure 10.23a. Boussingault (credit—Ricardo Borba).

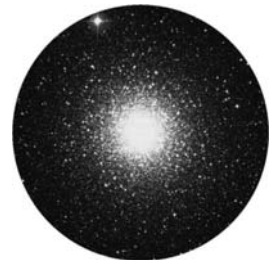


Figure 10.23b. M15 (credit—Palomar Observatory, courtesy of Caltech).

Saturday, October 24

Today we remember the launch of Deep Space 1 from Cape Canaveral in 1998. The primary mission of Deep Space 1 was extremely successful, testing a dozen advanced technologies. During its extended mission, Deep Space 1 headed for Comet Borrelly and sent back the best images from a comet up to that time. The mission continued to test new techniques until it was finally retired on December 18, 2001, after three fantastic years of service.

In 1819, a professor named Johannes Burg discovered Antares's companion star during an occultation event. Would you like to see the lunar crater named for him? We'll begin by using past study crater Posidonius as our guide. How many more of these craters can you identify?

If you walk along the terminator to the northwest, you'll see the punctuation of 40-kilometer-wide Burg just emerging from the shadows. Although it doesn't appear to be a grand crater, like Posidonius, it has a redeeming feature: it's deep, very deep. If Burg were filled with water here on Earth, it would require a deep submergence vehicle such as the Alvin to reach its 3,680 meter floor! This Class II crater stands nearly alone on an expanse of lunar landscape known as Lacus Mortis. If the terminator has advanced enough at your time of viewing, you may be able to see this walled plain's western boundary peeking out of the shadows.

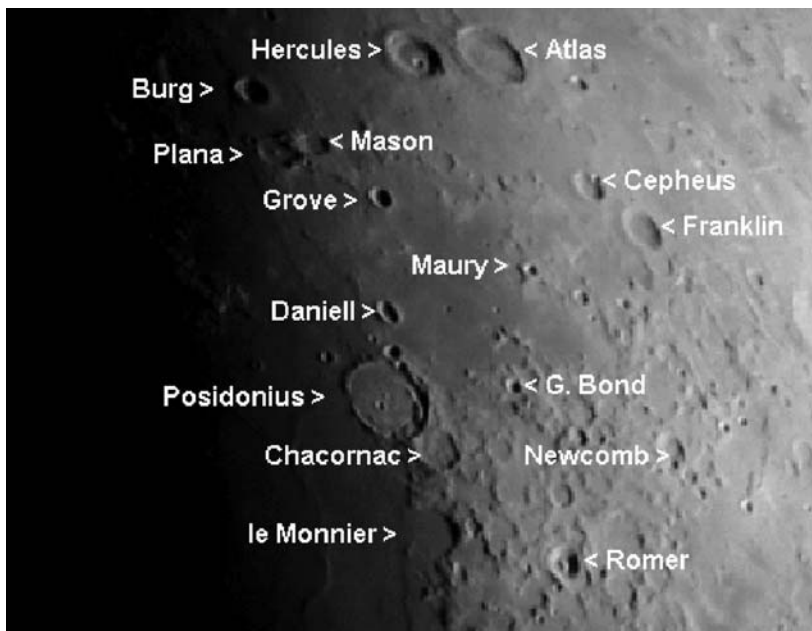


Figure 10.24a. Detail view of Posidonius (credit—Greg Konkel).



Figure 10.24b. Comet Borrelly (credit—NASA).

Sunday, October 25

Who was undoubtedly watching the planets on this date in 1671? None other than Giovanni Cassini, because he'd just discovered Saturn's moon Iapetus. If you're up before dawn this morning, have a look at Saturn for yourself. Iapetus usually holds around a magnitude of 12 and orbits well outside of bright Titan's path. Tonight explore our own Moon for a binocular curiosity located on the northeast shore of Mare Serenitatis. Look for the bright ring of Posidonius, which contains several equally bright points both around and within it. Now look at Mare Crisium and get a feel for its size. A little more than one Crisium's length west of Posidonius you'll meet Aristotle and Eudoxus. Drop a similar length south, and you will be at the tiny, bright crater Linne on the expanse of Mare Serenitatis. So what's so cool about this little white dot? With only binoculars you are resolving a crater that is 1 mile wide—in an 11-kilometer-wide patch of bright ejecta—from close to 400,000 kilometers away! And you thought Iapetus was tiny. . .

Now let's celebrate the birthday of Henry Norris Russell. Born in 1877, Russell was the leader in establishing the modern field of astrophysics in the United States. As the namesake for the American Astronomical Society's highest award (for lifetime contributions to the field), Russell is the "R" in H-R diagrams, along with Hertzsprung. This work was first used in a 1914 paper published by Russell. Honor Russell by observing a star that resides right in the middle of the H-R diagram as we have a look at Beta Aquarii (RA 21 31 33 Dec -05 34 16). Named Sadal Suud (Luck of Lucks), this star of spectral type G is around 1,030 light-years distant from our Solar System and shines 5,800 times brighter than our own Sun. The main sequence beauty also has two 11th magnitude optical companions. The one closest to Sadal Suud was discovered by John Herschel in 1828, while the further star was reported by S.W. Burnham in 1879.

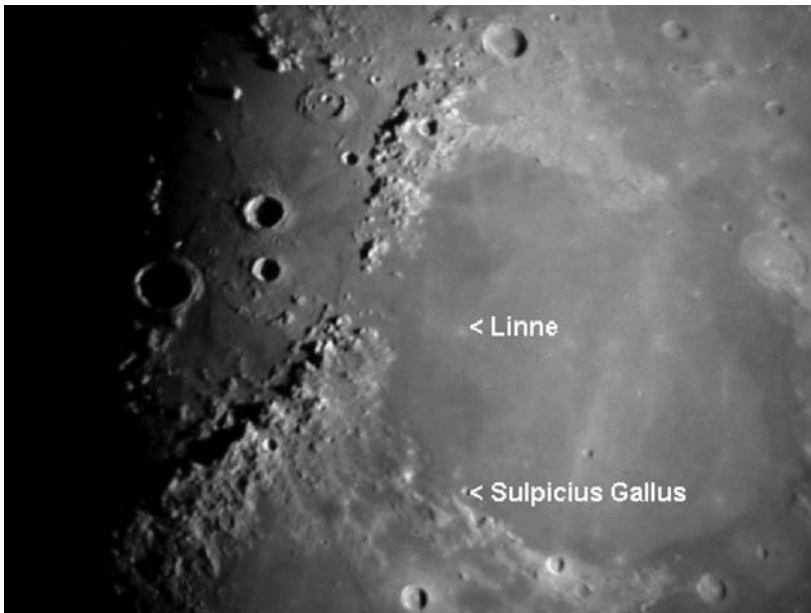


Figure 10.25a. Crater Linne (credit—Greg Konkell).



Figure 10.25b. Beta Aquarii: Sadal Suud (credit—Palomar Observatory, courtesy of Caltech).

Monday, October 26

For observers the world over, it's almost time for Halloween! For the next 5 days, let's take a look at some of the "spookiest" objects in the night sky. This evening we are once again going to study a single star, which will help you become acquainted with the constellation of Perseus. Its formal name is Beta Persei (RA 03 08 10 Dec +40 57 20), and it is the most famous of all eclipsing variable stars. Tonight, let's identify Algol and learn all about the "Demon Star." Ancient history has given this star many names. Associated with the mythological figure Perseus, Beta was considered to be the head of Medusa the Gorgon and was known to the Hebrews as Rosh ha Satan, or "Satan's Head." Seventeenth-century maps labeled Beta as Caput Larvae, or the "Specter's Head," but it is from the Arabic culture that the star was formally named. They knew it as Al Ra's al Ghul, or the "Demon's Head," and we now know it as Algol. Because these medieval astronomers and astrologers associated Algol with danger and misfortune, we are led to believe that Beta's strange visual variable properties had been noted throughout history.

Italian astronomer Geminiano Montanari was the first to record that Algol occasionally "faded," and its regular timing was cataloged in 1782 by John Goodricke, who surmised that it was being partially eclipsed by a dark companion orbiting it. Thus was born the theory of the eclipsing binary, which was proved spectroscopically for Algol in 1889 by H.C. Vogel. At 93 light-years away, Algol is the nearest eclipsing binary and is treasured by the amateur astronomer because it requires no special equipment to easily follow its stages. Normally Beta Persei holds a magnitude of 2.1, but approximately every 3 days it dims to magnitude 3.4 and then gradually brightens again. The entire eclipse lasts only about 10 hours! Although Algol is known to have two additional spectroscopic companions, the true beauty of watching this variable star is not telescopic but visual. The constellation of Perseus is well placed this month for most observers and appears like a glittering chain of stars lying between Cassiopeia and Andromeda. To help further assist you, locate Gamma Andromedae (Almach) east of Algol. Almach's visual brightness is about the same as Algol's at maximum.



Figure 10.26.> Beta Persei: Algol (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, October 27

Tonight let's walk on the Moon and check off a few more features on your lunar list! Look for the prominent pair of Aristillus and Autolycus, caught just east of the Apennine Mountain range. If you haven't logged the shallow Archimedes, tonight is your chance. Take the time to closely inspect the differing lava flow patterns on the floor of Palus Putredinus, and you can't miss the bright ring of Manilius.

Now we need a jack-o-lantern...

The asteroid Vesta is considered to be a minor planet, since its approximate diameter is 525 kilometer (326 miles), making it slightly smaller in size than the state of Arizona. Vesta was discovered on March 29, 1807, by Heinrich Olbers, and it was the fourth such "minor planet" to be identified. Olbers' discovery was fairly easy because Vesta is the only asteroid bright enough to be seen unaided from Earth. Why? Orbiting the Sun every 3.6 years and rotating on its axis in 5.24 hours, Vesta has an albedo (or surface reflectivity) of 42%. Although it is about 350 million kilometers away, pumpkin-shaped Vesta is the brightest asteroid in our Solar System because it has a unique geological surface. Spectroscopic studies show it to be basaltic, which means lava once flowed on the surface. (This is very interesting, since most asteroids were once thought to just be rocky fragments left over from our forming Solar System!) You'll find it before dawn—if you're up!



Figure 10.27a. Moon Walk (credit—Roger Warner).

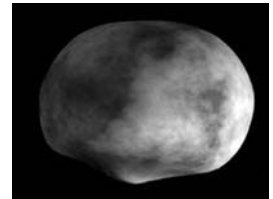


Figure 10.27b.
Asteroid Vesta
(credit—NASA).

Wednesday, October 28

It's bold. It's beautiful. You've looked at it hundreds of times. What is it? It's Copernicus. Although Copernicus is not the oldest, deepest, largest, or brightest crater on the Moon, it certainly is one of the most detailed. Visible in binoculars toward Plato and near the terminator, this youthful crater gives a highly etched appearance. Its location in a fairly smooth plain near the center of the Moon's disk, and its prominent "splash" ray system, all combine to make Copernicus visually stunning in a small telescope. Spanning 100 kilometers, with 23-kilometer-thick walls, the "Mighty One" is most definitely an impact crater that left its impression down to 3,840 meters below the surface. Geologist Gene Shoemaker cited many features of Copernicus that mirror our own terrestrial impact features. Many of these Copernican features could have been caused by a large meteoritic body, a body about the size of Comet Halley's nucleus. No matter what optical aid you use, mid-placed Copernicus simply rocks!

Now let's go vampire...and find a drop of blood. The red star, Mu Cephei (RA 21 43 30 Dec +58 46 48), is dying. It has stopped burning hydrogen and will eventually explode. It is visible with binoculars, and although faint, it is very large. If it were placed at the center of our Solar System, it would reach outward to between the orbits of Jupiter and Saturn! It was named the "Garnet Star" by Sir William Herschel for its lovely red color when at minimum, varying by a little more than a magnitude in 850–4,400 days. As a red, Class M, low-temperature (about 3,500 K) supergiant, it must be one of the larger stars visible with the naked eye and is one of the largest and most luminous stars in the entire Milky Way Galaxy.



Figure 10.28. Copernicus (credit—Greg Konkel).

Thursday, October 29

While we're cursing the Moon for blinding us, let's take a look through the telescope as we first identify Palus Epidemiarum to the south. Not much more than a slightly darker extension of Mare Nubium to the northeast, this innocent-looking area holds a wealth of rimae. Power up, and look at the south shore for the peninsula-like feature of crater Capuanus. Named for the Italian theologian and astronomer Francesco Capuano di Manfredonia, this awesome little crater is 60 kilometers wide and has a very strong west wall!

On this night in 1749, the French astronomer Le Gentil was at the eyepiece of an 18' focal length telescope. His object of choice was the Andromeda Galaxy, which he believed to be a nebula. Little did he know at the time that his descriptive notes also included M32, a satellite galaxy of M31. It was the first small galaxy discovered, and it would be another 175 years before these were recognized as such by Edwin Hubble. Tonight, take the time to view the Andromeda Galaxy for yourself. Located just about a degree west of Nu Andromedae, this "ghost" set against the starry night was known as far back as 905 AD. and was referred to as the "Little Cloud." Located about 2.2 million light-years from our Solar System, this expansive member of our Local Group has delighted observers of all ages throughout the years. No matter if you view with just your eyes, a pair of binoculars, or a large telescope, M31 still remains one of the most spectacular galaxies in the Moonlit night. *Boo-tiful*...



Figure 10.29a. Capuanus (credit—Wes Higgins).



Figure 10.29b. M31 (anonymous image).

Friday, October 30

Tonight we'll let Gassendi be our guide as we head north to examine the ruins of crater Letronne. Sitting on a broad peninsula on the south edge of Oceanus Procellarum, this Class V crater once spanned 118 kilometers. Thanks to the lava flows that formed Procellarum, virtually the entire northern third of the crater was submerged, leaving the remaining scant walls to rise no more than a thousand meters above the surface. Although this might seem shallow, it's as high as El Capitan in Yosemite.

Shall we continue our Halloween tour with a pair of spooky eyes? Then look no further than Gamma Arietis (RA 01 53 32 Dec +19 17 38). . .

Also known as Mesarthim, this magnitude 4 (combined) beauty was unintentionally discovered in 1664 by Robert Hooke while he was following a comet. Although no real change has been spotted in the more than 343 years since that time, there has been a slight difference detected in the components' radial velocities. Roughly 160 light-years away, you'll enjoy this almost matched magnitude pair of white stars, but look carefully. In 1878, S.W. Burnham found a third star nearby that might not be a physical member but is also a double!



Figure 10.30a. Apollo 16 image of Letronne (credit—NASA).

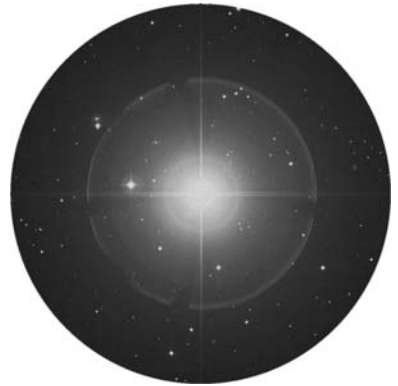


Figure 10.30b. Gamma Arietis (credit—Palomar Observatory, courtesy of Caltech).

Saturday, October 31

Happy Halloween! Many cultures celebrate tonight with “Trick or Treat.” Instead of tricking your visitors, treat them to a view through your telescope or binoculars! So far, we’ve collected a demon, a pumpkin, vampire blood, and a galactic ghost. . .now for a witch! The Pleiades can be easily spotted on the northeastern horizon within a couple of hours of nightfall. Many of the seven bright components resolve without optical aid, but telescopes and binoculars will find M45 stunning! The recognition of the Pleiades dates back to antiquity, and its stars are known by many names: the “Starry Seven,” “Net of Stars,” “The Seven Virgins,” “Subaru,” “The Daughters of Pleione,” and even “The Children of Atlas.” However, the Russians called them “Baba,” after Baba Yaga, the witch who flew through the skies on her fiery broom. Now, let’s have some Halloween fun!

The date of the Pleiades culmination (its highest point in the sky) has been celebrated throughout history, but one particular rite really fits this occasion. The ancient Druids celebrated the Pleiades’ midnight “high” with Black Sabbath! This night of “unholy revelry” is still observed in the modern world as All Hallow’s Eve, or Halloween. Although the date of the Pleiades midnight culmination is now November 21 instead of October 31, why break with tradition? Thanks to its nebulous regions, M45 looks wonderfully like a “ghost” haunting the starry skies. Treat yourself and your loved ones to the “scariest” object in the night. Binoculars give an incredible view of the entire region, and small telescopes at lowest power will enjoy M45’s rich, icy-blue stars and fog-like nebulosity. Larger telescopes and higher power reveal many pairs of double stars buried within its silver folds. No matter what you choose, the Pleiades definitely rock!

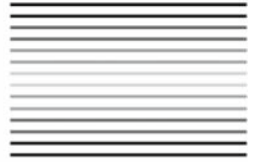
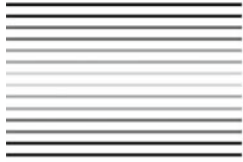


Figure 10.31. M45: the Pleiades (credit—John Chumack).

CHAPTER ELEVEN



November, 2009



Sunday, November 1

On this day in 1977, Charles Kowal made a wild discovery—Chiron. This was the first sighting of one of the multitude of tiny, icy bodies inhabiting the outer reaches of our Solar System. Collectively known as Centaurs, they reside in unstable orbits between Jupiter and Neptune and are almost certainly “refugees” from the Kuiper Belt.

Do you like looking at things that are considered dubious? Then tonight let’s start on the lunar surface and peek at a ray system whose origins are uncertain. You’ll find the bright ring of Bessel almost in the center of Mare Serenitatis, but the rays are splashed all over it. Did they come from Menelaus on the mare’s edge? Or from as far south as Tycho? Next time the terminator passes over this region, look closely. Do you see the rays now, or just a complicated system of dorsa?

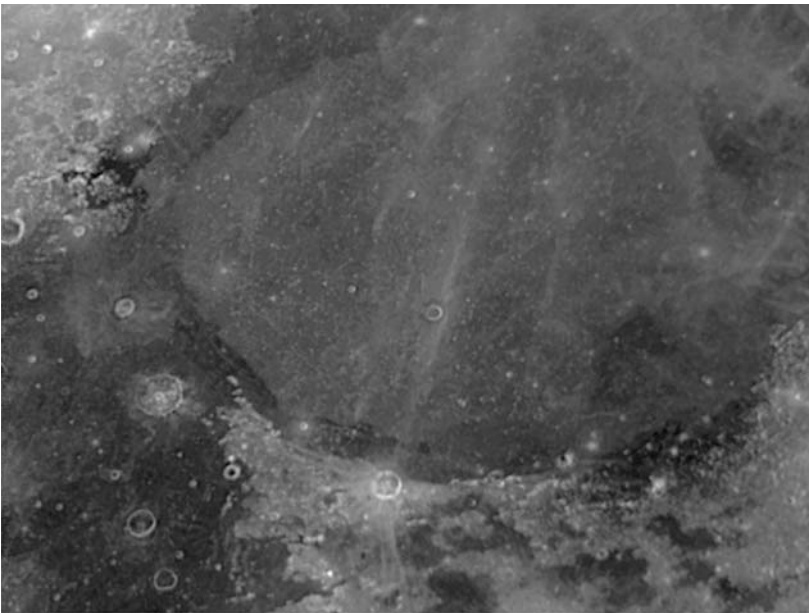


Figure 11.1a. Bessel Rays (credit—Ricardo Borba).



Figure 11.1b. Chiron (credit—NASA).

Monday, November 2

Today we celebrate the birth of an astronomy legend, Harlow Shapely. Born in 1885, the American-born Shapley paved the way in determining distances to stars, clusters, and the center of our Milky Way Galaxy. Among his many achievements, Shapely was also the director of Harvard College Observatory for many years. Today also represents the night in 1917 when first light was seen through the Mt. Wilson 100" telescope.

Tonight is the "Full Frost Moon," and there is little doubt about how its name came to be! For those of you interested in viewing lunar features tonight, libration could be favorable for studying a collection of shallow, dark craters known as Mare Australe. Located on the southeastern limb, this large binocular and telescopic object is well worth looking out for...because it's a challenge that's not always visible.

Now let's give deep sky a rest as we travel to the northwest corner of Capricornus and have a look just south of Alpha at beautiful Beta (RA 20 21 00 Dec -14 46 52).

Named Dabih, this lovely white 3rd magnitude star has a very easy to split 6th magnitude companion that will appear slightly blue. Over 100 times brighter than our own Sun, the primary star is also a spectroscopic triple, one whose unseen companions orbit in a little over 8 days and 1,374 days. Oddly enough, the B star is also a very tight binary as well, yet the two major stars of this system are separated by about a trillion miles! If you have a large aperture telescope, power up. According to T.W. Webb, a 13th magnitude unrelated double is also found in between the two brighter stars. No matter if you choose binoculars or a telescope, you'll find the 150-light-year trip worth your time to add to your doubles' list!

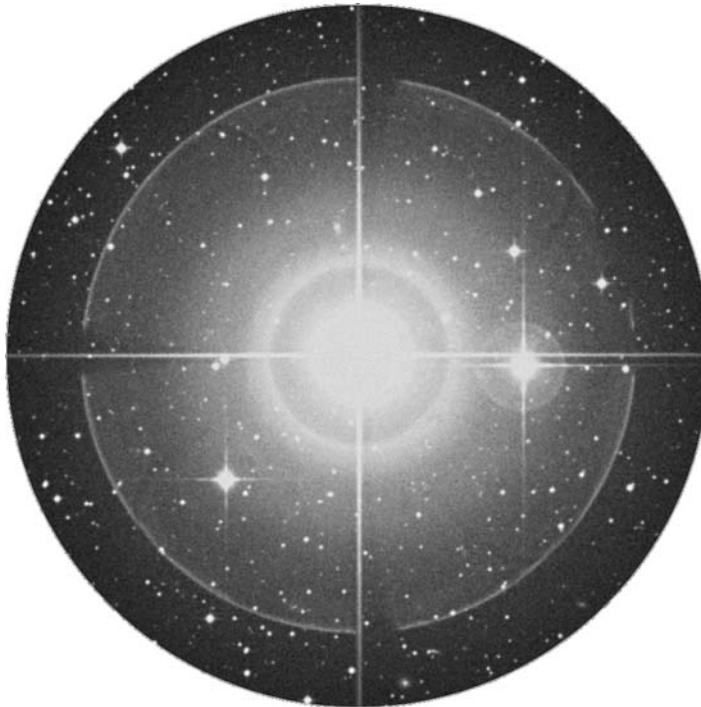


Figure 11.2. Beta Capricorni (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, November 3

On this date in 1955, one of the few documented cases of a person being hit by a meteorite occurred. What are the odds on that? In 1957 the Russian space program launched its first “live” astronaut into space—Laika. Carried on board Sputnik 2, this canine hero was the first living creature to reach orbit. The speedily developed Sputnik 2 was designed with sensors to transmit the ambient pressure, breathing patterns, and heartbeat of its passenger; it also had a television camera on board to monitor its occupant. They also studied ultraviolet and X-ray radiation to further assess the impact of space-flight on live beings. Unfortunately, the technology of the time offered no way to return Laika to Earth, so she perished in space. On April 14, 1958, Laika and Sputnik 2 returned to Earth in a fiery re-entry after 2,570 orbits.

Tonight before the Moon rises, let’s take on a galaxy challenge and locate NGC 7606 just north of the triple Psi Aquarii (RA 23 19 04 Dec -08 29 06). Located around 97 million light-years away, it’s small wonder that this 10.8-magnitude galaxy isn’t a more popular object. The average telescope will spy a faint, elongated galaxy, with two arms and a slightly brighter center. Yet, the tightly wound spiral construction of NGC 7606 makes it similar to others. Through study, astronomers have learned that NGC 7606 is slowing down its rate of star formation and may someday form a barred nucleus!



Figure 11.3a. NGC 7606 (credit—Adam Block/NOAO/AURA/NSF).



Figure 11.3b. Laika (historical image).

Wednesday, November 4

This morning will be the peak of the Southern Taurid meteor shower. Already making headlines around the world for producing fireballs, the Taurids will be best visible in the early morning hours, but the Moon will interfere. The radiant for this shower is, of course, in the constellation of Taurus and near the red giant Aldebaran. But did you know that the Taurids are divided into two streams? The original parent comet is believed to have shattered as it passed our Sun 20,000–30,000 years ago. The larger “chunk” continued orbiting and is known as periodic comet Encke. The remaining debris field turned into smaller asteroids, meteors, and other fragments. These occasionally pass through our atmosphere, creating the astounding “fireballs” known as bolides. Although the fall rate for this particular shower is rather low, at 7 per hour, these slow-traveling meteors (27 kilometers per second) are usually very bright and appear to almost “trundle” across the sky. With the chances high all week of seeing a bolide, this makes a bit of quiet contemplation under the stars well worth a morning walk!

Tonight let’s have a look at a very unusual little globular located about a fist-width south-southeast of Beta Ceti and just a couple of degrees north-northwest of Alpha Sculptoris (RA 00 52 48 Dec -26 35 24), as we have a look at NGC 288.

Discovered by William Herschel on October 27, 1785, and cataloged by him as H VI.20, the Class X globular cluster blew apart scientific thinking in the late 1980s when a study of perimeter globulars showed it to be more than 3 million years older than similar globulars—thanks to the color magnitude diagrams of Hertzsprung and Russell. By identifying both its blue and red branches, it was shown that many of NGC 288’s stars are being stripped away by tidal forces and contributing to the formation of the Milky Way’s halo structure. In 1997, three additional variable stars were discovered in this cluster. At magnitude 8, this small globular is easy for southern observers to see but faint for northern ones. If you are using binoculars, be sure to look for the equally bright spiral galaxy NGC 253 to the globular’s north.

Now keep watching as the Moon rises. . . There may be a Pleiades occultation event! Check the Resources section of this book and International Occultation and Timing Association (IOTA) for times and locations.



Figure 11.4. NGC 288 (credit—Palomar Observatory, courtesy of Caltech).

Thursday, November 5

On this date in 1906, a man named Fred Whipple was born. If that name doesn't ring a bell for you, it should! Thanks to Whipple's work, we have a clearer understanding of the orbital mechanics of comets and their relation to meteoroid streams. Not only that, Whipple founded the Smithsonian Astrophysical Observatory (SAO) in Arizona, discovered six comets, made invaluable contributions to research in the upper atmosphere, and was the first to call a comet a "dirty snowball." His guess about the outgassing properties of comets was proved true when the first flyby of Comet Halley was made!

To honor Whipple, let's have a look at a beautiful optical pair (possibly a multiple system) as we journey to the southernmost star in the Circlet—Kappa Piscium (RA 23 26 55 Dec +01 15 20). Easily split even in binoculars, this lovely green and violet combination of stars may have once belonged to the Pleiades group. Magnitude 5 Kappa A is a chromium star, which rotates completely in around 48 hours. It shows unusual iron lines in its spectrum and also displays lines of uranium and osmium—and possibly those of a very rare element known as holmium. Both the uranium and osmium contents could be the result of a supernova explosion in a nearby star. Enjoy this colorful pair tonight!



Figure 11.5a. Kappa Piscium (credit—Palomar Observatory, courtesy of Caltech).



Figure 11.5b. Fred Whipple (historical image).

Friday, November 6

Today we heartily salute the 1638 birth of James Gregory, inventor of the reflector telescope! In 1660, he published his *Optica Promota*, in which he described the first practical reflecting Gregorian telescope. Light bounced off a concave elliptical secondary mirror is brought to a focus just behind a hole in the primary mirror. Not bad for a fellow Scot!

Tonight we return to NGC 288 to have a look at that galaxy under darker skies!

Discovered by Caroline Herschel on September 23, 1783, NGC 253 (RA 00 47 33 Dec -25 17 17) is the brightest member of a concentration of galaxies known as the Sculptor Group, near to our own Local Group and the brightest of all outside it. Cataloged as both H V.1 and Bennett 4, this 7th magnitude beauty is also known as Caldwell 65, and due to both its brightness and oblique angle it is often called the "Silver Dollar Galaxy." As part of the SAC 110 best NGCs, you can spot this one even if you don't live in the Southern Hemisphere. At around 10 million light-years away, this very dusty, star-forming Seyfert galaxy delights in even a modest telescope!



Figure 11.6a. NGC 253: the Silver Dollar Galaxy (credit—R. Jay GaBany).



Figure 11.6b. James Gregory (historical image).

Saturday, November 7

Today in 1996, the Mars Global Surveyor left on its journey. Just 30 years beforehand on this same day, Lunar Orbiter 2 was launched. In 1631, Pierre Gassendi made the first observation of the transit of a planet. Kepler had predicted that a transit of Mercury would occur in 1631, and Gassendi was one of the first to witness it by using the projection method. His reports indicate amazement at its small size! Where is Mercury now? Up before dawn and heading for superior conjunction!

Tonight let's go for something small but white-hot as we head for a dwarf star and planetary nebula, NGC 246. You'll find it just a bit more than a fist-width north-northeast of Beta Ceti (RA 00 47 03 Dec -11 52 19). Discovered by Sir William Herschel and cataloged as object V.25, this 8th magnitude planetary nebula has a wonderful patchy, diffuse structure that envelops four stars. Around 1,600 light-years away, the nebulosity you can see around the exterior edges was once the outer atmosphere of a star much like our own Sun. At the center of the nebula lies the responsible star—the fainter member of a binary system. Although it is now in the process of becoming a white dwarf, we can still enjoy the product of this expanding shell of gas that is often called the "Skull Nebula."

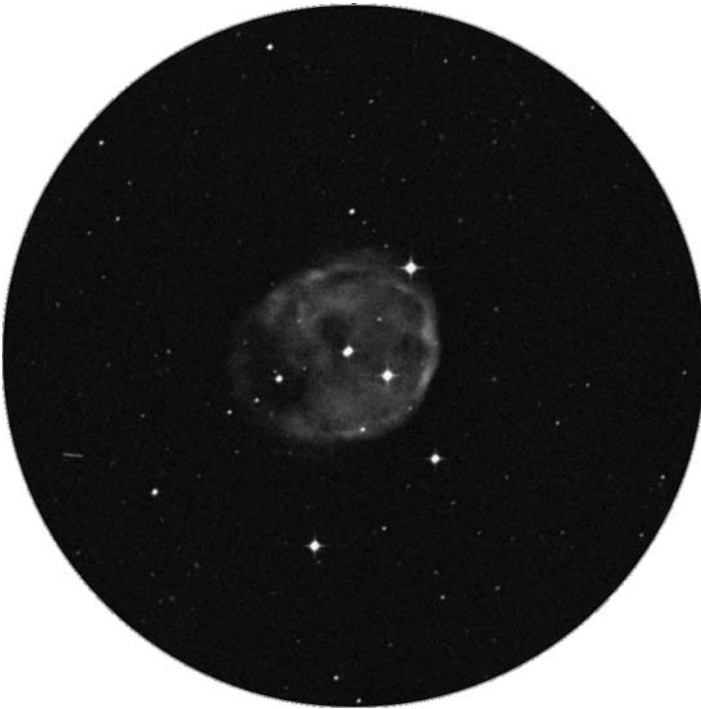


Figure 11.7a. NGC 246 (credit—Palomar Observatory, courtesy of Caltech).

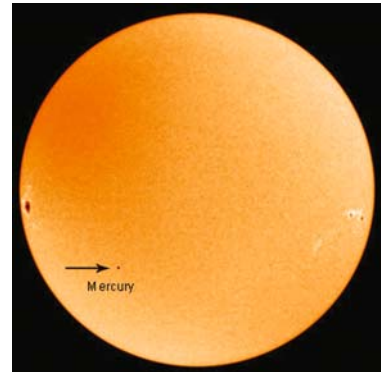


Figure 11.7b. Mercury transit (credit—NASA).

Sunday, November 8

Born on this day in 1656, the great Edmund Halley made his mark on history as he became best known for determining the orbital period of the comet bearing his name. English scientist Halley had multiple talents, however, and in 1718 discovered that what were then referred to as “fixed stars” actually displayed (proper) motion! If it were not for Halley, Sir Isaac Newton may never have published his now-famous work on the laws of gravity and motion.

Now turn your eyes or binoculars just west of bright Aldebaran and have a look at the Hyades Star Cluster. Aldebaran appears to be part of this large, V-shaped group but is not an actual member. The Hyades cluster is one of the nearest galactic clusters, and it is roughly 130 light-years away at its center. This moving group of stars is drifting slowly away toward Orion, and in another 50 million years will require a telescope to view!

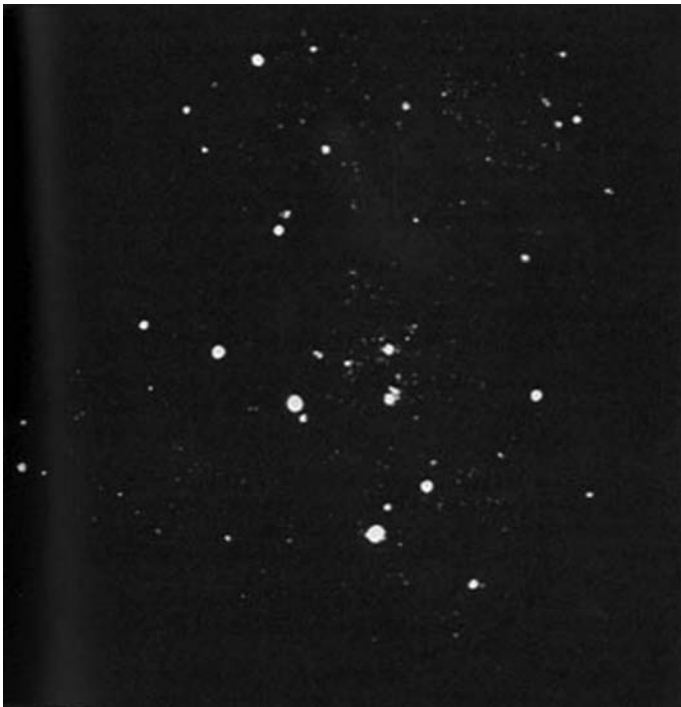


Figure 11.8a. The Hyades Star Cluster (credit—NASA).



Figure 11.8b. Edmund Halley (widely used public image).

Monday, November 9

Today is the birthdate of Carl Sagan. Born in 1934, Sagan was an American planetologist, exobiologist, popularizer of science and astronomy, and novelist. His influential work and enthusiasm inspired us all. If Sagan were with us tonight, he would encourage amateurs at every level of astronomical ability! So let us honor his memory by beginning with a galaxy grouping that features the magnificent M77. Just head less than a degree south-southeast of Delta Ceti (RA 02 43 41 Dec -00 00 48).

Discovered on October 29, 1780, by Pierre Méchain, Messier cataloged the galaxy, which is 47 million light-years away, around 6 weeks later as number 77 and described it as a “nebulous cluster”—pretty accurate for a small telescope. It wasn’t until 1850, when Lord Rosse uncovered its spiral nature that we began to view it as the grand structure seen in today’s modern telescopes.

Seen through a larger telescope, the galaxy’s wide spiral arms are where the older stars call home, and the concentrated core region is where gigantic gas clouds move rapidly and new stars are being formed. The core contains such a massive energy source that it emits a spectrum of radio waves. After decades of study, the highly active nucleus of this Seyfert galaxy is known to have a mass equaling 10 million suns. A 5-light-year-wide disk rotates around it, which has intense star-forming regions. This is one of the brightest known Seyferts, and Arp cataloged it as number 37 on his list of peculiar galaxies. Although binoculars can spot the core and modest scopes can reveal M77’s glory, larger telescopes will also spy the 10th magnitude edge-on NGC 1055 about half a degree north-northwest and 11th magnitude face-on NGC 1073 about a degree north-northeast. Enjoy them tonight! As Dr. Sagan would have said, “We are all just star stuff.”



Figure 11.9a. M77 (credit—NOAO/AURA/NSF).



Figure 11.9b. Carl Sagan (widely used public image).

Tuesday, November 10

Today we begin with celebrating the 1861 birth of Robert Innes. This Scottish astronomer discovered the nearest star to our Solar System—Proxima Centauri—in the year 1915. He also made 1,628 discoveries of binary stars!

Let's start with Delta Ceti and head north about a degree for NGC 1032 (RA 02 39 24 Dec +01 05 38). Discovered in 1783 by Sir William Herschel and cataloged as H II.5, this 13th magnitude edge-on galaxy isn't for the smaller scope, but that doesn't mean it's not interesting. Possessing a bright core region and an almost stellar nucleus, this superb galaxy was home to a supernova event in 2005!

Now have a look at M77 again and head less than 2 degrees east for a pair of north-south oriented galaxies—NGC 1090 and NGC 1087 (RA 02 46 34 Dec -00 30 00). At around 120 million light-years away, northern NGC 1090 (H II.465) is also a supernova candidate, with events being reported in both 1962 and 1971. At close to magnitude 13, this barred spiral isn't easy to locate, but it can be spotted with aversion and a mid-sized telescope. About 15' south is NGC 1087. Although the pair seems quite close, no interaction between them has been detected. At magnitude 11, smaller scopes stand a much better chance of picking out 1087's faint, round glow, while large scopes will get a sense of tightly wound spiral arms around Herschel II.466. Its barred structure is quite curious—far smaller than what is known to be common in this type of structure but still a grand star-forming region. A region that held a supernova event in 1995! Check out this active group tonight. . .and look for the close pairing of Regulus and the Moon!



Figure 11.10a. NGC 1032 (credit—Palomar Observatory, courtesy of Caltech).

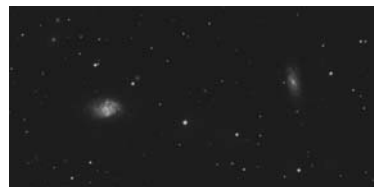


Figure 11.10b. NGC 1090/1087 (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, November 11

A true observer was born on this date in 1875. His name was Vesto Slipher, and he spent some very quality time with the 60" and 100" telescopes on Mt. Wilson. Slipher was the first to photograph galaxy spectra and measure their redshifts, which led to the discovery of the expansion of the universe by Edwin Hubble. If Slipher were alive today, you could bet that he'd have a big scope aimed about 4 degrees east of the Zeta and Chi pairing in Cetus to have a look at Hickson Compact Galaxy Group 16 (RA 02 09 32 Dec -10 09 00).

Consisting of four faint, small galaxies designated as NGC 835, NGC 833, NGC 838, and NGC 839 clustered around a 9th magnitude star, these aren't for a small scope but are a true challenge for a seasoned observer. Groups of galaxies such as Hickson 16 are believed to be some of the very oldest objects in our universe, and this particular one has a reputation of having an extremely large amount of starburst activity that is close enough for scientists to study. These galaxies were all cataloged by William Herschel in this month (on November 28) in 1785. The northernmost, NGC 833, is known as H II.482, with roughly magnitude 13; this is followed by NGC 835 (H II.483), which holds a magnitude of 12. Next in line is NGC 838 (H II.484) at close to magnitude 13, followed by southernmost NGC 839 (H II.485) at magnitude 13. Not easy, but this beautiful crescent of four is worth the effort!



Figure 11.11a. Hickson 16 (credit—Palomar Observatory, courtesy of Caltech).



Figure 11.11b. Vesto Slipher (historical image).

Thursday, November 12

Wouldn't we all have loved to have been there in 1949 when the first scientific observations were made with the Palomar 5-meter (200") telescope? Or to have seen what Voyager 1 saw as it made its closest approach to Saturn on this date in 1980? To watch the space shuttle Columbia launch in 1981? Or even better, to have been around in 1833, the night of the Great Leonid meteor shower! But this is here and now, so let's make our own mark on the night sky as we view an optical pairing of stars known as Zeta (RA 01 51 27 Dec -10 20 06) and Chi (RA 01 49 35 Dec -10 41 11) Ceti, a little more than a fist-width northeast of bright Beta. Be sure to have a look with binoculars or a small scope because you'll find that each has its own optical companion!

And northeast we continue with the largest of telescopes to investigate a galaxy cluster known as Abell 194 (RA 01 26 01 Dec -01 22 02). Over 100 galaxies have been found in this area, and most of them are about 265 million light-years away. Among the brightest are NGC 547 and the pairing of NGC 547/545, the latter of which may be interacting with the elliptical NGC 541. Other viewable members include NGCs 548, 543, 535, 530, 519, 538, and 557, as well as the far more southern 564, 560, and 558, just north of another optical double.



Figure 11.12a. Zeta and Chi Ceti (credit—Palomar Observatory, courtesy of Caltech).



Figure 11.12b. Abell 194 (credit—Palomar Observatory, courtesy of Caltech).

Friday, November 13

Start your day the astronomy way! Get up early and take a look at the pleasing pairing of Saturn and the Moon. On this date in 1990, Carolyn Porco was appointed leader of the imaging team for the Cassini mission to Saturn. Porco's career as a planetary scientist is unsurpassed, and she is an expert on planetary ring systems. For all of you who look at Saturn's rings with wonder, be sure to send your best to Porco; her undying love of astronomy began with observations just like yours!

Today is also the birthdate of James Clerk Maxwell. Born in 1831, Maxwell was a leading English theoretician on electromagnetism and the nature of light. Tonight let's take a journey of 150 light-years as we honor Maxwell's theories of electricity and magnetism and take a look at a star that is in nuclear decay—Alpha Ceti (RA 03 02 19 Dec +04 14 10). Its name is Menkar, and this 2nd magnitude orange giant is slowly using up its nuclear fuel and gaining mass. According to Maxwell's theories of the electromagnetic and weak nuclear forces, W bosons must be produced in such circumstances, an extremely advanced line of thinking for the time. Without getting deep into the physics, simply enjoy reddish Alpha for the beauty that it is. Even small telescopes will reveal its 5th magnitude optical partner 93 Ceti to the north. It's only another 350 light-years further away! You'll be glad you took the time to look this one up, because the wide separation and color contrast of the pair make this tribute to Maxwell well worth your time!



Figure 11.13a. Alpha Ceti (credit—Palomar Observatory, courtesy of Caltech).



Figure 11.13b. Carolyn Porco (credit—NASA).

Saturday, November 14

This morning before dawn, look for the Moon as it nears beautiful, blue-white Spica. This date in history marks the discovery of what we now refer to as a “*Trans-Neptunian Object*”—Sedna. In 2003 Brown, Trujillo, and Rabinowitz went into the history books for having observed the most distant natural Solar System body to date. The rethinking of what it means to be a planet that this discovery inspired would eventually spell the end to Pluto’s reign as our ninth planet! Also on this date in 1971, Mariner 9 became the first space probe to orbit Mars. Can you still spot the faint westerling Mars at sunrise?

Tonight let’s have a look at one of the most elusive Messiers’ of all, as we head about two finger-widths northeast of Eta Piscium in search of M74 (RA 01 36 42 Dec +15 47 00).

Discovered at the end of September in 1780 by Méchain, M74 is a real challenge to smaller backyard telescopes, even at magnitude 9. This near perfect presentation of a face-on spiral galaxy has low surface brightness, and it takes really optimal conditions to spot much more than its central region. Located 30–40 million light-years away, M74 is roughly the size of the Milky Way yet contains no central bar. Its tightly wound spiral arms contain clusters of young blue stars and traces of nebulous star-forming regions that can be seen in photos. Yet little more than vague concentrations in structure are all that can be seen, even in a large scope. But if the sky conditions are great, even a small telescope can see details! Add the slightest bit of light pollution and even the biggest scopes will have problems locating it. Don’t be disappointed if all you see is a bright nucleus surrounded by a small hazy glow. Just try again another time. Who knows what might happen? A supernova was discovered in 2002 by a returning amateur, and again in 2003 from the Southern Hemisphere. When it comes to M74, this is the very best time of year to try with a smaller scope!



Figure 11.14. M74 (credit—R. Jay GaBany).

Sunday, November 15

Up early? Then check out the Moon as it slides its way along the ecliptic toward the Sun and passes Venus! It's celebrating this day, for in 1738 on this date William Herschel was born. Among this British astronomer's and musician's many accomplishments, Herschel was credited with the discovery of the planet Uranus in 1781; detecting the motion of the Sun in the Milky Way in 1785; finding Castor's binary companion in 1804; and he was the first to record infrared radiation. Herschel was well known as the discoverer of many clusters, nebulae, and galaxies. This came through his countless nights studying the sky and creating catalogs whose information we still use today. Just look at how many we've logged this year! For the next few days, let's look toward Cassiopeia as we remember this great astronomer. . .

Herschel discovered many of the famous "400" objects in Cassiopeia just 2 days after his birthday in 1787. Begin by familiarizing yourself with the area between Delta and Epsilon Cassiopeia as we have a look at NGC 654. At magnitude 6.5, NGC 654 (RA 01 44 00 Dec +61 53 00) is achievable with binoculars but shows as nothing more than a hazy spot bordered by the resolvable star HD 10494. Yet, set a telescope its way and watch this diminutive beauty resolve. It is a very young open cluster, which has been extensively studied spectroscopically. Oddly enough, it did not cease the production of low-mass stars after the heavier ones formed and shows distinct polarization. Enclosed in a shell of interstellar matter, almost all of NGC 654's stars have reached main sequence, and two have been identified as detached binaries.



Figure 11.15a. NGC 654 (credit—Palomar Observatory, courtesy of Caltech).

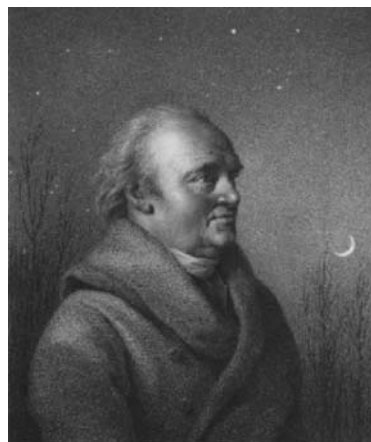


Figure 11.15b. Sir William Herschel (widely used public image).

Monday, November 16

On this date in 1974, there was a party at Arecibo, Puerto Rico, as the new surface of the giant 1,000-foot radio telescope was dedicated. At that time, a quick radio message was released in the direction of the globular cluster M13.

Tonight let's continue with our Herschel tribute as we head for NGC 663 (RA 01 46 12 Dec +61 14 00). At magnitude 7, NGC 663 is also viewable as a faint glow in binoculars but is best in a telescope. With an age of about 9 million years, this cluster contains the largest concentration of Be-type stars known; such stars show strong emission lines in hydrogen. Although this might be considered "normal" for a B-type star, the mystery behind Be-types is that their emissions can simply end at any time, only to resume later. This could be in a matter of days, or it could be decades, but these odd stars may very well be victims of rapid rotation, hosts of high magnetic activity (similar to flare stars), or may even be interacting with companions.

Time to head toward the faintest of the three—NGC 659 (RA 01 44 24 Dec +60 40 00). At magnitude 8, NGC 659 is still within the reach of larger binoculars and will be fully resolved with a mid-sized telescope. Studied as recently as 2001, this looser collection contains seven newly discovered variables, three of which are Be stars. But, give credit where credit is due! For as avid as Sir William was about observing, he had an equally avid observing partner: his sister Caroline. This time it was her call, as she is credited with the discovery of this particular open cluster, 4 years before her brother added it to his list in 1787!

Now, if you can, stay up late... The Leonids are coming!



Figure 11.16a. NGC 663 (credit—Palomar Observatory, courtesy of Caltech).



Figure 11.16b. NGC 659 (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, November 17

Stay up late or get up early this morning to catch the Leonids. Each year we pass through the filaments—both old and new—of Comet Tempel–Tuttle’s debris, and the chances of encountering a particular stream from any particular year becomes a matter of mathematical estimates. We know when it passed. . . We know where it passed. . . But will we encounter it and to what extent?

Traditional dates for the peak of the Leonid meteor shower are as early as the morning of November 17 or as late as November 19, but what about this year? On November 8, 2005, Earth passed through an ancient stream shed in 1001. Predictions ran high for viewers in Asia, but resulted in a dud. We crossed through the stream, but its dissipation is impossible to calculate. Debris trails left by the comet in subsequent years look promising, but we simply don’t know where and when the Leonids might strike. But we do know that a good time to look for this activity is well before dawn on November 17, 18, and 19. The Moon will interfere, but wait until the radiant constellation of Leo rises and chances are good of spotting one of the offspring of periodic comet Tempel–Tuttle.

Today in 1970, Soviet mission Luna 17 successfully landed on the Moon and the Lunokhod 1 rover became the first wheeled vehicle to explore. Lunokhod was designed to function for 3 lunar days, but lasted 11. Transmissions from Lunokhod officially stopped on October 4, 1971, the anniversary of Sputnik 1. Lunokhod had traversed 10,540 meters, transmitted more than 20,000 television pictures, sent home over 200 television panoramas, and performed more than 500 lunar soil tests. *Spaseba!*

Tonight while skies are so dark, also be sure to keep watch for members of the Pegasid meteor shower; the radiant is roughly near the Great Square. This meteoroid stream, which is at its peak tonight, last from mid-October through late November.



Figure 11.17a. Leonid meteor shower (credit—NASA).

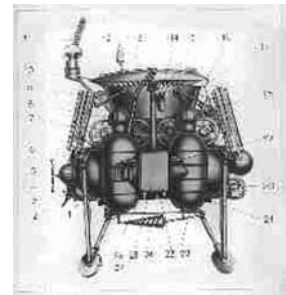


Figure 11.17b. Luna 17 (credit—NASA).

Wednesday, November 18

If you were clouded out of the Leonids yesterday morning, there is no harm in trying again. The meteor stream varies, and your chances are still quite good of catching one of these bright meteors. Tonight, return to Cassiopeia and start at the centermost bright star, Gamma. Just 4 degrees southeast is our marker for this starhop, Phi Cassiopeiae. By aiming binoculars or telescopes at this star, it is very easy to locate an interesting open cluster, NGC 457 (RA 01 19 40 Dec +58 17 18), because it will be in the same field of view.

This bright and splendid galactic cluster has received a variety of names over the years because of its uncanny resemblance to a figure. Some call it Angel, others see it as the "Zuni Thunderbird." Still others call the "Owl" or the "Dragonfly," but perhaps the most fun is the "E.T. Cluster." As you view it, you can see why! Bright Phi and HD 7902 appear like eyes in the dark, and the dozens of stars that make up the body appear like outstretched arms or wings. (For E.T. fans, check out the red "heart" in the center.)

All this is very fanciful, but what is NGC 457, really? Both Phi and HD 7902 may not be true members of the cluster. If 5th magnitude Phi were actually part of this grouping, it would have to be at a distance of approximately 9,300 light-years, making it the most intrinsically luminous star in the sky, far outshining even Rigel! To get a rough of idea of what this means, if we were to view our own Sun from this far away, it would be no more than magnitude 17.5. The fainter members of NGC 457 comprise a relatively young cluster spanning about 30 light-years. Most of the stars are only about 10 million years old, yet there is an 8.6-magnitude red supergiant at its heart. No matter what you call it, NGC 457 is an entertaining and bright cluster that you will find yourself returning to again and again. Enjoy!



Figure 11.18. NGC 457 (credit—Ken and Emilie Siarkiewicz/Adam Block/NOAO/AURA/NSF).

Thursday, November 19

Start your day by wishing happy birthday to Eileen Marie Collins, the first female space shuttle commander and pilot! This is also the 1908 birthdate of Hendrik Christoffel van de Hulst, an astronomer who predicted that in interstellar space the amount of neutral atomic hydrogen, which in its hyperfine transition radiates and absorbs at a wavelength of 21 centimeters, might be expected to occur at such high column densities as to provide a spectral line strong enough to measure.

Before the Moon interferes with fainter studies, let's head far north for one of the oldest galactic clusters in our visible sky—NGC 188. Hovering near Polaris (RA 00 44 30 Dec +85 20 00), this circumpolar open cluster also goes by other names: Collinder 1 and Melotte 2. Discovered by John Herschel on November 3, 1831, this 8th magnitude collection of faint stars will require a telescope to resolve its 120 members. At one time, it was believed to be as old as 24 billion years, later revised to 12 billion, but it is now considered to be around 5 billion years old. No matter how old it may truly be, it is one of the time-honored great studies and is also number one on the Caldwell list!

Now it's time to make our own fine transition to the Moon, as we take a much closer look at the southeastern edge of Mare Crisium. To the southeast, you will spot the large crater Condorcet. Due east of Crisium, you will see a smooth, dark area near the limb—Mare Marginus. Continuing south of Marginus you will see a very elongated, on-the-edge feature known as crater Jansky, bordered on the inside by Neper. Return to Crisium and look for the blank, gray oval of Firmicus to the southeast just before you meet Mare Undarum. Note the fine central peak in Firmicus!

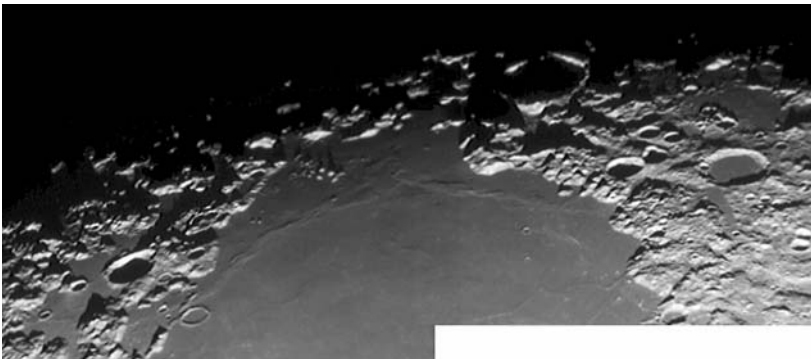


Figure 11.19a. Crisium's edge (credit—Alan Chu).



Figure 11.19b. NGC 188 (credit—Palomar Observatory, courtesy of Caltech).

Friday, November 20

Today celebrates the birth of another significant astronomer, Edwin Hubble. Born on this date in 1889, Hubble became the first American astronomer to identify Cepheid variables in M31, which in turn established the extragalactic nature of the spiral nebulae. Continuing with the work of Carl Wirtz, and using Vesto Slipher's redshifts, Hubble could then calculate the velocity–distance relation for galaxies. This has become known as Hubble's Law and demonstrates the expansion of our universe.

Tonight we'll pass the Moon and head just a little more than a fist-width west of the western-most bright star in Cassiopeia, to have a look at Delta Cephei (RA 22 29 10 Dec +58 24 54). This is the most famous of all variable stars and the granddaddy of all Cepheids. Discovered in 1784 by John Goodricke, its changes in magnitude are not due to a revolving companion but rather the pulsations of the star itself.

Ranging over almost a full magnitude in 5 days, 8 hours, and 48 minutes precisely, Delta's changes can easily be followed by comparing it to nearby Zeta and Epsilon. Upon reaching its dimmest point, it will brighten rapidly in a period of about 36 hours yet take 4 days to slowly dim again. Take time out of your busy night to watch Delta change and change again. It's only 1,000 light-years away and doesn't even require a telescope! (But even binoculars will show its optical companion.)



Figure 11.20a. Delta Cephei (credit—Palomar Observatory, courtesy of Caltech).



Figure 11.20b. Edwin Hubble (widely used public image).

Saturday, November 21

Tonight let's go to the southern lunar cusp to identify two small but very nice craters. Using previous study Fabricus, continue south and look for the pair connected side-to-side rather than end-to-end. This is crater Watt, with Steinheil intruding on it. Remember the distance traveled south from Fabricus to this pair and extend that distance even further south. Seen on the limb is crater Biela. If conditions are stable, you might pick up a tiny black point in Beila's west wall, Biela C.

Before we retire to the shadows tonight, let's study the small, open cluster NGC 225, located a finger-width northwest of Gamma Cassiopeiae (RA 00 43 42 Dec +61 47 00). This 7th magnitude collection has been described by some as looking like a sailboat. A fascinating name might be the "Metamorphosis Cluster," since the southwestern region of the cluster looks like a butterfly asterism and, to the northeast is the caterpillar-like asterism. Although just barely detectable as an unresolved patch through binoculars on a dark night, tonight's Moon means that magnification is needed just to make out its half-dozen brighter 9th magnitude members. Modest scopes should reveal two dozen stars to magnitude 12.

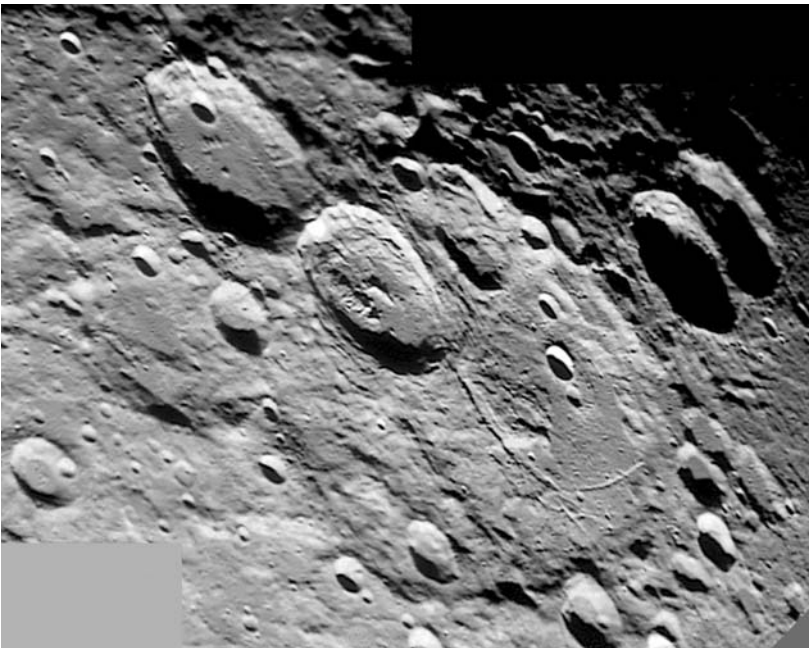


Figure 11.21a. Steinheil and Watt at limb (credit—Alan Chu).



Figure 11.21b. NGC 225 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, November 22

On the lunar surface tonight, the three rings of Theophilus, Cyrillus, and Catharina will emerge, but tonight let's power up on Theophilus and see what we can find! The area just northeast of Theophilus—where Mare Tranquillitatis and Mare Nectaris join—is called Sinus Asperitatis. Toward its center, you will see the remains of a once grand (nameless) crater holding the younger, sharper Torricelli in its center. Dropping back to Theophilus, just outside of its east wall, you will also find a young crater, Madler. As you head east across the northern shore of Mare Nectaris, look carefully for two partial rings. The northernmost is so eroded that it never received a name, while a slight, faint horseshoe marks all that remains of Daguerre.

Tonight let's test our starhopping and observing talents by starting first with a beautiful double—Gamma Arietis. Now look about a fist-width east-southeast for dim little Pi. When you have Pi centered, move about half a degree southwest for an alternative catalog study—DoDz 1. Although you might find this sparkling double handful of stars of little interest, think twice before you hop on. Although DoDz studies are far more scattered and less populous than most galactic clusters, it doesn't make them less interesting. What you are looking at are basically the fossils of once active and more concentrated regions of stars. As the cluster has matured, the lower mass members have been stripped away and joined the general population. Known as a "dissolving cluster," DoDz 1 is all that's left of a far grander collection. Very ancient...yet still very beautiful!

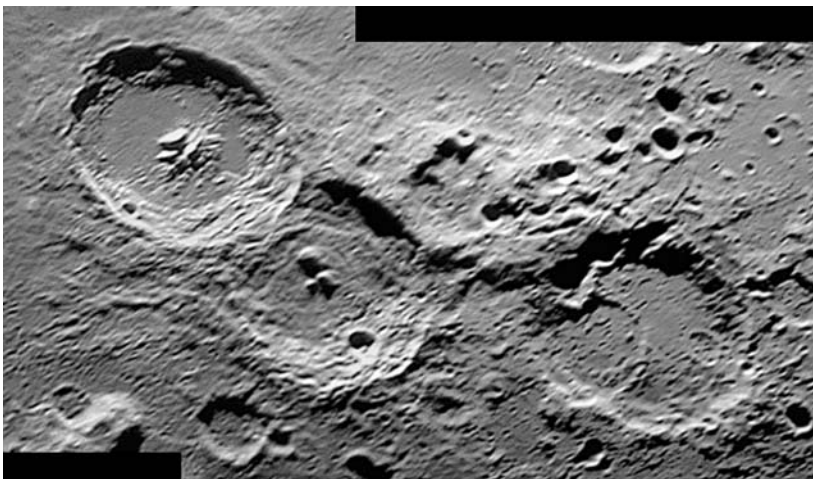


Figure 11.22a. Theophilus, Cyrillus, and Catharina (credit—Alan Chu).



Figure 11.22b. Dolidze-Dzimselejsvili 1 (credit—Palomar Observatory, courtesy of Caltech).

Monday, November 23

Are you ready for some more lunar work? Then let's start by identifying previous study Maurolycus. Maurolycus is found about two Crisium lengths southwest of Theophilus and in tonight's light will appear especially fine. But look just north of Maurolycus to pick out the battered remains of Class III crater Gemma Frisius, an Astronomical League challenge. Spanning 56 miles and descending 17,100' below the lunar surface, you'll find its walls broken, yet enough of its northern boundary remains to clearly reveal the impact that created Goodacre. Look for the shadows blending Goodacre and Gemma Frisius together.

Tonight let's familiarize ourselves with the vague constellation of Fornax. Its three brightest stars form a shallow V just south of the Cetus/Eridanus border and span less than a hand-width of sky. Although it's on the low side for northern observers, there are a wealth of sky objects in this area. Try having a look at the easternmost star—40-light-year distant Alpha (RA 03 12 04 Dec -28 59 25). At magnitude 4, it is not easy, but what you'll find there is quite beautiful. For binoculars, you'll see a delightful cluster of stars around this long-term binary, but telescopes will enjoy it as a great golden double star! First measured by John Herschel in 1835, the distance between the Alpha pair has narrowed and widened over the last 174 years, and it is suspected that its orbital period may be 314 years. Although the 7th magnitude secondary can be spotted with a small scope, watch out, because it may also be a variable that drops by as much as a full magnitude!

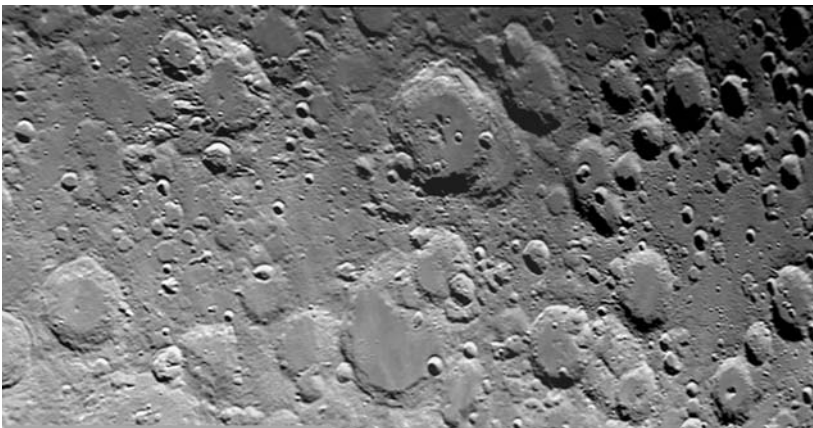


Figure 11.23a. Maurolycus area (credit—Alan Chu).



Figure 11.23b. Alpha Fornacis (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, November 24

On this date in 1639, Jeremiah Horrocks, an English astronomer, measured the first observed transit of Venus. Based on Kepler's prediction, Horrocks calculated transits that occurred not as solitary events but in pairs 8 years apart. Using the projection method, he beamed the solar image to a piece of paper marked with 6" graduated circles, finding that the value for the solar parallax was smaller than previously recorded.

Tonight let's head back to the Moon's north toward the long scar of the Alpine Valley, also known as Vallis Alpes. This easy to spot feature will help to find another challenge crater. Where the valley joins the lunar Alps, follow the range south into Mare Imbrium. Along the way, you will see the protruding bright peaks of Mons Blanc, Promontorium DeVille, and, at the very end, Promontorium Agassiz ending in the smooth sands. Southeast of Agassiz you will spot the Astronomical League challenge Cassini. This shallow crater holds another challenge within, Cassini A. But look carefully! Can you spot the B crater on Cassini's inner southwestern rim? Or the very small M crater just outside the northern edge?

Now let's return to Cassiopeia and explore its bright central star (RA 00 56 42 Dec +60 43 00). At 2.8 magnitude, 100-light-year-distant Gamma is very unusual. Once thought to be a variable, it has been known to go through some very radical shifts in terms of temperature, spectrum, magnitude, color, and diameter. It is also a visual double star, but its close, disparate companion is not easy to see. At magnitude 11, the companion is 3,000 times fainter than the primary!



Figure 11.24a. Vallis Alpes (credit—Alan Chu).



Figure 11.24b. Gamma Cassiopeiae (credit—Palomar Observatory, courtesy of Caltech).

Wednesday, November 25

Tonight on the lunar surface, we'll start at the Carpathian Mountains directly north of mighty Copernicus's east wall. Some of these peaks reach as high as 2,000 meters (6,600') and could have been formed from extruded lava. Can you trace them beyond the terminator? To the northeast, Eratosthenes shows very nicely. Continue about one Crisium length north of Copernicus for the sharp puncture of Class I Pytheas. Another half-Crisium length further north, discover a slightly larger but less prominent Class I crater—Lambert—residing on an unnamed ridge.

Now, set your sights on double star Alfirk—Beta Cephei—(RA 21 28 39 Dec +70 33 38). At magnitude 3.3, Alfirk is easily spotted as the most northwestern star of the constellation Cepheus. Beta A is a hot, 3.5-magnitude, spectral type B star. It is accompanied to its west-southwest by a 13.6'' distant, magnitude 7.8 blue companion. This one is comparable to Polaris in resolution, so take the opportunity to view both!

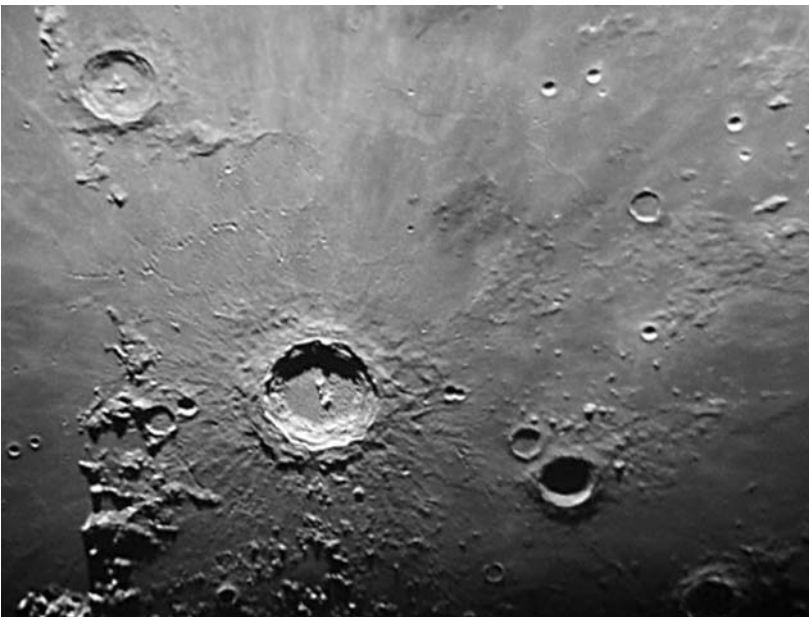


Figure 11.25a. Copernicus (credit—Alan Chu).



Figure 11.25b. Beta Cephei (credit—Palomar Observatory, courtesy of Caltech).

Thursday, November 26

Today in 1965 marked the launch of the first French satellite, Asterix 1. Today is also the ninth anniversary of the discovery of the meteorites SaUs 005 and 008, the “Mars Meteorites.” These meteorites are known to be of Martian origin because of gases preserved in the glassy material of their interiors. They were hurled into space some 600,000 years ago, when a probable asteroid impact on Mars tossed them high enough to escape the planet’s gravity. They were captured by our own gravity many thousands of years later. Besides SaUs 005 and 008, at least 30 other meteorites found on Earth have been positively determined, thanks to their chemical composition, to be of Martian origin.

Tonight peaceful Gassendi calls, but we’ll visit the “Ocean of Storms” by taking a voyage across the southern Oceanus Procellarum. Set sail from the port of Gassendi and head north to small crater Gassendi B. As you move across the gray sands, look for a serene wave following the southwestern shore. This is Dorsum Ewing, and you’ll see it trail south into the pockmark of Herigonius east of Gassendi B. East of Herigonius are two additional craters, the northernmost of which is Norman. Return to Dorsum Ewing and follow it north, where it leads to some low hills and the tiny crater Scheele—and more prominent Wichmann even further north. If you look closely at Wichmann, you will see it as a small impact on what appears to be the remains of a long-ago flooded, now terribly eroded, crater. Ride the waves in the “Ocean of Storms” to see which port they take you to!

Now we’re off to Aquarius to resolve a stunning matched set of 4th magnitude stars separated by 2.1”—Zeta Aquarii. To locate Zeta, start at Alpha and look due east about two finger-widths (RA 22 28 49 Dec 00 01 11). Center on the pair and use as much power as sky conditions permit.

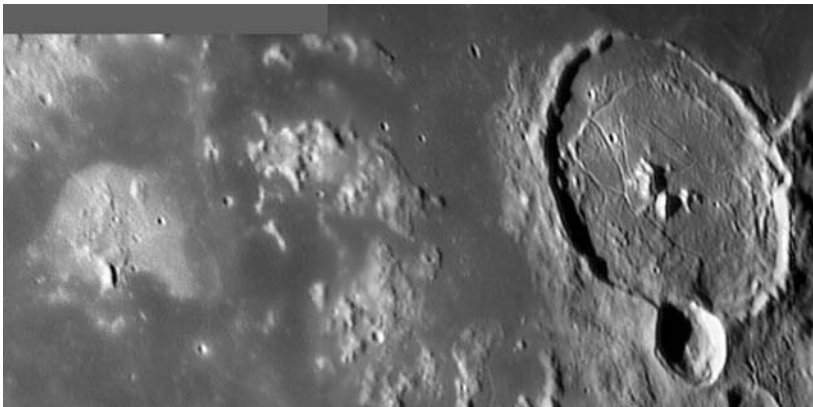


Figure 11.26a. Gassendi region (credit—Alan Chu).



Figure 11.26b. Zeta Aquarii (credit—Palomar Observatory, courtesy of Caltech).

Friday, November 27

Today is the birthday of Anders Celsius, born in 1701. Although you might easily recognize the name Celsius in connection with temperature, you might not know about the contributions Anders made to astronomy some three centuries ago. Born to a Swedish family of mathematicians and astronomers, one of his first achievements came when he participated in an effort to determine the true shape of Earth. He was also the very first scientist to recognize the connection between magnetism and the aurora. And, by age 39, he had become the director of an observatory. Celsius also developed the first instrument for measuring the brightness of starlight. Ever resourceful, he already possessed tools to measure position and motion but had nothing with which to gauge magnitude. His idea was so simple it was downright elegant: he simply blocked the light with identical glass plates until the star disappeared. The brighter the star, the more plates it took!

Tonight let us go from one extreme to another as we begin on the northernmost limb of the lunar surface. From the northernmost Sinus Roris, look for lens-shaped crater Markov. To Markov's northeast is a large, flat crater with very few distinguishing characteristics. Its name is Oenopides. If conditions are stable, look for a gray slash known as Cleostratus on the lunar limb further north of Oenopides. On the southern limb, look for familiar craters Wargentín, Nasmyth, and Phocylides. Even farther south, note the long oval Pingré.

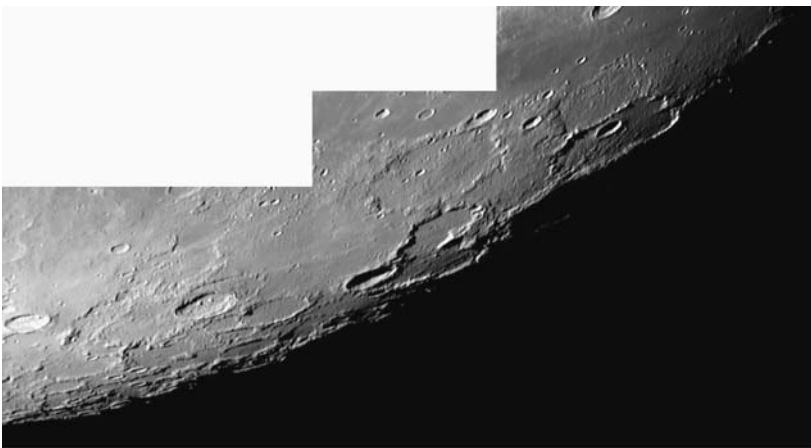


Figure 11.27a. Northwest Limb Mosaic (credit—Alan Chu).



Figure 11.27b. Anders Celsius (widely used image).

Saturday, November 28

On this date in 1659, Christian Huygens was busy at the eyepiece, but he wasn't studying Saturn. This was the first time any astronomer had seen dark markings on Mars! Why don't you try your luck at Mars tonight, too? Wait for it to rise well above atmospheric disturbance and power up! It's too bad it isn't as close as the Moon. . .

Tonight the great Grimaldi will again capture the eye, but let's head southeast for another featureless dark gray oval, Crueger. Continuing south, the next crater—Darwin—is hard to see because of its rather un-craterlike appearance. Darwin is best caught by focusing on the rima that includes its eastern wall. Look for a Y formation pointing toward Crueger.

Although skies are bright, we can still see double. Locate 5-magnitude Lambda Arietis (RA 01 57 55 Dec +23 35 45) and its companion. This wide pair is an excellent challenge for binoculars. Both stars are F-spectral types and should appear ivory in color to most observers. Having trouble in binoculars? Try a finderscope of equal power and aperture. To locate Lambda, look a finger-width west-southwest of Hamal, at Alpha Arietis.

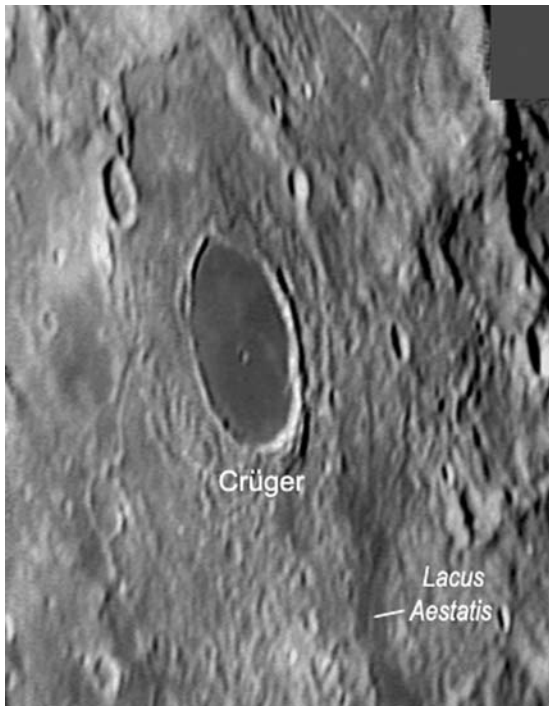


Figure 11.28a. Crueger (credit—Alan Chu).



Figure 11.28b. Lambda Arietis (credit—Palomar Observatory, courtesy of Caltech).

Sunday, November 29

On this date in 1961 Enos the Chimp was launched into fame! His story is a long and colorful one, but Enos was a true astronaut. Selected to make the first American orbital animal flight only 3 days before the launch, he flew into space on board a Mercury-Atlas 5 and completed his first orbit in just under 90 minutes. Although Enos was scheduled to complete three orbits, he was brought back due to “attitude difficulties.” But whose? Malfunctions caused the chimp to be repeatedly shocked when performing the correct maneuvers, but Enos continued to perform flawlessly and was said to run and jump enthusiastically on board the recovery ship. Although he died a year later from an unrelated disease, Enos the chimp remains one of our most enduring space heroes. Tonight, launch your way toward the Moon and see if you can spot crater Riccioli. . . You’ll find it centermost and almost on the limb!

Now that you’ve viewed a challenging crater, would you like to have a look at a challenging double star? All you have to do is locate Theta Aurigae (RA 05 59 43 Dec +37 12 45) on the east side of the pentagonal shape of this constellation. Located about 110 light-years away, 2.7-magnitude Theta is a four star system, whose members range in magnitude from 2.7 to 10.7. Suited even to a small telescope, the brightest member—Theta B—is itself a binary at magnitude 7.2; it was first recorded by Otto Struve in 1871. The pair moves quite slowly and may take as long as 800 years to orbit at their separation of about 110 Astronomical Units (AU). The furthest member of this system was also noted by Struve as far back as 1852, but it is not a true member, with the separation only occurring thanks to Theta’s own proper motion. While you are there, be sure to note Theta’s unusual color. Although it will appear “white,” look closely at the diffraction caused by our own atmosphere, which acts much like a prism. You’ll notice a lot more purple and blue around this star than many others of the same spectral type. Why? Theta is a silicon star!

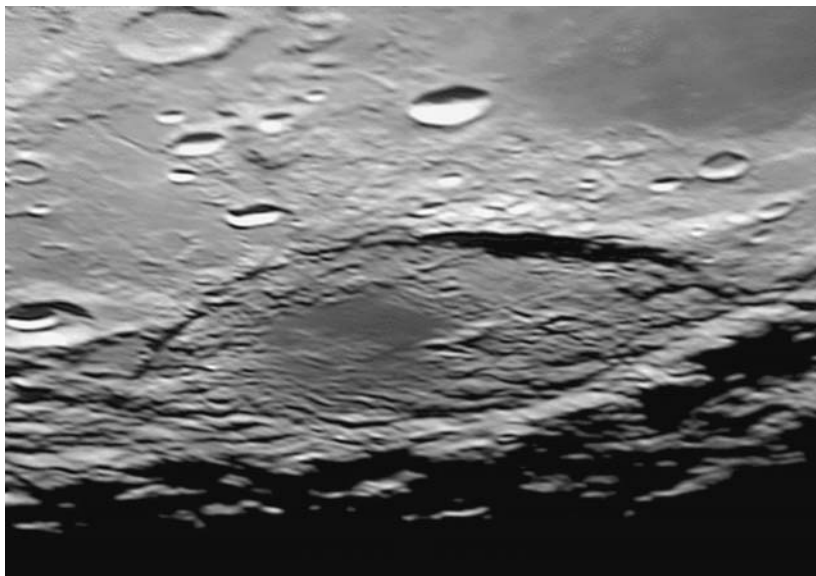


Figure 11.29a. Riccioli (credit—Alan Chu).



Figure 11.29b. Theta Aurigae (credit—Palomar Observatory, courtesy of Caltech).

Monday, November 30

Are you ready for a real lunar challenge? A lot will depend on the age of the Moon at the time of your observations. Look along the western limb and see if you can spot Montes Cordillera!

Now for the “star” of tonight’s show, Beta Andromedae. More commonly known as Mirach, you’ll find this irregular, slightly variable star at home 199 light-years away (RA 01 09 43 Dec +35 37 14). Notable even to the eye as slightly red in color, this dying star’s core may be mainly helium or carbon now, and soon Beta will become a dense white dwarf. For now, it is fairly small (for this type of star), no more than the size of Mercury’s orbit. If you have steady skies, power up. This star was also a topic of study for E.E. Barnard, who in 1898 discovered a 14th magnitude companion star over 800 times fainter than Sol and 60,000 times fainter than Mirach! Return again to Beta on a good dark night and see if you can spot the “Ghost of Mirach” in the same field and no more than 7' to the northwest. This is the small elliptical galaxy NGC 404, not an error!

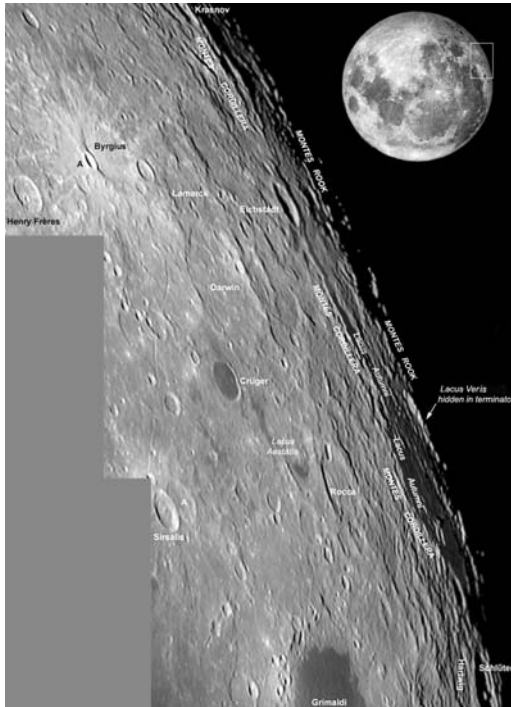


Figure 11.30a. Montes Cordillera (credit—Alan Chu).



Figure 11.30b. Beta Andromedae (credit—John Chumack).

CHAPTER TWELVE



December, 2009

Tuesday, December 1

Born on this date in 1811 was Benjamin (Don Benito) Wilson, the namesake of Mt. Wilson, California, which is home to what were once the largest telescopes in the world, the 60" Hale and the 100" Hooker. Later, three solar telescopes were added on the mountain, two of which are still in use, as well as the CHARA array and active interferometers. It was here that Edwin Hubble first realized that the "spiral nebulae" were actually distant galaxies and discovered Cepheid variables in them.

If you'd like to stay out a bit longer, then have a look at another fine double for moonlit nights—Eta Persei (RA 02 50 41 Dec +55 53 43). Eta is a challenge for smaller binoculars, because the faint secondary puts this one squarely into the class of small scope studies. Eta A is a K-type star appearing golden-yellow to the eye. Larger scopes will reveal the 8.5-magnitude secondary's A-type blue tint. The overall impression is of a widely disparate version of summer's famous Albireo! You'll find this one about a fist-width northwest of Alpha Persei.



Figure 12.1a. Eta Persei (credit—Palomar Observatory, courtesy of Caltech).

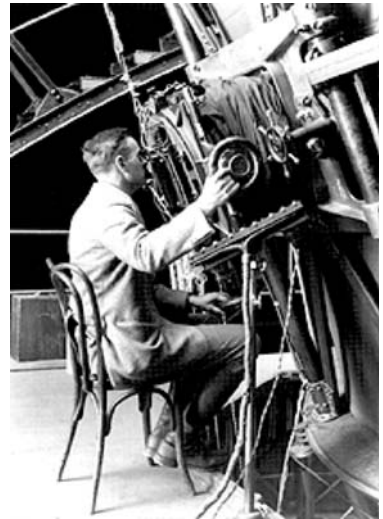


Figure 12.1b. Edwin Hubble at the Hooker Telescope (historical image).

Wednesday, December 2

On this date in 1934, the largest mirror in telescope history began its life when the blank for the 200" telescope was cast in Corning, New York. We'll take a look in the weeks ahead at the important role the 200" scope played in astronomy.

'Twas 23 days before Christmas in a sky filled with stars. . .

And low on the horizon are the Yule Moon and Mars!

That's right. It's the Full Yule Moon, and arriving about an hour behind it is Mars! With skies getting dark much earlier, why not do a little stellar observing before chasing the Red Planet? Although the Moon will command tonight's skies, we can still have a look at a tremendous star as we head 150 light-years away to Menkar.

Better known as Alpha Ceti, you'll find this nearly second magnitude giant orange beauty just west of Orion's "bow" (RA 03 02 17 Dec +04 05 23). With even a small telescope, you will also see 5th magnitude 93 Ceti in the eyepiece as well! Although they are not a true physical pair (the blue 93 is 350 light-years further away), they make a wonderful color contrast, which is well worth your time. Just think. . . If 93 were as close as Menkar, it would be 250% brighter. But up the magnification to see if you can spot another true double in the field!



Figure 12.2a. Full Yule Moon (credit—Alan Chu).

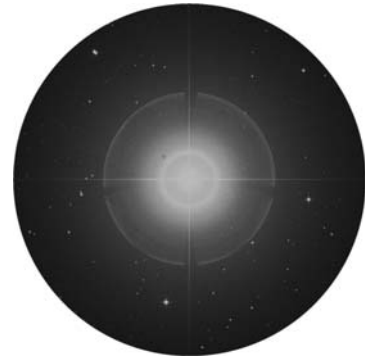


Figure 12.2b. Alpha Ceti (credit—Palomar Observatory, courtesy of Caltech).

Thursday, December 3

On this date in 1971, the Soviet Mars 3 became the first spacecraft to make a soft landing on the Red Planet, and 2 years later on this same date the Pioneer 10 mission made the first flyby of Jupiter. One year later on this same date? Pioneer 11 flew by Jupiter! Whatever you do, take the time to have a look at Jupiter tonight. It's having a visible flyby of the asteroid Psyche less than half a degree away! Is that a Galilean moon you see... or an asteroid?!

Now turn your focus to this date 36 years ago. With only 4 days to go before the last manned lunar mission headed skyward, we wonder how Eugene Cernan about being the last person of the twentieth century to set foot on the Moon. Somehow, did Cernan know the importance of his role in history? On December 14, 1972, he called his last step in Taurus-Littrow Valley the "end of the beginning." As we reach the end of our observing year, let this be only the beginning for you as we look no further tonight than the incredible "Double Cluster" about four finger-widths southeast of Delta Cassiopeiae (RA 02 18 04 Dec +57 30 58). At a dark-sky site, the incredible pair known as Chi Persei is easily located visually and is stunning in any size binoculars or telescope.

As part of the constellation of Perseus, this double delight is around 7,000 light-years away, and less than 100 light-years separate the pair. Although open clusters in this area are not really a rarity, what makes the Double Cluster so inviting is the large amount of bright stars within each of them. Well known since the very beginnings of astronomy, both Chi (NGC 884) and H Persei should be viewed very carefully. Note how many colorful stars you see and the vast array of doubles, multiples, and variables!



Figure 12.3. Chi Persei (credit—Nigel Sharp/NOAO/AURA/NSF).

Friday, December 4

On this date in 1978, the Pioneer Venus Orbiter became the first spacecraft to orbit Venus. And, in 1996, the Mars Pathfinder mission was launched. Tonight we'll launch toward a bright open cluster known by many names: Herschel VII.32, Melotte 12, Collinder 23, and NGC 752. You'll find it three finger-widths south (RA 01 57 41 Dec +37 47 06) of Gamma Andromedae.

Under dark skies, this 5.7-magnitude open cluster can just be spotted with the unaided eye, is revealed in the smallest of binoculars, and can be completely resolved with a telescope. Chances are NGC 752 was discovered by Hodierna over 350 years ago, but it was not cataloged until Sir William gave it a designation in 1786. But give credit where credit is due, for it was Caroline Herschel who observed it on September 28, 1783! Containing literally scores of stars, galactic cluster NGC 752 could be well over a billion years old and is strung out in chains and knots in an X pattern over a rich field. Take a close look at the southern edge for orange star 56; although this is a true binary star, the companion you see is merely optical. Enjoy this unsung symphony of stars tonight!



Figure 12.4. NGC 752 (credit—Palomar Observatory, courtesy of Caltech).

Saturday, December 5

No one is certain, but it is believed that Werner Heisenberg was born on this date in 1901! Heisenberg was a physicist and philosopher who discovered a way to formulate quantum mechanics in terms of matrices. His uncertainty principle won him the Nobel Prize for Physics in 1932.

Is it gone yet? Nope. The Moon will rise a little later this evening, but we're going to run ahead of it tonight and enjoy some studies in Auriga! Looking roughly like a pentagon in shape, Capella is the brightest of these stars. Due south of Capella is the second brightest star, El Nath. By aiming binoculars at El Nath, go north about one-third the distance between the two and enjoy all the stars!

You will note two very conspicuous clusters of stars in this area, and so did Le Gentil in 1749. Binoculars will reveal the pair in the same field, as will telescopes using lowest power. The dimmest of these is M38 (RA 05 28 43 Dec +35 51 18), and it will appear vaguely cruciform in shape. At roughly 4,200 light-years away, the 100 or so fainter members will require larger aperture to resolve. About 2.5 degrees to the southeast (RA 05 36 12 Dec +34 08 24) you will see the much brighter M36. More easily resolved in binoculars and small scopes, this "jewel box" galactic cluster is quite young and about 100 light-years closer!



Figure 12.5a. M38 (credit—Palomar Observatory, courtesy of Caltech).



Figure 12.5b. M36 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, December 6

Today we note the 1848 birth on this date of Johann Palisa. He discovered 122 asteroids with a 6" refractor, and all were visual observations. Check out some asteroids for yourself over the next few days as they approach easily noted objects. You'll still find the asteroid Psyche close to Jupiter!

The Moon will be along shortly, but we still have time to set our sights about halfway between Theta Aurigae and El Nath. Our study object will be the open cluster M37 (RA 05 52 19 Dec +32 33 12). Apparently discovered by Messier himself in 1764, this galactic cluster will appear almost nebula-like to binoculars and very small telescopes, but comes to perfect resolution with larger instruments. About 4,700 light-years away and spanning a massive 25 light-years, M37 is often billed as the finest of the three Aurigan open clusters for bigger scopes. Offering beautiful resolvability, this one contains around 150 members down to magnitude 12 and has a total population in excess of 500.

What makes it unique? As you view, you will note the presence of several red giants. For the most part, open clusters are composed of stars that are all about the same age (usually young), but the brightest star in M37 appears orange in color and not blue! So what exactly is going on here? Apparently, some of these big, bright stars have evolved much faster, consuming their fuel at an incredible rate. Other stars in this cluster are still quite young on a cosmic scale, yet they all left the "nursery" at the same time! In theory, this allows us to judge the relative age of open clusters. For example, M36 is around 30 million years old and M38 about 40, but the presence of the red giants in M37 puts its estimated age at 150 million years!



Figure 12.6a. M37 (credit—NOAO/AURA/NSF).



Figure 12.6b. Johann Palisa (historical image).

Monday, December 7

Today is the birthday of Gerard Kuiper. Born in the Netherlands in 1905, American planetary scientist Kuiper discovered moons of both Uranus and Neptune. He was the first to know that Titan had an atmosphere, and he studied the origins of comets in the Solar System—the Kuiper Belt!

Before the Moon rises tonight, let's enjoy the early dark skies and go to our maps west of M36 and M38 to identify AE Aurigae (RA 05 16 18 Dec +34 18 44). As an unusual variable, AE is normally around 6th magnitude, and resides approximately 1,600 light-years distant. The beauty in this region is not particularly the star itself but the faint nebula in which it resides. Known as IC 405, this is an area of mostly dust and very little gas. What makes this view so entertaining is that we are looking at a "runaway" star.

It is believed that AE originated in the M42 region in Orion. Cruising along at a very respectable speed of 130 kilometers per second, AE flew the "stellar nest" some 2.7 million years ago! Although IC 405 is not directly related to AE, there is evidence within the nebula that areas have been cleared off their dust by the rapid northward motion of the star. AE's hot, blue illumination and high-energy photons fuel what little gas is contained within the region, and its light reflects off the surrounding dust as well. Although we cannot "see" with our eyes like a photograph, together this pair makes an outstanding view for the small backyard telescope, and it is known as the "Flaming Star."

And when the Moon rises? Look for Mars to join it!



Figure 12.7a. AE Aurigae: the Flaming Star (credit—T.A. Rector and B.A. Wolpa/NOAO/AURA/NSF).



Figure 12.7b. Gerard Kuiper (historical image).

Tuesday, December 8

Today let's honor the 1795 birth of Peter Andreas Hansen on this date. This Dutch astronomer made celestial mechanics his life's work. He is best known for his theories on the motions of comets, minor planets, and the Moon.

Is the Moon gone yet? No. It will rise later, bringing the asteroid Vesta with it around 8 degrees from the lunar north limb. This would be a great opportunity to locate an easy Messier object—M34. If you remember our previous study stars Almach and Algol, you're halfway there. Draw an imaginary line between them and look with your binoculars or finderscope just a shade north of center (RA 02 42 06 Dec +42 46 00).

In binoculars, M34 will show around a dozen fainter stars clustered together and perhaps a dozen more scattered around the field. Small telescopes at low power will appreciate M34 for its resolvability and the distinctive orange star in the center. Larger aperture scopes will need to stay at lowest power to appreciate the 18-light-year span of this 100-million-year-old cluster, but take the time to power up and study. You will find many challenging doubles inside!



Figure 12.8a. M34 (credit—REU Program/NOAO/AURA/NSF).



Figure 12.8b. Peter Hansen (historical image).

Wednesday, December 9

If you're out before dawn, take a close look on the dawn horizon, where Venus and Antares will make a pleasing pair. Southern Hemisphere viewers, you're in luck! This is the maximum of the Puppis-Velid meteor shower. With an average fall rate of about 10 per hour, this particular shower could also be visible to those Northerners far enough south to see the constellation of Puppis. Very little is known about this shower except that the streams and radiants are very tightly bound together. Since studies of the Puppis-Velids are just beginning, why not take the opportunity to watch? Viewing will be possible all night long; although most of the meteors are faint, this one is known to produce an occasional fireball.

Tonight we're going nebular as we head first to the incredible M76 (RA 01 42 19 Dec +51 34 31). Located in western Perseus just slightly less than 1 degree north-northwest of Phi, M76 is often referred to as the "Little Dumbbell." Originally discovered by Messier's assistant Méchain in September of 1780, Charles didn't get around to cataloging it for another 6 weeks. What a shame it took him so long to view this fine planetary nebula! Its central star is one of the hottest known, but its resemblance to M27 is what makes it so fascinating. Looking very much like a miniature of the much larger M27, M76 is rather faint at magnitude 11 but is quite achievable in scopes of 4.5" in aperture or larger. It is small, but its irregular shape makes this planetary nebula a real "class act!"

For our Southern Hemisphere friends, get thee out there and view Eta Carinae! First recorded by Halley in 1677, this nebular variable star left even the great Sir John Herschel at a loss to describe its true beauty and complexities. This "slow nova" is filled with all the wonders that we "northerners" can only dream about. . .



Figure 12.9a. M76: the Little Dumbbell (credit—Nigel Sharp/NOAO/AURA/NSF).



Figure 12.9b. Eta Carinae (credit—NOAO/AURA/NSF).

Thursday, December 10

If you are out stargazing until the morning hours, look for the peak of the Monocerotid meteor shower. Its fall rate is around 1 per hour, and its radiant point is near Gemini. Then perhaps you should celebrate the 1815 birth of Countess Augusta Ada King Lovelace? She was Lord Byron's daughter, and this accomplished amateur astronomer could have gone a lot further had she not been denied the use of the Royal Society's library!

With early dark skies, let's have a look at NGC 7793 at around 4 degrees south-southeast of Delta Sculptoris (RA 23 57 49 Dec -32 35 30). Although Southern Hemisphere observers are favored, some viewers in the north can still get a glimpse of this 9.1-magnitude galaxy. This fairly large galaxy is moderately inclined and as a result may appear quite misty at the edges. Look for fainter and more challenging NGC 7755 about 2 degrees to the northwest.

Tonight when the Moon rises, you'll find it joined with Saturn... a holiday treat! If you're still in the mood to chase asteroids, take a look at Neptune. You'll find the asteroid Psyche cruising by, just 0.3 degrees to the north of the giant planet.

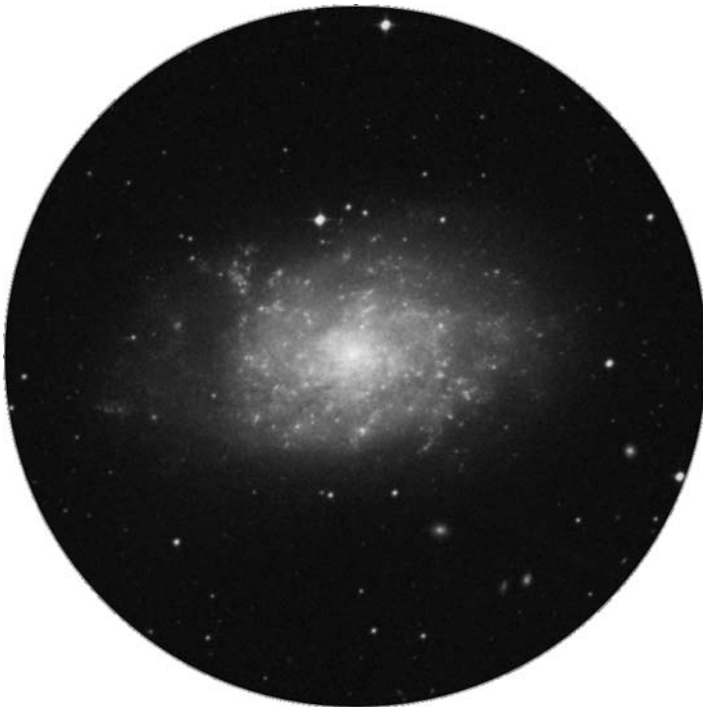


Figure 12.10a. NGC 7793 (credit—Palomar Observatory, courtesy of Caltech).



Figure 12.10b. Countess Augusta Ada King Lovelace (historical image).

Friday, December 11

On this date in 1863, Annie Jump Cannon was born. She was an American astronomer who created the modern system for classifying stars by their spectra. Tonight we celebrate this achievement. Come along with me and have a look at some very specific stars with unusual visual spectral qualities! Let's grab a star chart, brush up on our Greek letters, and start first by returning to Mu Cephei. Nicknamed the "Garnet Star," this is perhaps one of the reddest stars visible to the unaided eye. At around 1,200 light-years away, this spectral type M2 star will show a delightful blue-purple "flash." If you still don't perceive color, try comparing Mu to its bright neighbor Alpha, a spectral type A7, or "white," star. Perhaps you'd like something a bit more off the beaten path? Then head for S Cephei, about halfway between Kappa and Gamma toward the pole. Its intense shade of red makes this magnitude 10 star an incredibly worthwhile hunt.

To see an example of a B spectrum star, look no further than the Pleiades. All the components are blue-white. Want to taste an "orange?" Then look again at Aldebaran, or Alpha Tauri, and say hello to a K spectrum star. Now that we have your curiosity aroused, would you like to see what our own Sun would look like? Then choose Alpha Aurigae, better known as Capella, and discover a spectral class G star that's "only" 160 times brighter than the one that holds our Solar System together! Still no luck in seeing color? Don't worry. It does take a bit of practice! The cones in our eyes are the color receptors, and when we go out in the dark, the color-blind rods take over. By intensifying the starlight with either a telescope or binoculars, we can usually excite the cones in our dark-adapted eyes to respond to color.

Tonight is also the peak of the Sigma Hydrid meteor stream. Its radiant is near the head of the Serpent, and the fall rate is about 12 per hour—but these are fast! While you're watching, check out the very close pairing of Spica and the Moon as they rise together. You'll find the asteroid Ceres 8.7 degrees north of the lunar limb!



Figure 12.11a. Aldebaran (credit—John Chumack).



Figure 12.11b. Annie Jump Cannon (widely used public image).

Saturday, December 12

Today we honor the birth of S.W. Burnham. Born in 1838, this American astronomer spent 50 years of his life surveying the night sky for double stars. Although at the time it was believed that all visual binaries had been accounted for, Burnham's work was eventually published as the *General Catalogue of 1,290 Double Stars*. His keen eye and diligent study opened the doors for him at observatories such as Yerkes and Lick. His lifetime count of binaries discovered eventually reached 1,340. He was also the very first to observe what would eventually be termed a "Herbig-Haro object," and he discovered 6 New General Catalog (NGCs) and 21 Index Catalog (IC) objects.

Today in 1961, OSCAR 1 was launched. This name of this project, which started in 1960, stands for Orbital Satellite Carrying Amateur Radio. OSCAR 1 operated in orbit for 22 days, transmitting a signal in Morse code: the simple greeting "Hi." The success of the mission helped to promote interest in amateur radio, which continues to this day!

Let's honor Burnham's work and our summering southern friends once again as we head toward the incomparable NGC 55. Located about two finger-widths north-northwest of Alpha Phoenicis (RA 00 15 08 Dec -39 13 13), this large, near edge-on galaxy is truly a southern gem. At magnitude 7.8, this bright member of the Sculptor Galaxy group can easily be spotted in binoculars. Mid-sized scopes will begin resolution of mottling in the structure, while large aperture will show individual stars, nebulous areas, and dark dust clouds—with a very prominent one east of the nucleus. Rock on...



Figure 12.12a. NGC 55 (credit—Palomar Observatory, courtesy of Caltech).

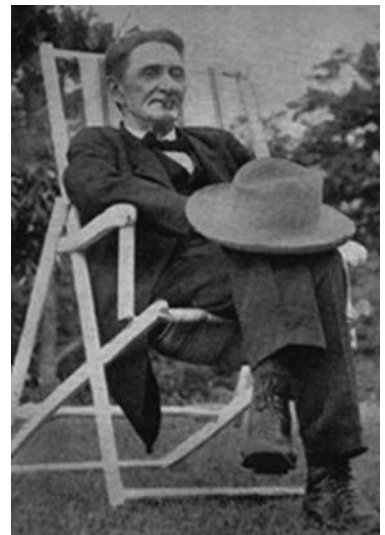


Figure 12.12b. S.W. Burnham (historical image).

Sunday, December 13

Tonight we have the hauntingly beautiful and mysterious displays of the Geminid meteor shower. First noted in 1862, the stream was weak but has intensified with time. Around 10 years ago, observers recorded an outstanding 110 per hour during a moonless night. . .and we've got a moonless night.

So why are the Geminids a mystery? Most meteor showers are cometary debris, documented and recorded for hundreds of years. When astronomers began looking for the Geminids' parent comet, they found none. It wasn't until 1983 that an object was detected matching the meteoroid stream. . .an asteroid. Originally designated as 1983 TB, but later renamed 3200 Phaethon, this apparently rocky Solar System member has a highly elliptical orbit, placing it within 0.15 Astronomical Unit (AU) of the Sun about every year and a half. But asteroids can't fragment like comets—or can they? Phaethon may have collided with one or more asteroids in passing, creating rocky debris. Plausible, but the meteoroid "path" occurs when Phaethon nears the Sun—behaving like a comet, yet developing no tail. By studying the spectral signature of the Geminid meteor shower, scientists have determined that the fragments are denser than cometary material, yet not as dense as an asteroid. Phaethon may be an extinct comet that has gathered a thick layer of interplanetary dust during its travels yet retains the ice-like nucleus. Without physical samples of this "mystery," we may never fully understand what Phaethon is, but we can fully appreciate the annual display it produces!

Thanks to the wide path of the stream, folks the world over get an opportunity to enjoy the show. The traditional peak time is tonight as soon as the constellation of Gemini appears, around mid-evening. The radiant for the shower is near the bright star Castor, but meteors can originate from many points in the sky. From around 2:00 a.m. tonight until dawn (when our local sky window is aimed directly into the stream), it is possible to see about one "shooting star" every 30 seconds. Enjoy the incredible and mysterious Geminids!

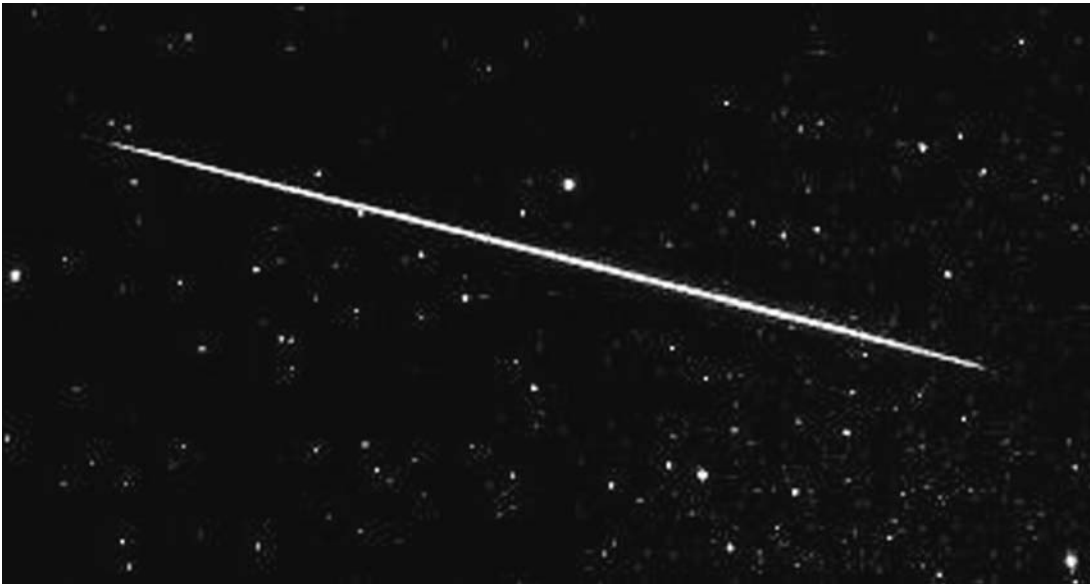


Figure 12.13. Geminid meteor (credit—NASA).

Monday, December 14

This date was a very busy one in astronomy history. Tycho Brahe was born in 1546. Brahe was a Danish pre-telescopic astronomer who established the first modern observatory in 1582 and gave Kepler his first job in the field. And, in 1962, the Mariner 2 spacecraft made a flyby of Venus and became the first successful interplanetary probe.

There are a number of very fine dark-sky studies present tonight. Using low power, start at Beta Ceti and drop south-southeast around four finger-widths (RA 00 47 33 Dec -25 17 17) to one of the finest galaxies in the night sky—NGC 253, the Sculptor Galaxy. At a combined magnitude of 7.1, this large, highly tilted, spindle-shaped galaxy is a delight in large scopes! Featuring a broad range of knots, voids, broken lanes, and spiral arms, use no more power than necessary to darken the background sky, then power up for the details. Discovered by Caroline Herschel on September 23, 1783, using a small reflector, this 10-million-light-year-distant galaxy is a real treat!



Figure 12.14a. NGC 253 (credit—Palomar Observatory, courtesy of Caltech).



Figure 12.14b. Tycho Brahe (historical image).

Tuesday, December 15

If you're out just before daybreak, look for Venus and Antares to sparkle with the very last, super-thin crescent Moon. Can you see it before the dawn? On this date in 1970, the Soviet spacecraft Venera 7 registered a first as it made a successful soft landing on Venus and so went into the history books as the first craft to land on another planet.

How about something a little more suited to a mid-sized scope tonight? Set your sights on Alpha Fornacis and let's head about three finger-widths northeast (RA 03 33 15 Dec -25 52 18) for NGC 1360. In a 6" telescope, you'll find the 11th magnitude spectroscopic double star in the center of this planetary nebula to be very easy to spot, but be sure to avert because the nebula itself is very elongated. Like many of the most interesting sights, this planetary is a rule-breaker, since it doesn't have an obvious shell structure. But why? Rather than believe it is not a true planetary nebula, studies have shown that it could quite possibly be a very highly evolved one, an evolution that has allowed its gases to begin to mix with the interstellar medium. Although faint and diffuse for northern observers, those in the south will recognize this as Bennett 15!



Figure 12.15a. NGC 1360 (credit—Palomar Observatory, courtesy of Caltech).



Figure 12.15b. Venera 7 (credit—NASA).

Wednesday, December 16

Tonight celebrate the 1857 birth of Edward Emerson (E.E.) Barnard—American observational astronomer and absolute legend. He led a very colorful life, and his sharp skills led to a multitude of discoveries. Barnard was known to simply set the scope on one point in the sky and watch for new objects as the field moved! For an example of Barnard's touch, explore Beta Aurigae (RA 05 59 31 Dec +44 56 50). First identified in 1890 as a spectroscopic binary, Algol-type variable Beta is also part of a moving group of stars which includes Sirius. Although you won't see changes as dramatic as those of the Demon Star, it has a precise drop of 0.09 in magnitude every 3.96 days. This system contains nearly identical stars that are more than two and a half times the size of our Sun, but orbit each other at a distance of less than 0.1 AU! Although Menkalinan's 10th magnitude optical companion was first spotted by Sir William Herschel in 1783, only E.E. Barnard noticed the 14th magnitude true tertiary to this incredible multiple system!

For more advanced observers, take a look at a galaxy cluster—Abell 347—located almost directly between Gamma Andromedae and M34 (RA +44 56 50 Dec +41 52 30). You'll find a grouping of at least a dozen galaxies that can be fitted into a wide-field view. Let's tour a few! The brightest and largest is NGC 910, a round elliptical with a concentrated nucleus. Northwest, you'll see faint, edge-on NGC 898 and faint, small NGC 912 is northeast of 910. To the north, slightly brighter and rounder 911 shows a substantial core region. Further north, faint 909. Fainter yet is the more northern NGC 906—a round contrast change. Northeast is NGC 914, which appears almost as a stellar point with a very small haze around it. Southeast is NGC 923, which is just barely visible with aversion. Enjoy this Abell quest!



Figure 12.16a. Abell 347 (credit—Palomar Observatory, courtesy of Caltech).

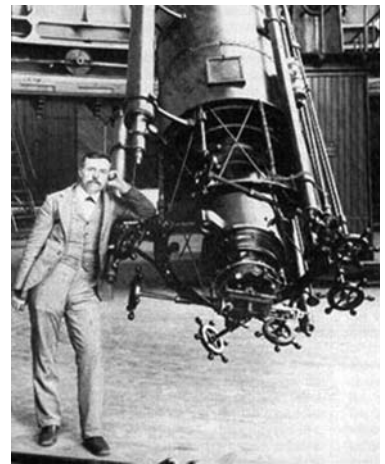


Figure 12.16b. E.E. Barnard (historical image).

Thursday, December 17

On this date in 1965, David Levy began his comet search. Since that time, Levy has found 8 visual and 13 photographic comets, credit for which was shared with the Shoemakers. Levy's career is a very illustrious one, including authoring 7 books and cataloging more than 300 deep-sky objects during his sky sweeps. Along with his wife Wendee and Tom Glinos, he discovered over 150 asteroids, including the first Martian Trojan. With yet another comet discovery in 2006, Levy has now taken third place all-time in the number of comets found—and most of his discoveries were made with a backyard telescope! Move over, M. Messier. There's a new kid in town!

Tonight let's go north for a mid-size scope challenge about two finger-widths east-northeast of the beautiful double star Gamma Andromedae (RA 02 22 32 Dec +43 20 45). At 12th magnitude, NGC 891 is a perfect example of a spiral galaxy seen edge-on. To the mid-sized scope, it will appear as a pencil-slim scratch of light, but larger telescopes will be able to make out a fine, dark, dust lane upon aversion. Discovered by Caroline Herschel in 1783, NGC 891 contained a magnitude 14 supernova recorded on August 21, 1986. Often considered a "missed Messier," you can add this one to your Caldwell list as number 23.



Figure 12.17a. NGC 891 (credit—Palomar Observatory, courtesy of Caltech).



Figure 12.17b. David Levy (public image).

Friday, December 18

So where has Sir William Herschel been lately? Rest assured that one of the most prolific observers of the cosmos never stopped exploring, discovering, and documenting some of the finest deep-space objects, and was doing so almost every single night of the year. Tonight let's start with a Herschel discovery made on this date in 1788 as we take a look in northern Perseus, about a fist-width northeast of Alpha, for NGC 1444 (RA 03 49 24 Dec +52 40 00). Well known as a source of radio emission, NGC 1444 holds a rough cumulative magnitude of 6.5; in binoculars it will show as a small compression of stars around SAO 24248, but use a scope if you can! Even modest aperture and magnification will reveal a delightful chain of stars in an S-pattern around this Herschel "400" object.

If you'd like to explore something a little more off the beaten path (and an object not discovered by Herschel), head about a degree and a half southwest for King 7 (RA 03 59 00 Dec +51 48 00). Very rich and compressed, this alternative catalog study is slightly larger than tonight's Herschel and is definitely more set apart from the surrounding star fields. Studied by (and named for) Ivan R. King, this intermediate-to-old open cluster seems to be very relaxed in its evolutionary state. Be sure to power up, because King 7 is definitely a stellar region you won't want to miss!



Figure 12.18a. NGC 1444 (credit—Palomar Observatory, courtesy of Caltech).



Figure 12.18b. King 7 (credit—Palomar Observatory, courtesy of Caltech).

Saturday, December 19

Tonight let's return to Fornax and start with binoculars. For a real treat, look just below Beta for the triple Eta. To limited optics, this sweet triple grouping will show two stars closer together—northeastern Eta 3 and southwestern Eta 2. This is a visual combination in a delightful starry field, but take out your telescope and have a closer look at Eta 2 (RA 02 50 14 Dec -35 50 37). Separated by 5.0'' this disparate magnitude 5.9 and 10.1 binary system is a challenge object on many double stars' lists!

For larger telescopes, set sail for Beta Fornacis and head 3 degrees southwest (RA 02 39 42 Dec -34 16 08) for a real curiosity—NGC 1049. At magnitude 13, this globular cluster is a challenge for even large scopes, and with good reason: it isn't even in our galaxy. This cluster is a member of the Fornax Dwarf Galaxy, a 1-degree span that's so large it was difficult to recognize as extragalactic—at least it was until the great Harlow Shapely figured it out! NGC 1049 was discovered and cataloged by John Herschel in 1847, only to be reclassified as Hodge 3 (by Paul Hodge) in a 1961 study of the system's five globular clusters. Since that time, yet another globular has been discovered in the Fornax Dwarf! Good luck...



Figure 12.19a. Eta 3 and Eta 2 Fornacis (credit—Palomar Observatory, courtesy of Caltech).



Figure 12.19b. NGC 1049 (credit—Palomar Observatory, courtesy of Caltech).

Sunday, December 20

Tonight's twilight crescent Moon has a visitor 2.4 degrees north—the asteroid Iris! Check out Jupiter's northern visitor, too. Neptune is still just 0.6 degrees away! Tonight is the peak of the Delta Arietid meteor shower, an early evening event that must be viewed before the radiant sets. The fall rate is modest, about 12 per hour. Today also marks the founding of Mt. Wilson Solar Observatory in 1904, and the birth of Walter Adams in 1876. While studying at Mt. Wilson, Adams revealed the nature of Sirius B, the first known white dwarf star. Let's pretend the skies are still as dark as they were at Mt. Wilson in Adams' time as we aim our binoculars and telescopes toward one of the most elusive galaxies of all—M33. Located about one-third the distance between Alpha Trianguli and Beta Andromedae (RA 01 33 51 Dec +30 39 37), this member of our Local Group was probably first seen by Hodierna but was recovered independently by Messier some 110 years later. Right at the edge of unaided visibility, M33 spans about four Moons' width of sky, making it a beautiful binocular object and a prime view in a low power telescope.

Smaller than both the Milky Way and the Andromeda Galaxy, the Triangulum may be average in size, but it's not an average study. So impressed was Herschel that he gave it its own designation of H V.17 after having already cataloged one of its bright star-forming regions as H III.150! In 1926 Hubble also studied M33 at Mt. Wilson with the Hooker Telescope during his work with Cepheid variables. Larger telescopes often "can't see" M33 with good reason: it overfills the field of view. But what a view! Not only did Herschel discover a region much like our own Orion Nebula, but also the entire galaxy contains many NGC and IC objects (even globular clusters) attainable with a larger scope. Although M33 might be 3 million light-years away, tonight it's as close as your own dark-sky site.



Figure 12.20a. M33: the Triangulum Galaxy (credit—NOAO/AURA/NSF).

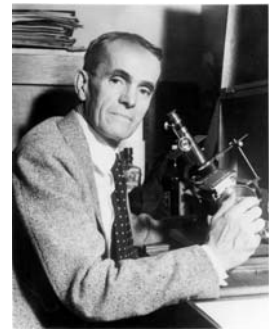


Figure 12.20b. Walter Adams (credit—Yerkes Observatory, University of Chicago).

Monday, December 21

Today marks the winter solstice. For the Northern Hemisphere, it is the shortest day and the longest night of the year, and the point when the Sun is furthest south. Now is a wonderful time to demonstrate for yourself Earth's movements by choosing a "solstice marker." Anything from a fence post to a stick in the ground will suffice! Simply measure the shadow when the Sun reaches the zenith. Repeat your experiment in the weeks ahead and watch as the shadow grows shorter and the days grow longer! Tonight's solstice treat is the very close conjunction of Jupiter, Neptune—and the Moon! They won't all be visible for long, so be out as the sky begins to darken.

Now—apparently for no good reason—let's head for Alpha Persei (RA 03 24 19 Dec +49 51 40). Although there's nothing particularly interesting about this 570-light-year-distant star named Mirfak, what is incredible is the field in which it resides. Take a look at lowest power with a rich field telescope or binoculars, and be prepared to be blown away! You are looking at the Alpha Persei moving group—a fantastic field of main sequence stars that contains a little over 100 members. Even though it will take 90,000 years before any perceptible change is seen in this bright collection, the stars are happily moving at a pace of about 16 kilometers per second toward Beta Tauri! Enjoy this fine group, which is also known as Melotte 20.



Figure 12.21. Melotte 20 (credit—T. Credner and S. Kohl at allthesky.com).

Tuesday, December 22

Up early? Fantastic! In the pre-dawn hours of this morning, we have a treat for you—the Ursid meteor shower! Cruising around the Sun every 13.5 years, Comet 8P/Tuttle sheds a little skin. Although it never passes inside Earth’s orbit, and it has been some 6 years after its closest approach, we do pass through its debris stream. Not so unusual? Then think again, because it takes as much as 6 centuries before a particular meteoroid trail is affected enough by Jupiter’s gravity to deflect its stream into our atmosphere. With no interference from the Moon, this circumpolar meteor shower could see activity of up to 12 streaks per hour in the hours before dawn. By keeping watch on the constellation of Ursa Major, you just might spot one of these slow-moving, 600-year-old travelers on their path only halfway between us and Selene!

Tonight we’ll return to the Moon as we look back on this date in 1968, when the first US live telecast from a manned spacecraft in outer space was transmitted at 3:01 p.m. from Apollo VIII. Earth appeared in this transmission as a blurred ball of light. The craft was 139,000 miles from Earth, 31 hours after launch. Let’s time travel back and listen in as we view the same features through our telescopes! Jim Lovell:

“Roger. For information, we’re passing over just to the side of the crater Langrenus at this time, going into the Sea of Fertility. The Moon is essentially gray, no color; looks like plaster of Paris or sort of a grayish beach sand. We can see quite a bit of detail. The Sea of Fertility doesn’t stand out as well here as it does back on Earth. There’s not as much contrast between that and the surrounding craters. The craters are all rounded off. There’s quite a few of them, some of them are newer. Many of them look like—especially the round ones—look like hit by meteorites or projectiles of some sort. Langrenus is quite a huge crater; it’s got a central cone to it. . . Okay over to my right are the Pyrenees Mountains coming up and we’re just about over Messier and Pickering [Messier A] right now. . .”



Figure 12.22a. Earth as seen from Apollo 8 (credit—NASA).



Figure 12.22b. Apollo 8 view of the Moon (credit—NASA).

Wednesday, December 23

Only one more day left until Christmas Eve, and astronomers have just discovered a unique feature on the lunar surface. Although accepted for many years to be a natural feature of selenography, modern photography coupled with today's high-powered telescopes have discovered an area near the lunar North Pole that's being used as a runway by a man in a red suit piloting an unusual spacecraft. . . Be sure to spark the imaginations in your young viewers as you show them the Alpine Valley!

On this date in 1672, astronomer Giovanni Cassini discovered Saturn's moon Rhea. Although you will have to wait until a lot later in the evening to catch the Ringed Planet at its best, why not try your hand at finding Rhea as well? A well-collimated scope as small as 4.5" is perfectly capable of seeing Tethys, Rhea, and Dione as they orbit very near the edge of the ring system. All that's required are steady skies and a little magnification!



Figure 12.23a. Santa's landing strip (credit—Wes Higgins).



Figure 12.23b. Saturn (credit—NASA).

Thursday, December 24

Tonight there are craters galore to explore: Plato, Aristotle, Eudoxus, Archimedes. . . But let's head to the north of Sinus Medii and have a look at a pair we've not yet encountered on our lunar travels—Agrippa and Godin. The larger of the two, Agrippa, measures around 46 kilometers in diameter and drops to a depth of 3,070 meters. To the south is Godin, which is somewhat smaller at 35 kilometers in diameter, but a bit deeper at 3,200 meters. Note how Godin's interior slopes toward its central peak.

In 1968, Apollo 8 became the first manned spacecraft to orbit the Moon. Until this date, no one had seen with their own eyes what lay beyond. Frank Borman, James Lovell, and William Anders were to become the first to directly view the "dark side"—and so would be the first to witness Earthrise over the Moon. If you enjoyed this year's lunar studies, let your mind take flight to the distant orb. What courage it took for these brave individuals to journey so far from hearth and home!

And from the crew of Apollo 8, we close with good night, good luck, a Merry Christmas, and God bless all of you, all of you on the good Earth.

—Astronaut Frank Borman



Figure 12.24a. Agrippa and Godin (credit—Wes Higgins).



Figure 12.24b. Earthrise (credit—Apollo 8/NASA).

Friday, December 25

Wishing you all the very best for the Christmas season! Like a present, Sir Isaac Newton was born on this date in 1642. Newton was the British “inventor” of calculus and a large part of what we now consider modern classical physics. Even young children are aware of his simple laws of motion and gravity. It wasn’t until the time of Einstein that things changed!

In keeping with the season, tonight’s astronomical object is a celebration of both starlight and asterism. Located 10 degrees east of Betelgeuse (RA 06 41 00 Dec +09 53 00), NGC 2264 will be a challenging object thanks to the Moon. Also known as the “Christmas Tree Cluster,” this asterism of approximately 20 bright stars and over 100 fainter ones is embroiled in a faint nebula that will be lost to bright skies, leaving only the delightful Christmas tree shape adorned with stars. The very brightest of these, S Monocerotis, is 5th magnitude and will show clearly in the finderscope as a double at magnification. Steady skies will reveal that the “star” at the top of our “tree” is also a visual double. Many of the stars will also appear to have companions, as well as tints of silver and gold. The visual effect of this splendid open cluster will be well worth the challenge it presents. Happy holidays!



Figure 12.25a. NGC 2264: the Christmas Tree Cluster (credit—Palomar Observatory, courtesy of Caltech).



Figure 12.25b. Sir Isaac Newton (historical image).

Saturday, December 26

Although the mighty Copernicus on the terminator will draw the eye like no other crater tonight, it's time to pick up another study that you may not have logged—Crater Davy. You will find it just west of the large ring of Ptolemaeus on the northeastern edge of Mare Nubium. It will appear as a small, bright ring, with the large crater Davy A on its southern border. Now skip across the gray sands of Nubium further west, and let's take a look at the crater on the peninsula-like feature Guericke. Named for Dutch physicist Otto von Guericke, this 58-kilometer-diameter crater has all but eroded away. Look for a break in its eastern wall, and notice how lava flow has eradicated the north!

Tonight we'll travel to Omicron 2 Eridani, located roughly a handspan west of Rigel (RA 4 15 16 Dec -07 39 10). As the southernmost of the Omicron pair, it is sometimes known as 40 Eridani, and you'll find it to be an interesting multiple-star system that's very worthy of your time. Discovered by William Herschel in 1783, this 16-light-year-distant system is the eighth nearest of the unaided visible stars. Well spaced from the primary, the companion star is also a double for high powers and will reveal a red dwarf discovered by Otto Struve. Now, look closely at the 9th magnitude B star. This is the only white dwarf that can be considered "easy" for the backyard telescope. Its diameter is only about twice the size of Earth and its mass is about that of our Sun. Power up and locate the 11th magnitude companion, for it's one of the least massive stars known! And this white dwarf may be the smallest stellar object visible in an amateur telescope. It would be like spotting a tennis ball on the Moon!

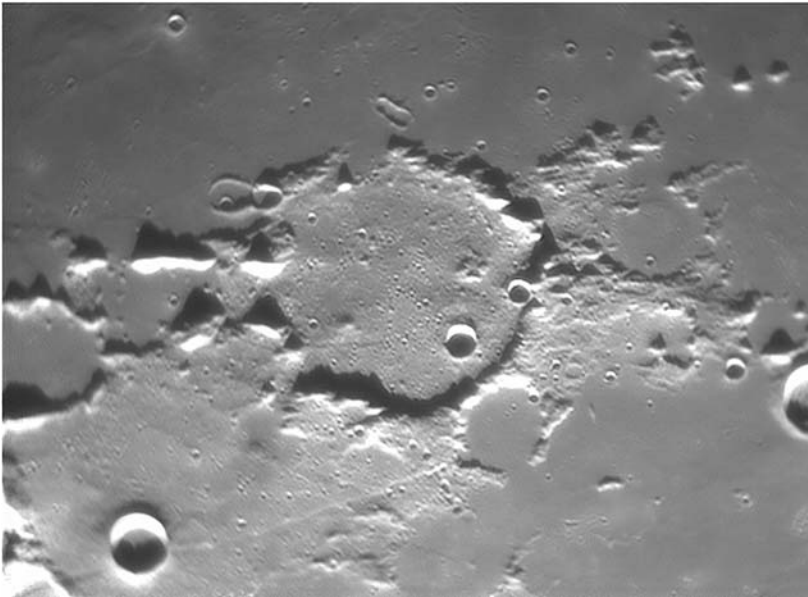


Figure 12.26a. Guericke (credit—Wes Higgins).



Figure 12.26b. 40 Eridani (credit—Palomar Observatory, courtesy of Caltech).

Sunday, December 27

Born on this date in 1571 was Johannes Kepler, a Danish astronomer and assistant to Tycho Brahe. Kepler used Brahe's copious notes of Mars's positions to help formulate his three laws of planetary motion. These laws are still applicable today. If you're up before dawn this morning, you can see them in action as Mars sets about the time Venus rises!

On the lunar surface, we're going to head to the deep south as we pick up one of the last of our lunar studies—Longomontanus. Named for the Danish astronomer Christian Longomontanus (an assistant to Tycho), this wonderland of details stretches about 145 kilometers across the surface. Look for a great collection of interior craters along its northwest interior wall, and note how it has eradicated a much older crater that still shows an edge to the east.

Now let's have a look at a fine triple-star system, Iota Cassiopeiae (RA 02 29 03 Dec +67 24 08). Iota is easily found by making a mental line between Delta and Epsilon—the two easternmost stars of the Cassiopeia "W." Now go northeast a little less than the same distance between them for Iota. Resolvable through small scopes, this splendid and disparate triple is close! Magnitude 7.6 Iota B is 2.6" southwest of magnitude 4.7 Iota A. The 8.4-magnitude turquoise C star is more comfortably spaced; it's found 7.1" east-southeast of the primary. The colors are warm yellow, aqua, and turquoise. . .and it takes a steady night to separate that B star!

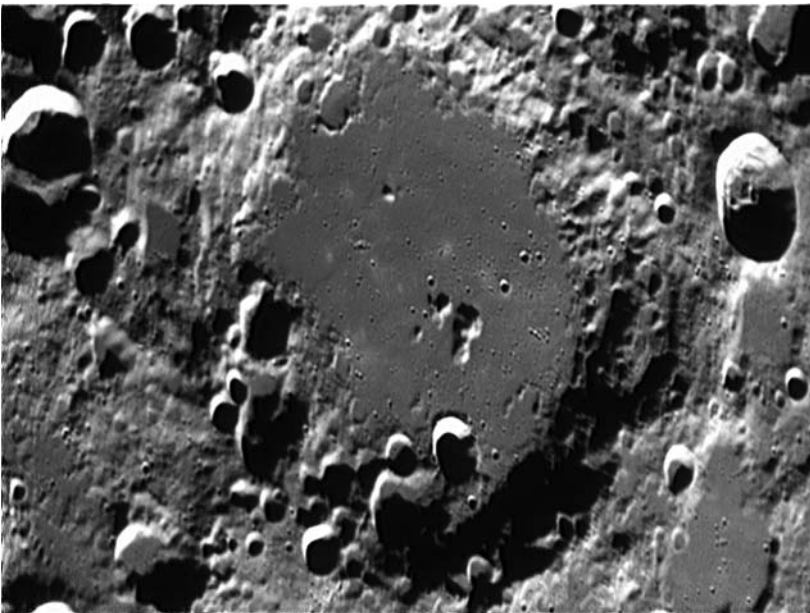


Figure 12.27a. Longomontanus (credit—Wes Higgins).



Figure 12.27b. Iota Cassiopeiae (credit—Palomar Observatory, courtesy of Caltech).

Monday, December 28

Today we celebrate the birth of Arthur S. Eddington. Born on this date in 1882, Eddington was a British theoretical astrophysicist whose work was fundamental to interpreting and explaining stellar nature. Eddington also coined the phrase “expanding universe” to refer to the mutual recession of the galaxies. This idea would eventually become known as “Hubble’s law,” as the massive 200” telescope at Palomar Observatory played another important role when Eddington’s work in this field was continued by Edwin Hubble.

Tonight, slide to the lunar southern highlands as we complete some of our last observing quests with craters Hainzel and Mee. Hainzel was named for Tycho Brahe’s assistant; it measures about 70 kilometers in length and sports several interior wall structures. To its south is the eroded Mee, named for a Scottish astronomer. Although Crater Mee doesn’t appear to be much more than simple scenery, it spans 172 kilometers.

Now let’s turn toward Cetus to have a look at a star known as the “Wonderful.” Omicron Ceti (RA 02 19 20 Dec -02 58 39), best known as Mira, was the first variable discovered (in 1596) and is the prototype of all long-term variable stars. When Fabricius first viewed it, he believed it to be a nova and did not wait for a return. Consequently, Mira wasn’t seen again until 1603, when Bayer added it to his catalog as a 4th magnitude star and assigned it the designation of Omicron. Imagine Bayer’s embarrassment when it later disappeared! Careful observation revealed its presence a year later, and the age of variable stars was ushered in. Oddly enough, Mira has a blue companion star. First viewed in 1918, it is far too faint for backyard telescopes, but we can still enjoy Mira.



Figure 12.28a. Hainzel and Mee (credit—Alan Chu).

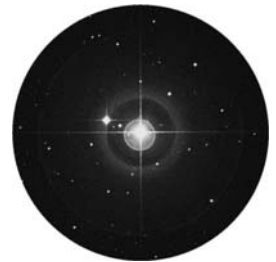


Figure 12.28b. Omicron Ceti: Mira (credit—Palomar Observatory, courtesy of Caltech).

Tuesday, December 29

On this date in 1987, cosmonaut Yuri Romanenko ended his record 326-day space flight orbiting Earth in the Mir space station, landing in a Soyuz spacecraft at a snow-covered site in Kazakhstan. Tonight the snowy white Moon will command the skies, but look on the bright side. . .look to the eastern limb to view the bright splash ray patterns surrounding ancient Furnerius, rays that themselves emanate from the much younger crater Furnerius A. All over the surface, we see small points light up, giving testimony to the Moon's violent past written in the crater's scarred lines. Take a look now at the western limb, for the sunrise is about to advance around it.

To avoid the Moon's bright influence, let's head north to Cassiopeia and check out wide double star 35 Cassiopeiae about two finger-widths west of Epsilon and an equal distance north of Gamma (RA 01 21 05 Dec +64 39 29). This is an easy split for telescopes and can be resolved in steady binoculars.



Figure 12.29a. Furnerius (credit—Alan Chu).



Figure 12.29b. 35 Cassiopeiae (credit—Palomar Observatory, courtesy of Caltech).

Thursday, December 31

It is the last day of our 2009 observing year together, and the date commemorates the 1864 birth of Robert Grant Aitken, who specialized in the study of double stars and discovered more than 3,000 of them. Aitken made systematic surveys of binary stars, measuring their positions visually. His massive *New General Catalogue of Double Stars Within 120 Degrees of the North Pole* allowed orbital determinations that increased astronomers' knowledge of stellar masses. Aitken also measured positions of comets and planetary satellites. He wrote an important book on binary stars, and he lectured and wrote widely for the public.

Tonight's Full Moon is known as the Old Moon, or the Moon after Yule. And tonight we're going to call it Blue. No matter what it is called, it is still a lovely sight to watch it rise and glide across the luminous night sky. But for some lucky viewers in much of Europe, Africa, Asia, and Australia the Old Blue Moon after Yule will also partially eclipse!

What a wonderful way to end our year together. . . at light speed!



Figure 12.31a. Blue Moon (credit and copyright—Kostian Iffica/NASA).



Figure 12.31b.
Robert Grant Aitken
(historical image).



Glossary

Absolute magnitude

Brightness any given star would have if viewed 10 parsecs from Earth

Absorption nebula

Dark nebula, as one seen in silhouette

Accretion

Accumulation of dust or gas circling larger bodies such as stars, planets, or moons; also, a disk of particles around an existing body

Airy disk

Pattern of illumination caused by diffraction, usually around a bright star

Albedo

Measure of reflectivity of an object; the value is expressed in a ratio of light reflected as compared to incident light

Analemma

Painstaking photographic process of recording the Sun's position as seen from the same vantage point, at the same time of day, over a year

Annular eclipse

Variation of a solar eclipse that leaves a full or partial ring around the Sun

Aphelion

Object's furthest point from the Sun during its orbit

Aperture

Term applied to the size of the light-gathering element in either a telescope or binoculars

Apparent magnitude

Brightness factor of any object as seen visually

Apparition

Period of time in which a planet, comet, etc., is visible

Arcminute

Unit of astronomical measurement; 1/60th of a degree

Arcsecond

Unit of astronomical measurement; 1/60th of an arcminute, and 1/360 of a degree

Asterism

Recognizable pattern of stars

Asteroid

An orbiting minor planet; also, a small, rocky planetoid with a diameter of less than 1,000 kilometers

Asteroid Belt

Place between Mars and Jupiter where a large number of minor planets orbit

Astronomical Unit (AU)

Average distance from Earth to the Sun (149,598,550 kilometers)

Astrometry

Precise measurement of an object's distance and motion

Atmosphere

Layer of gas that surrounds an astronomical body, such as a planet

Aurora

Magnetic, electric, and solar phenomenon causing a variety of light phenomena visible on Earth

Averted vision

Observing technique for increasing contrast of faint visual objects by using the more light-sensitive areas on the edges of the retina

Barnard nebulae

Classification catalog of dark nebulae as studied by E.E. Barnard

Bayer designation

Greek letters assigned to the stars in a constellation, usually in descending order of brightness; also, the stellar catalog entries of Johannes Bayer

Belts

General term for dark bands of clouds such as on Jupiter that show the differences in climate zones; also known as bands

Binary star

Multiple-star system whose members are gravitationally bound to each other

Blackbody

Object that absorbs all incident radiation, regardless of wavelength

Black hole

Region of space where gravity is so intense that nothing can escape, not even light

Blue straggler

Union of two stars into one

Bok globule

Area of dark dust spanning no more than one light-year

Brown dwarf

Failed star; one with too little mass to ignite nuclear fusion and energy is released by gravitational contraction

Cassini division

Wide separation between Saturn's A and B rings

Celestial equator

Imaginary circle above Earth's equator on the celestial sphere

Celestial longitude

Measured in degrees, hours, and minutes along the ecliptic, i.e., right ascension

Celestial pole

Point in the sky where Earth's poles intersect the celestial sphere

Celestial sphere

Imaginary sphere around Earth showing the positions of the celestial bodies

Cepheid variable

Star that varies in brightness in the same manner as Delta Cephei

Circumpolar

Star, constellation, or other object that can be seen all year

Comet

Rocky, icy body that orbits the Solar System in an expanded ellipse but not necessarily in the ecliptic plane

Conjunction

Alignment of two celestial bodies occurring when they reach the same celestial longitude; also, a close visual pairing

Constellation

One of 88 regions of the sky divided by distinct borders; also, asterisms of bright stars that represent mythological figures

Cosmic ray

Extremely fast, energetic particle

Cosmos

Universe; derived from Greek meaning "everything"

Crescent

Describes the appearance of one of the phases of the Moon or the inner planets

Culmination

Where an object reaches its highest point in the visible sky

Danjon scale

Scale by which the apparent darkness of a lunar eclipse is judged

Dark adaptation

Observer's term referring to the time it takes the eyes to adjust to lower light conditions

Dark nebula

Area of unilluminated gas or dust

Declination

Angular distance (in degrees) of a point either north or south of the celestial equator

Deep-sky object

Slang term (DSO) given to an observed astronomical subject beyond the Solar System

Deep space

Region outside our Solar System

Double star

Two stars appearing close together in the sky, either due to a random optical alignment or a gravitationally interacting pair

Dust lane

Thin disk or line of light obscuring material located in another galaxy

Dwarf star

Main sequence star too small to be classified as a giant or supergiant; our Sun is a yellow dwarf star

Earthshine

The visible portion of the Moon not lit by direct sunlight, the darker portion of which appears gray or blue-gray

Eclipse

When one celestial body passes in front of another, from the viewpoint of an observer

Eclipsing binary

Multiple-star system where one stellar body passes in front of the other from our viewpoint

Ecliptic

Apparent path the Moon, Sun, and planets take across the visible sky

Egress

Term given to the movement of an astronomical object when leaving a specified area

Elliptical

Elongated oval, such as in an "elliptical" orbit; galaxies that exhibit this structure

Elongation

Angle between the inner planets and the Sun as seen from Earth

Emission nebula

Region of gas illuminated by the energy absorbed from a nearby star

Equinox

Time when the Sun crosses the celestial equator, denoting a change in seasons, such as spring (vernal) and fall (autumnal); times of the year when there are equal hours of day and night

Ergoregion

Area with vortex-like properties that resides around the outside of the event horizon of a black hole

Eyepiece

Viewing lens of a telescope

Faint fuzzy

Astronomical slang for an unresolved deep-sky object

Field of view (FOV)

The term that describes the amount of sky as seen through any particular telescope eyepiece or pair of binoculars

Filament

Long strand; descriptive of nebulae and, in solar terminology, prominences

Finderscope

Small, low power telescope mounted to, and aligned with, a larger telescope to help locate specific stars or areas of the sky

Fireball

Slang term given to any meteor brighter than the visual magnitude of Venus

Flamsteed number

Catalog number assigned to specific stars in order of right ascension

Galactic

Pertaining to our galaxy, the Milky Way Galaxy

Galactic cluster

See Open cluster

Galactic plane

Apparent angle in the sky described by the Milky Way's disk

Galaxy

Expansive star systems containing innumerable individual stars, dust, gases, planets, etc., which are held together by gravity; galaxies are classed by their shapes, e.g., spiral, barred, or elliptical

Galilean moons

Common term for Jupiter's four largest natural satellites: Io, Europa, Ganymede, and Callisto

Geosynchronous orbit

Also referred to as geostationary orbit; the orbit of a satellite whose velocity is matched to Earth's rotation

Giant

Star larger and brighter than its similarly evolved group members

Gibbous

Phase of the Moon or a planet in which the visible surface is more than half illuminated

Globular cluster

Spherical cluster of older stars of common origin

Granulation

Term that describes the appearance of the Sun's surface; caused by convection

Gravitational lensing

Curvature of space-time where a light ray is bent around a gravitational source

Handspan

Average measurement from tip of thumb to tip of little finger when the hand is fully extended and held at arm's length. Approximate measurement: 20°

Half Moon

Slang term given to either the first or third quarter Moon; disk is half illuminated

Heliocentric

Sun-centered

Herbig-Haro object

Newly forming star that is expelling jets of matter

Hour

Sidereal time elapsed since a given object was on the meridian; expressed as a number in right ascension

Hubble's law

Velocity and distance relationship; describes the expansion of the universe

IC

Stands for Index Catalog; reference as assigned by J.L.E. Dreyer

Inferior conjunction

Describes when an inner planet's orbit carries it between Earth and the Sun

Infrared

Portion of the electromagnetic spectrum with wavelengths longer than those visible to the human eye

Interacting galaxies

Two or more galaxies sharing common material; tidal forces

Interferometry

Act of combining more than one wavelength to study an object

Intergalactic

Area between two distinct galaxies

Ionization nebula

Extended low-density nebula of very high temperature and excitation

Jove

Alternate word for Jupiter

Jovian

Belonging to, or pertaining to, Jupiter

Julian day

Number of days that have elapsed since January 1, 4713 BC; used partly to calculate intervals and avoid leap years

Kirkwood gap

Area between clusters of asteroids

Kuiper Belt

Orbiting group of rocky and/or icy bodies that reside at the outer reaches of our Solar System

Lagrange points

Locations in space where gravitational forces and the orbital motion of a body balance each other

Libration

Slight changes in the visible face of the Moon, allowing you to see more along the lunar limb at certain times

Limb

Outer edge of the visible surface of an astronomical object bordered by background space

Light curve

Amount of light generated by a variable star and plotted on a graph over a period of time

Light pollution

Overpowering glow of a terrestrial light source; reduces visibility of faint objects

Light-year

Distance light travels in an Earth year; 9,460,000,000,000 kilometers

Luminosity

Total brightness of a star or galaxy

Lunar

Pertaining to Earth's Moon

Lunar eclipse

When Earth passes between the Sun and Moon; Earth's shadow can be seen then on the Moon

Magnitude

Logarithmic scale used to denote the optical brightness of a star or celestial object. Smaller numbers are brighter, while larger numbers are fainter. Sixth magnitude is roughly 100 times fainter than first magnitude

Main sequence

Stars undergoing nuclear fusion; represented on a graph of stellar temperatures versus stellar brightness as a band

Mare

Vast lava plain on the surface of Earth's Moon; plural: maria

Maximum

Time when a variable star reaches its brightest point; plural: maxima

Metal

Descriptive term used in astronomy for all elements heavier than lithium

Meridian

Imaginary north-south line passing through the zenith of the visible sky

Messier object

Any object found in the catalog of Charles Messier; abbreviated "M" with corresponding number

Meteor

Piece of debris entering our atmosphere; slang: "shooting star"

Meteor shower

Designated time period during which many meteors can be seen

Minimum

Time when a variable star reaches its faintest point; plural: minima

Mira-type

Type of variable star similar to the star named Mira

Moondog

Atmospheric phenomenon appearing like a rainbow patch near the Moon

Multiple-star system

Gravitationally bound star system containing more than two members

Nebula

Cloud of gas or dust in space; plural: nebulae

Nebulosity

Faint presence of an illuminated nebula

Neutron star

Collapsed star that contains only densely packed neutrons

NGC

Abbreviated term given to the New General Catalog objects; compiled by J.L.E. Dreyer

Nova

Star that can suddenly erupt to epic brightness

Nutation

Slight irregular motion in the axis of rotation of a largely axially symmetric object

Occultation

When one celestial body passes in front of another, partially or totally obscuring it from view

Open cluster

Group of stars that are gravitationally bound and move at the same speed; also known as a "galactic" cluster

Opposition

Point where a planet appears opposite the Sun in the visible sky

Orbit

Path any celestial object takes around another due to the influence of gravity

Parallax

Apparent change in a nearer object's position when measured against a more distant object

Parhelia

Atmospheric phenomenon resulting in a rainbow-like appearance around the Sun or Moon; a full or partial ring

Parsec

Distance at which one Astronomical Unit appears to cover one second of arc; about 3.26 light-years

Penumbra

Part of an eclipse (solar or lunar) where a portion of the Sun's limb is still visible; also, term used to denote outer region of a sunspot

Perihelion

Point at which an orbiting body is closest to the Sun

Perturbation

Change in orbital pattern of an object when influenced by a second gravitational source

Phase

Variance in illumination of the Moon or planets

Photometry

Study of the light energy emitted by stars, giving a reasonably accurate gauge of their distance and structure

Photon

Particle (quantum) of light; "collecting photons" is slang for observing

Planetary nebula

Shell of gas expelled from a dying star equal to its mass

Population I stars

Younger stars with high chemical and metal abundances

Population II stars

Older stars that have shed their heavy elements

Pre-main sequence

Star that has not yet begun the process of nuclear fusion

Primary star

Brightest of two or more components in a multiple-star system; often referred to as the "A" star

Proper motion

Apparent motion of an object across the sky in relation to background stars

Pulsar

Rotating neutron star that emits radio waves

Quantum

Fundamental unit of energy

Quark

One of the constituent particles of electrons, protons, etc.

Quasar

Compact radio source that displays a stellar appearance but has an extremely large redshift

Ray

High albedo (surface brightness) linear feature on the lunar surface

RR Lyrae-Type

Type of star that varies in the same way as RR Lyrae

Radiant

Area of the sky from which meteors appear to originate

Radiation

Energy transmitted through space as waves

Radio astronomy

Study of celestial bodies via the radio waves they emit and absorb

Red giant

Massive dying star; stars become red giants at the end of their main sequence period

Redshift

Apparent motion of the spectral lines toward the red end of the spectrum; caused by relative velocity lengthening the light's wavelengths as the object and viewer recede from each other

Reflection nebula

Area of gas or dust that reflects a nearby star's light

Resolution

Act of resolving an object, such as a globular cluster, open cluster, or double star

Resolving power

Ability of an optical aid to show two or more close objects as separate entities

Retrograde

Apparent backward or contrary motion of a planet across the visible sky as Earth overtakes its orbit

Revolution

Orbit of one body around another, such as a moon around a planet

Right ascension

Angle of an object around the celestial equator as measured from the vernal equinox and expressed in hours, minutes, and seconds; abbreviated RA

Rille

Long, narrow valley or ridge on the lunar surface

Rotation

Spinning of a body on its own axis

Satellite

Any small object orbiting a larger one, such as a moon of a planet; also, an artificial object orbiting a body

Secondary star

Less bright companion of a double star; also referred to as the "B" star

Seeing

Slang term applied to steadiness and clarity of the atmosphere

Separation

Angular distance between components of a double star; usually expressed in terms of arcminutes

Shooting star

Slang for meteor; also called "shooter"

Sidereal time

Time required for a moon or a planet to complete one revolution around its host body relative to the background stars

Skyglow

Slang term referring to light pollution, usually from major cities

Solar flare

Violent emission of energy from the Sun, which releases radiation and charged particles; also known as a coronal mass ejection (CME)

Solar System

Our Sun and everything that orbits it, including planets, moons, comets, and asteroids

Solar wind

High-speed stream of energetic particles flowing from the Sun

Solstice

Position or time of year when the Sun reaches its northernmost or southernmost declination

Spectrum

Wavelengths of light expressed in colors; plural: spectra

Spectral line

Wavelength where the intensity is greater than (emission line) or less than (absorption line) neighboring values

Spectroscopy

Analysis of light, using absorption lines to determine chemical properties and an object's motion and velocity

Starhopping

Slang term used to describe a method of moving from star to star to locate a faint object

Star cloud

Apparent grouping of stars that are actually independent of each other

Star cluster

Group of stars that share the same relative motion

Star field

Stars that are apparent in any given field of view

Sun dog

Atmospheric phenomena that resemble a rainbow patch near the Sun

Sunspot

Darker, cooler, highly magnetized area of the visible solar surface

Supergiant

Largest known type of star

Superior conjunction

Point in an inner planet's orbit when the Sun is between it and Earth

Supernova

Massive and violent explosion of a star, which expels nearly all of its mass; may briefly outshine an entire galaxy in magnitude; plural: supernovae

Supernova remnant

Shell of debris from an exploded star, usually rich in heavy elements

Surface brightness

Total value of light spread out over a large area; also, the magnitude of a large object as compared to the background sky

Terminator

Edge of a lighted area, such as appears on the lunar or a planetary surface

Trail

Visible path left in the sky by a meteor; also known as a train

Transient lunar phenomenon

Unexpected brightening, outgassing, or other change on the lunar surface

Transit

Passing of an orbiting body over its parent disk, such as Mercury or Venus crossing the Sun as seen from Earth or a Galilean moon passing in front of Jupiter from our viewpoint; the moment a celestial body crosses the meridian

Transparency

Slang term to denote the presence or absence of a thin cloud cover

Ultraviolet

Part of the electromagnetic spectrum where the wavelengths are shorter than the bluest light visible to the human eye

Umbra

Inner part of an eclipse shadow; also, the inner dark portion of a sunspot

Universal Time (UT)

Astronomical time that coordinates observers around the world; based on Greenwich Mean Time (GMT)

Variable nebula

Nebula that periodically changes in brightness

Variable star

Star that periodically changes in brightness or magnitude

Wavelength

Peaks and troughs of any emission across the electromagnetic spectrum

White dwarf

Small, hot star; the core remnant of a red giant

Wilson effect

Visual magnetic warping of a sunspot's appearance as it approaches the solar limb

Wolf-Rayet star

Hot, massive star with an extremely high rate of mass loss

X-ray

Band of the electromagnetic spectrum invisible to the human eye

X-ray binary

Binary star system whose members orbit so closely that they can only be distinguished by changes in their X-ray spectra

Yellow star

Ordinary star (such as our Sun) at a stable point in its evolution

Young

Slang term used to denote new features, such as on a planet; also describes a relatively newly evolved star and a nebula or star cluster less evolved than its neighbors

Zenith

Area directly overhead in the visible dome of the sky

Zodiac

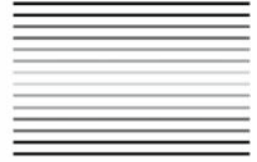
Constellations that are situated on the ecliptic plane

Zodiacal light

Slang term given to the visible cone of light that sometimes appears before or after sunrise or sunset; also, possible solar accretion disk remnants

Zones

Bright bands in cloud layers visible on the planets



Resources

"If I were to pray for a taste which would stand by me under every variety of circumstances, and be a source of happiness and cheerfulness to me through life, and a shield against its ills, however things might go amiss, and the world frown upon me, it would be a taste for reading."

–*Sir William Herschel*

Although there are many great resources out there to help you enjoy the hobby of astronomy, here are a few you should find very useful.

www.lunar-occultations.com/iota

This is the International Occultation and Timing Association (IOTA) site. The accurate information they provide for viewers around the globe will prove invaluable.

www.heavens-above.com

This site is easy to use, concise, and offers accurate information and charts for viewing satellites and bright comets.

www.spaceweather.com

Spaceweather will keep you up to date on solar and auroral events and many other things. This is definitely a good tool!

www.astroleague.org

The Astronomical League website offers many fine observing programs for the amateur astronomer and a wealth of resources, including links to current information on comets.

www.fourmilab.ch/yoursky

Yoursky is a wonderful interactive planetarium tool that allows you to create customized maps and sky views specific to your location.

www.skyandtelescope.com

Sky and Telescope magazine offers terrific online tips, charts, and information, as well as many articles for the amateur astronomer.

www.astronomy.com

Astronomy magazine also has online resources, observing tips, and more.

www.lpl.arizona.edu/alpo

The Association of Lunar and Planetary Observers (ALPO) has a comprehensive, educational, and very useful website.

www.aavso.org

The American Association of Variable Star Observers (AAVSO) will offer you the kind of information you need to study variable stars.

www.lunarrepublic.com

Lunar Republic offers up some of the very finest online reference materials available.

www.cfa.harvard.edu/iau/Ephemerides/

The IAU's Minor Planet Center offers excellent ephemerides for locating currently observable comets, asteroids, and a variety of other objects.

www.soho.com

The definitive site for studying solar phenomena!

Although there are many more terrific websites out there, you'll find the ones listed here some of your most often used "tools." Be sure to visit your local library as well, where you'll find other great observing books and star charts.

For many readers, it is helpful to have celestial coordinates for deep-sky objects. In the interest of preventing clutter during the Messier Marathon, we have included a table of these coordinates for your use, listed according to the days on which the objects were mentioned.

Friday, March 20

M77	(RA 02 42 40 Dec -00 00 48)
M74	(RA 01 36 41 Dec +15 46 59)
M33	(RA 01 33 51 Dec +30 39 36)
M31	(RA 00 42 44 Dec +31 16 09)
M32	(RA 00 42 41 Dec +40 51 57)
M110	(RA 00 40 22 Dec +41 41 07)
M52	(RA 23 24 48 Dec +61 35 00)
M103	(RA 01 33 24 Dec +60 39 00)
M76	(RA 01 42 19 Dec +51 34 31)
M34	(RA 02 42 06 Dec +42 46 00)

Saturday, March 21

M45	(RA 03 47 24 Dec +24 07 00)
M79	(RA 05 24 10 Dec +24 31 27)
M42	(RA 05 35 17 Dec -05 23 28)
M43	(RA 05 35 31 Dec -05 16 12)
M78	(RA 05 46 46 Dec +00 00 50)
M1	(RA 05 34 31 Dec +22 00 52)
M35	(RA 06 09 06 Dec +24 21 00)
M37	(RA 05 52 19 Dec +32 33 12)

M38 (RA 05 28 43 Dec +35 51 18)
M36 (RA 05 36 12 Dec +34 08 24)

Sunday, March 22

M41 (RA 06 46 00 Dec -20 46 00)
M47 (RA 07 36 36 Dec -14 29 00)
M46 (RA 07 41 42 Dec -14 49 00)
M93 (RA 07 44 26 Dec -23 52 00)
M50 (RA 07 02 48 Dec -08 22 36)
M48 (RA 08 13 42 Dec -05 45 00)
M44 (RA 08 40 24 Dec +19 41 00)
M67 (RA 08 51 18 Dec +11 48 00)
M105 (RA 10 47 49 Dec +12 34 54)
M96 (RA 10 46 45 Dec +11 49 10)

Monday, March 23

M95 (RA 10 43 57 Dec +11 42 12)
M65 (RA 11 18 55 Dec +13 05 32)
M66 (RA 11 20 15 Dec +12 59 21)
M81 (RA 09 55 33 Dec +69 03 55)
M82 (RA 09 55 52 Dec +69 40 48)
M108 (RA 11 11 31 Dec +55 40 31)
M97 (RA 11 14 47 Dec +55 01 08)
M109 (RA 11 57 35 Dec +53 22 35)
M40 (RA 12 22 24 Dec +58 05 00)
M106 (RA 12 18 57 Dec +47 18 14)

Tuesday, March 24

M94 (RA 12 50 52 Dec +41 07 09)
M63 (RA 13 15 49 Dec +42 01 46)
M51 (RA 13 29 52 Dec +47 11 40)
M101 (RA 14 03 12 Dec +54 20 53)
M102 (RA 15 06 29 Dec +55 45 47)
M53 (RA 13 12 55 Dec +18 10 09)
M64 (RA 12 05 43 Dec +21 41 00)
M3 (RA 13 42 11 Dec +28 22 31)
M98 (RA 12 13 48 Dec +14 53 58)
M99 (RA 12 18 49 Dec +14 25 00)

Wednesday, March 25

M100 (RA 12 22 54 Dec +15 49 19)
M85 (RA 12 25 24 Dec +18 11 26)
M88 (RA 12 31 59 Dec +14 25 13)
M91 (RA 12 35 26 Dec +14 29 45)
M60 (RA 12 43 40 Dec +11 33 08)
M59 (RA 12 42 02 Dec +11 38 45)
M58 (RA 12 37 43 Dec +11 49 04)
M89 (RA 12 35 40 Dec +12 33 22)
M90 (RA 12 36 50 Dec +13 09 45)

M87 (RA 12 30 49 Dec +12 23 28)

Thursday, March 26

M84 (RA 12 25 03 Dec +12 53 13)
M86 (RA 12 26 12 Dec +12 56 44)
M49 (RA 12 29 46 Dec +07 59 59)
M61 (RA 12 21 55 Dec +04 28 28)
M104 (RA 12 39 59 Dec -11 37 23)
M68 (RA 12 39 28 Dec -26 44 34)
M83 (RA 13 37 00 Dec -29 51 58)
M5 (RA 15 18 33 Dec +02 04 47)
M13 (RA 16 41 41 Dec +36 27 36)
M92 (RA 17 17 07 Dec +43 08 11)

Friday, March 27

M57 (RA 18 53 35 Dec +33 01 45)
M56 (RA 19 16 35 Dec +30 11 04)
M29 (RA 20 23 56 Dec +38 31 24)
M39 (RA 21 31 48 Dec +48 27 00)
M27 (RA 19 59 36 Dec +22 43 16)
M71 (RA 19 53 46 Dec +18 46 42)
M107 (RA 16 32 31 Dec -13 03 13)
M10 (RA 16 57 08 Dec -04 05 57)
M12 (RA 16 47 14 Dec -01 56 52)
M14 (RA 17 37 36 Dec -03 14 45)

Saturday, March 28

M9 (RA 17 19 11 Dec -18 30 58)
M4 (RA 16 23 35 Dec -26 31 31)
M80 (RA 16 17 02 Dec -22 58 30)
M19 (RA 17 02 37 Dec -26 16 04)
M62 (RA 17 01 12 Dec -30 06 44)
M6 (RA 17 40 18 Dec -32 12 00)
M7 (RA 17 53 48 Dec -34 47 00)
M11 (RA 18 51 00 Dec -06 16 00)
M26 (RA 18 45 18 Dec -09 23 00)
M16 (RA 18 18 48 Dec -13 49 00)

Sunday, March 29

M17 (RA 18 20 26 Dec -16 10 36)
M18 (RA 18 20 00 Dec -17 06 00)
M24 (RA 18 18 24 Dec -18 26 00)
M25 (RA 18 31 42 Dec -19 07 00)
M23 (RA 17 57 00 Dec -18 59 00)
M21 (RA 18 04 12 Dec -22 29 00)
M20 (RA 18 02 23 Dec -23 01 48)
M8 (RA 18 03 37 Dec -24 23 12)

Monday, March 30

- M28 (RA 18 24 32 Dec -24 52 11)
- M22 (RA 18 36 24 Dec -23 54 12)
- M54 (RA 18 55 03 Dec -30 28 42)
- M70 (RA 18 43 12 Dec -32 17 30)
- M69 (RA 18 31 23 Dec -32 20 52)

Tuesday, March 31

- M55 (RA 19 39 59 Dec -30 57 43)
- M75 (RA 20 06 04 Dec -21 55 16)
- M15 (RA 21 29 58 Dec +12 10 00)
- M2 (RA 21 33 27 Dec -00 49 24)
- M72 (RA 20 53 27 Dec -12 32 13)
- M73 (RA 20 59 00 Dec -12 38 00)
- M30 (RA 21 40 22 Dec -23 10 44)



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