

Stephen Chadwick · Ian Cooper

Imaging the Southern Sky

An Amateur
Astronomer's Guide

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Imaging the Southern Sky

An Amateur
Astronomer's Guide

Stephen Chadwick
Ian Cooper

Foreword by Sir Patrick Moore

 Springer

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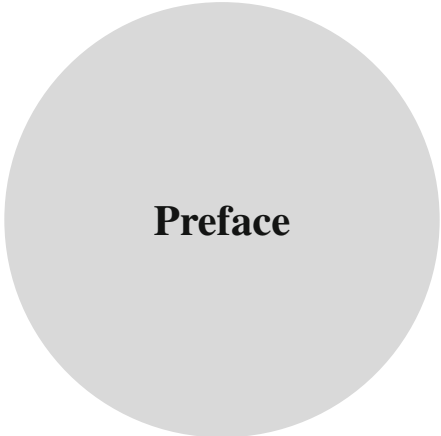
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Foreword

It is often said that the southern skies are richer and more interesting than those of the north. Yet there are not many books devoted mainly to them, and Stephen Chadwick and Ian Cooper's is a welcome edition. I am sure you will find it useful and enjoyable.

Sir Patrick Moore



Preface

The idea for this book arose after reading Ruben Kier's excellent book in this series, *The 100 Best Astrophotography Targets*. While there is no doubt that each of the targets included in the book are superb, one of the criteria used in their selection was the ability to image them successfully from northern latitudes, which meant that each one required a declination of at least -25° . Unfortunately, this meant that only a limited number of objects in the book were accessible to astroimagers living further south.

A gap therefore existed for a work that focused on the best targets for astroimaging situated outside of the area covered by Kier, and so this book came about. For the sake of simplicity, we decided to only include objects in the southern sky, i.e., south of the celestial equator. This doesn't mean, however, that this book is relevant only to those living in the southern hemisphere, but rather that the number of accessible objects increases the further south you are situated. Those living in the southern United States, for example, may find it possible to image down to Dec -35° on a good night and therefore will be able to target a large number of the objects we discuss. On the other hand, those living further south – say 20° south of the geographical equator – will be able to access all of the objects included here.

Aside from their location south of the celestial equator, various other factors have influenced the inclusion of each object in this book. Firstly, our chosen objects range from those that are familiar to both observers and amateur astroimagers, to lesser known (and hence rarely imaged) targets that, in some cases, we stumbled across by accident. Secondly, the chosen objects encapsulate the full range of targets available to amateur astroimagers including emission nebulae, dark nebulae, reflection nebulae, galaxies, planetary and bipolar nebulae, supernova remnants as well as wide-field images of large areas of the night sky. Thirdly, the objects have been selected to ensure that there are a variety of accessible targets for each individual astroimager regardless of experience, budget, available gear, and environmental conditions. It is simply a case of choosing objects that suit your particular set-up.

If you are relatively new to astroimaging, it might be worth reading the chapters in Part Two first as this will help you to decide which of the objects are suitable for your set-up and environmental conditions. It is particularly important to ascertain what field size is provided by your scope/camera combination, an issue which is discussed in Chapter 11. The field size of each image, along with other possible alternatives, is provided in the imaging information for each, so having ascertained your field size, you then simply choose a suitable target and start imaging.

In many cases, descriptive names have been provided for the objects in this book, making it easier to identify what you and others have imaged. Many of these names have been in use for centuries; John Herschel, for example, named the Keyhole Nebula in the nineteenth century due to the similarity of its visual appearance to a recognized object. As professional astronomy developed throughout the twentieth century, more descriptive names became common, such as the Pillars of Creation named by the Hubble Space Telescope photographers. With the rapid development in amateur digital astroimaging over the past 20 years, the best images available of some objects have actually been taken by amateurs from their own backyards, and amateur observers have also been responsible for coining the names of many astronomical objects. Thus we have collected together the descriptive names that are in use by observers and imagers (both professionals and amateurs alike). In a few cases, where no name seems to be in use, we have taken the liberty of suggesting our own name. Descriptive names have usually arisen from the way the image appears when orientated “north-up,” and this is the way most of the images are presented here, aside from a few instances where the dimensions of the book have made this impossible. On these occasions it is a good idea to turn the image so that north is up in order to get a proper feel for the object.

Each image is accompanied by a technical section that states how the particular image was taken. This is not to imply that this is the only or even the best way to image the object successfully. Due to the time constraints involved in the production of this book, many of the images – particularly emission nebulae – were taken using narrowband filters, which enable imaging in moonlight. It may be the case that equally good results can be achieved using traditional color imaging.

In summary, this book provides a substantial overview of many of the great objects of negative declination available to the amateur astroimager. It is, however, only the starting point. There are parts of the southern sky, such as the Magellanic Clouds, that have only been touched upon here. Years could be spent imaging the objects in these satellite galaxies alone. It is therefore hoped that this book will provide inspiration for astroimagers to really get stuck into imaging the huge variety of jewels of the southern sky that have not been included here.



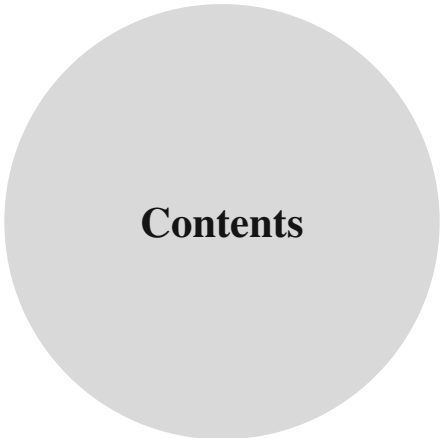
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Ian Cooper: I would like to firstly acknowledge my long-time friend and mentor Noel Munford of the Palmerston North Astronomical Society. Without Noel's input I wouldn't have been able to take my interest in astronomy to the levels that I have over the past four decades. I'd like to acknowledge a few others from the P.N.A.S. Firstly, the late Alex Wassilieff, a CCD pioneer in New Zealand from the early 1990s. Alex was very much the perfectionist in everything that he did and he tried his best to instill that ethos in those around him. Secondly, I'd like to thank another perfectionist, and a master optical craftsman, Peter Wilde. I wish to thank Stephen J. O'Meara for this ongoing encouragement and camaraderie since I first met him late last century. Finally, last but not least I'd like to thank my fellow author, Stephen Chadwick for inviting me to be a part of this first venture in astronomical

writing. Stephen's energy levels and willingness to tackle some of the obscure fields proposed meant that we were able to go where few but the professionals have gone before.

Finally, we would both like to thank Karen Jillings for proof reading, and John Watson, Maury Solomon and Megan Ernst at Springer for their help and support during the writing of this book.



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Part I



The Objects of the Southern Sky

Chapter One



The Hunter and His Dog

Canis Major
Eridanus
Lepus
Orion

We start our journey at the beginning of the year when the area containing Orion and Canis Major is on the meridian. This highly recognizable piece of sky is filled with the brilliant array of Gould's Belt, a band of nearby blue/white super giant stars that lie mainly south of the plain of the galaxy. This area is a rich star forming region, making it an astronomer's delight!

Many of the objects in this chapter are extremely well known to astroimagers the world over as the area is close to the celestial equator. Most of them are fairly large and bright and so make excellent introductory objects for those new to astroimaging. At the same time, there are countless ways that they can be imaged and so there is always something new to be appreciated from imaging them more than once as you acquire new equipment and gain new skills.

Barnard's Loop — Sh2 – 276

Constellation	Orion
RA	5 h 38 min 44 s
Dec	-02° 36' 00"

Fig. 1.1 shows all of the southern section of Barnard's Loop, but not the northernmost patch around the star Lambda Orionis, the head of Orion. This emission nebula is the largest component of the Orion Molecular Cloud that also includes the Great Nebula in Orion, M 42, and the Horsehead Nebula. The semi-circular arc with a radius of 6.5° is considered to be the shockwave front of an ancient supernova explosion that occurred about two million years ago, and lies at a distance of approximately 1,600 light years.

The nebula was named after E.E. Barnard who discovered it during a photographic survey of the Milky Way using the 40 inch Yerkes Observatory refractor in 1895. Along with Max Wolf he revealed that the dark areas along the Milky Way weren't rifts in the stellar clouds as was previously thought, but actual opaque nebulae that blotted out the background stars.

Imaging

In order to do this target justice you need a field of about $18^\circ \times 14^\circ$, which requires about a 60 mm camera lens. The whole region inside the arc is full of intricate folds of nebulosity and therefore the more exposures taken the greater the depth of detail revealed. Using a DSLR or OSC will bring out some of this nebulosity, but with a monochrome CCD extra H-alpha exposures can be taken and added to the RGB, as is the case with Fig. 1.1. A larger field of view, using a wide angle lens, will enable the Lambda Orionis Nebula (Sharpless 264), north of the celestial equator, to be captured too.



Fig. 1.1 Barnard's loop (south is up).

Technical Information – Fig. 1.1

Camera Lens:	Canon 18–55 mm at 55 mm
F-stop:	f/5.5
Camera:	QSI 683wsg Mono
Exposures:	6 × 5 min R
	6 × 5 min G
	6 × 5 min B
	11 × 15 min H-alpha (blended with the Red)
	(All unbinned)
Field Size:	18° × 14°

Great Orion Nebula — M 42 & 43 (NGC 1976)

Constellation	Orion
RA	5 h 35 min 00 s
Dec	−05° 25′ 00″

Possibly the Great Nebula in Orion is the most well known deep-sky object in the sky. It's certainly one of the easiest to find, being situated in the middle of Orion's sword. Even 7×50 binoculars show the nebulous shape well. Medium sized telescopes (8" aperture and above) start to show the strong color gradients in different parts of the nebula. The vivid wings display a cool blue/grey color whilst the center of the bowl, created by the stellar winds of the brilliant stars near the Trapezium, shows a delicate salmon pink coloration to those with good color acuity. The nebula was the first of its kind to be photographed by Henry Draper in 1883, and has since been the benchmark by which any would-be astroimagers measure their progress. The color and dynamic range make the Great Nebula a challenging but always rewarding subject.

Earlier film emulsions showed the brilliant crater hewn out by the energetic young stars being created (approx. 40,000 years old) as something in apparent isolation. As can be seen in the wide field image (Fig. 1.2, top image) and in the wider shot of Barnard's Loop (Fig. 1.1), M 42 is set in a deeply rich nebulous field that makes up the Orion Molecular Cloud. The Orion Nebula lies at approximately 1,340 light years away and covers an area of $65' \times 60'$.

Imaging

There are countless different ways to approach the imaging of this object and due to its popularity it is worth searching the internet for ideas that suit your particular imaging set-up and environmental conditions. It suits any focal length, from a 100 mm camera lens to a 3,000 mm plus scope. The top image in Fig. 1.2 was taken at 446 mm whereas the bottom one was taken at 2,010 mm. A field size of approximately $2.0^\circ \times 1.5^\circ$ will provide adequate space for the main Orion Nebula and the nearby Running Man Nebula (Fig. 1.5). However, a much smaller field size, of less than $30' \times 20'$ is excellent to show the detail around the Trapezium (Fig. 1.2, bottom image).

Due to the extensive dynamic range of the object it is very easy to burn out the core around the Trapezium. It is therefore worth taking a set of short exposures that don't saturate the core (e.g. 30 secs) and then progressively longer ones, which can then be combined during processing.

This object is particularly suitable for narrowband imaging, as it is bright and the narrowband filters help to prevent the central core from saturating. Hybrid HaRGB can be successful as can full narrowband images. Both of the images in Fig. 1.2 were taken solely with narrowband filters. In the bottom one the Trapezium is very evident. If narrowband filters are being used it is a great object to save until a night of bright Moonlight.



Fig. 1.2 Orion Nebula.

Technical Information – Fig. 1.2 top image

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	8 × 20 min H-alpha; 6 × 20 min OIII; 4 × 20 min H-beta Layered with (in order to restore the core): 4 × 2 min H-alpha; 4 × 2 min OIII; 4 × 2 min H-beta (All unbinned)
Field Size:	2.1° × 1.7°

Technical Information – Fig. 1.2 bottom image

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QHY9 Mono
Exposures:	7 × 20 min H-alpha; 7 × 20 min OIII; 5 × 15 min H-beta Layered with (in order to restore core): 4 × 2 min H-alpha; 4 × 2 min OIII; 4 × 2 min H-beta (All unbinned)
Field Size:	25' × 20'

Horsehead and Flame Nebulae — IC 434 (Barnard 33) and NGC 2024

Constellation	Orion
RA	5 h 40 min 40s
Dec	−02° 27′ 00″

A contender for being the most famous dark nebula in the sky, the Horsehead Nebula was first seen by Williamina Fleming from a photograph that she took at the Harvard Observatory in 1888. The Horsehead is seen as a dark extrusion like a surf board jutting out from the crest of the wave crashing into the nebulosity lit up by Sigma Orionis.

Despite its obvious nature when imaged, the Horsehead is a very difficult object to observe through a telescope. It requires a sufficiently wide field to give the dark nebula enough room to stand out against the faint background, yet not so wide as to have any influence spoiling the view from nearby fourth magnitude Alnitak. An 8" aperture without a filter will show the Horsehead as an indent into the faint emission nebula in the background. Observers will notice the apparent lack of stars below the Horsehead compared to the other south-western side. Larger apertures and an H-beta filter improve the contrast.

Imaging

These objects can be framed in many different ways using any set-up. DSLR and OSC can produce outstanding results. The one difficult aspect of imaging these objects is dealing with the presence of Alnitak, which easily saturates and can cause serious internal reflections. If the Horsehead itself is all that is desired, then imaging with a long focal length that provides a small field of view will keep Alnitak out of the image – a field of less than about $50' \times 30'$ is ideal for this (see Fig. 1.4). If, however, a wider field image is desired that includes both the Horsehead and the Flame Nebula then this star can be a real nuisance. A lot of short exposures will help to keep it from saturating. Fig. 1.3 is taken using narrowband filters so Alnitak is brought under reasonable control even with 10 min exposures. It is well worth using an H-beta filter here because there is far more H-beta emitted than OIII. A hybrid narrowband and RGB is also worth considering.

Technical Information – Fig. 1.3

Telescope:	TS 80 mm Super Apo Refractor with 0.8× flattener/reducer
Focal Length:	380 mm
F-ratio:	f/4.8
Camera:	QSI 683wsg
Exposures:	13 × 10 min H-alpha 7 × 10 min OIII 7 × 10 min H-beta (All unbinned)
Field Size:	2.6° × 1.7°

Technical Information – Fig. 1.4

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI683wsg Mono
Exposures:	14 × 5 min L 6 × 5 min R 6 × 5 min G 6 × 5 min B (All unbinned)
Field Size:	25' × 19'

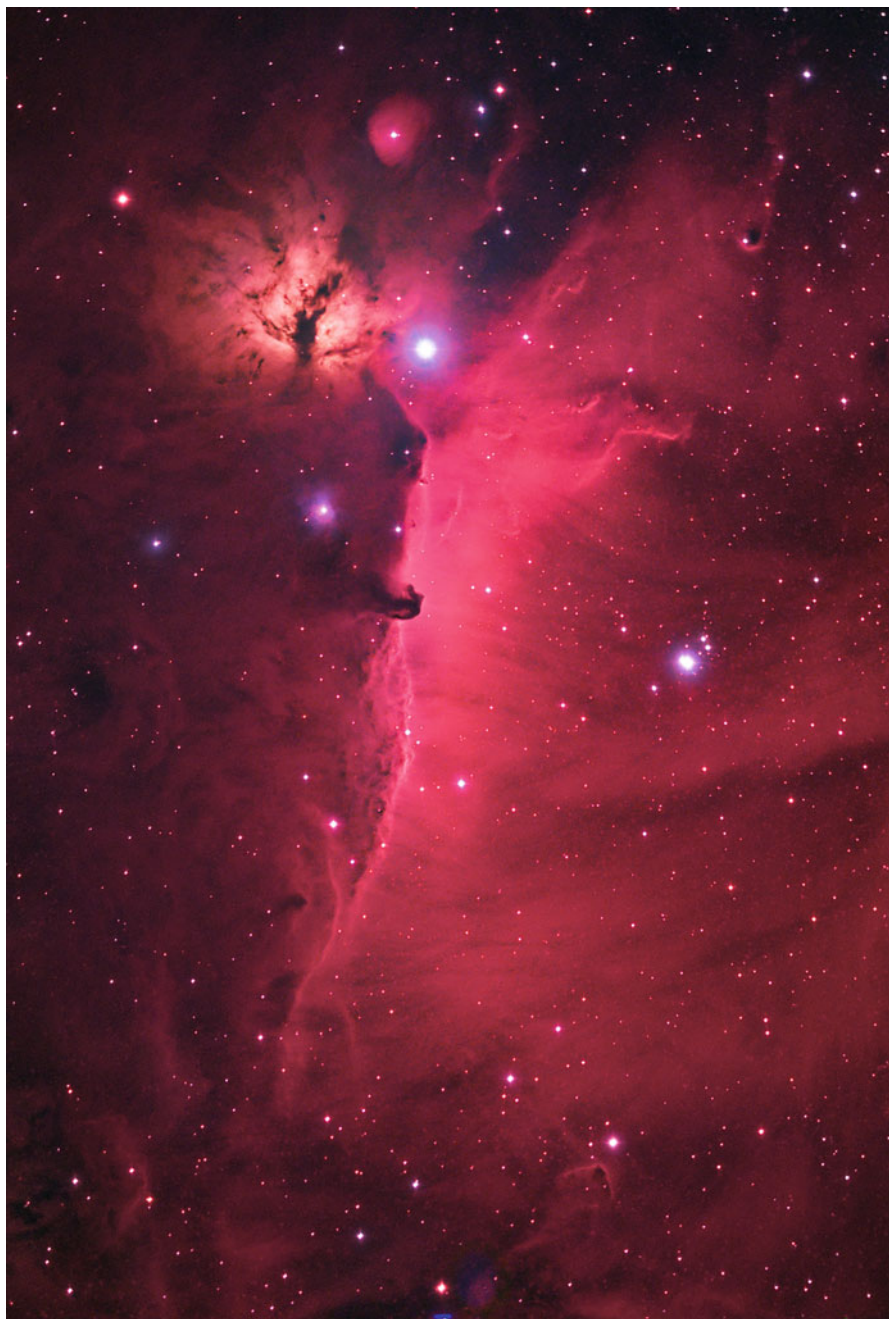


Fig. 1.3 Horsehead and Flame Nebulae (north is top left).



Fig. 1.4 Horsehead Nebula.

Running Man Nebula — NGC 1973-5-7

Constellation	Orion
RA	5 h 35 min 18 s
Dec	04° 49′ 00″

Often overshadowed by its more illustrious neighbor M 42, the Running Man Nebula is a great example of a combination emission and reflection nebula. One assumes that the Running Man is the dark feature in the middle with loping arms and legs. Some see this figure more as someone dressed in a ghostly cloak with draping arms.

The brilliant blue/white stars immersed in the nebula add to the setting of the field. The nebulosity covers 40' × 30', and lies about 1,500 light years distant.

Imaging

The Running Man Nebula is a beautiful object to frame separately from the wider Orion Molecular Cloud. Any camera will be able to produce effective results as it is a fairly bright object. However, due to the dazzling stars in the field, exposure times must be kept short to avoid saturation. Narrowband imaging is pointless because it will not capture the blue reflection nebulosity. However, collecting some H-alpha data and combining it with the red channel may help to highlight the Running Man.

A field of about 40' × 30' is ideal for this object, but a field up to 70' × 40' is also excellent as it will enable some of the surrounding red emission nebulosity to enter the frame. However, you don't want a huge field otherwise the Running Man will be overwhelmed by the presence of the Orion Nebula (as in the top image of Fig. 1.2).

Technical Information – Fig. 1.5

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QHY9 Mono
Exposures:	15 × 5 min L
	8 × 5 min R
	8 × 5 min G
	8 × 5 min B
	(All unbinned)
Field Size:	32' × 25'



Fig. 1.5 Running Man Nebula.



Fig. 1.6 M 79.

M 79 — NGC 1904

Constellation	Lepus
RA	5 h 24 min 11 s
Dec	-24° 31' 27"

In an area seemingly devoid of globular clusters, this is the best example. Covering nearly 9' and shining at magnitude 7.8, M 79 is a nicely resolved globular, even in small telescopes. Evenly bright across the core, there are several star chains that radiate away from the central mass in a spidery fashion.

Lying at a distance of 41,000 light years there is a belief that M 79 is an extra-galactic interloper, and may belong to the Canis Majoris Dwarf Galaxy, currently interacting with the Milky Way.

Imaging

M 79 is a small target, and is best captured in a field size of less than 30' × 30' and thus requires a long focal length. As with all globular clusters it should only be attempted on nights of good seeing. RGB is all that is required if using a monochrome CCD camera.

Technical Information – Fig. 1.6

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	5 × 5 min R 5 × 5 min G 5 × 5 min B (All unbinned)
Field Size:	17' × 13'

Witch Head Nebula — IC 2118

Constellation	Eridanus
RA	5 h 04 min 46 s
Dec	−07° 13′ 00″

The instantly recognizable form of the Witch Head Nebula is quite a large object to observe in moderate telescopes. It needs a telescope's widest field to show it well as it covers $3^\circ \times 1^\circ$. The light from the brilliant nearby blue/white giant star Rigel, Beta Orionis, makes what is believed to be an ancient supernova remnant (SNR) shine with a cold, blue glow. The nebula lies at about 900 light years. A clear, transparent sky in a rural location will give the best chance for viewing. Moving the telescope in a sweeping motion will enable the eye to notice the full extensions of the Witch Head, remembering to keep brilliant Rigel out of the field.

Imaging

A field of at least $2.1^\circ \times 1.7^\circ$ is required in order to satisfactorily frame this object. Thus a short focal length scope or a camera lens is ideal. There is actually more nebulosity to be imaged outside the frame of Fig. 1.7. However, imaging with a larger field of view can cause problems. The bright star Rigel is just out of this field of view and can produce problems due to internal reflections. If the field of view is any larger than shown in Fig. 1.7 then it might be necessary to image the nebula off-center, keeping Rigel out of the field, and then cropping where appropriate later. If reflections from Rigel are found to be a problem then exposures must be kept short.



Fig. 1.7 Witch Head Nebula (south is up).

Technical Information – Fig. 1.7

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	12 × 5 min L
	6 × 5 min R
	6 × 5 min G
	6 × 5 min B
	(All unbinned)
Field Size:	2.3° × 1.6°

Thor's Helmet — NGC 2359 (Gum 4)

Constellation	Canis Major
RA	7 h 18 min 31 s
Dec	−13° 14' 00"

Thor's Helmet is an emission nebula with a difference. Embedded in the nebulosity is a Wolf-Rayet star, i.e. one in the throes of becoming a supernova. The intricate bubble at the center of the complex is where the supernova progenitor lies. The strong oxygen component of the nebulosity responds well for larger apertures armed with an OIII filter. The helmet and its wings stand out well with this combination.

At a distance of 15,000 light years Thor's Helmet covers $25' \times 15'$ in astroim-ages, but only $9' \times 6'$ visually.

Imaging

This object is suited to DSLR and OSC as it is bright and colorful. The more data that is gathered the better as the whole object covers far more than just the helmet and wings. However, the helmet and wings make a nice image alone and so a smaller field of view – about $20' \times 20'$ – is also suitable for this object. It is particularly suited to narrowband imaging due to the high level of OIII present. The object is not, however, really suited to an HaRGB hybrid because the H-alpha will overpower the strength of the OIII in the blue/green channels.



Fig. 1.8 Thor's Helmet (north is left).

Technical Information – Fig. 1.8

Telescope:	7" Intes-Micro Mak-Cass with 0.67× reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 20 min H-alpha
	7 × 20 min OIII
	4 × 20 min H-beta
	(All unbinned)
Field Size:	40' × 27'

Chapter Two



Vast Explosive Remnants

Puppis
Vela

This chapter focuses on a part of the Milky Way that appears to have been ripped apart visually! A jagged dark-lane referred to as the Rift seems to split the Milky Way just west of the False Cross.

In the 1950s Australian astronomer Colin S. Gum began a photographic survey of the southern Milky Way in black and white using a hydrogen alpha filter at Mt. Stromlo Observatory. Amongst his many discoveries the most famous was the one that still bears his name, the Gum Nebula.

The Gum Nebula turned out to be just the first of several supernova remnants (SNRs) in this region that Colin Gum discovered in this fashion. The now equally famous Vela SNR sits in the background but steals the show with its intricate detail. The Gum Catalogue of objects contains many of his discoveries.

This area of star death still has enough star birth activity going on to balance the feel of it all. The emission nebulae and young clusters are the beneficiaries of all the heavy elements created in the supernova explosions of the past that we see spreading out into the interstellar medium, creating the beautiful shockwaves and filaments seen in the images within this chapter.

Due to the high levels of both H-alpha and OIII, these objects all respond well to narrowband imaging or hybridizing RGB with narrowband data.

Gum Nebula — Gum 12

Constellation	Vela/Puppis
RA	08 h 04 min 03 s
Dec	−40° 02′ 29″

The Gum Nebula refers to the largest single entity available photographically in the entire sky. It could be argued that the Milky Way fits that bill, but there is nowhere on Earth that it is possible to get the entire Milky Way into a field of view at any one time.

Covering an area of $35^\circ \times 25^\circ$ a standard wide angle lensed DSLR will readily reveal the faint oval nature of the Gum Nebula as it extends on both sides of the galactic plane. The Gum Nebula is believed to be the supernova remnant (SNR) of a spectacular explosion that occurred 2.6 million years ago! It is so vast that we are only 450 light years away from its front edge but over 1,500 light years from its back edge.

Imaging

Due to its immense size, this object can only be captured in its entirety using a camera lens. The nebulosity actually stretches nearly as far as Canopus, the bright star at the top of Fig. 2.1. This image was taken with an 18 mm lens orientated perpendicular to the plane of the Milky Way. Due to its low surface brightness, and the fact that much of it is in the plane of the Milky Way it is actually quite difficult to prevent the faint nebulosity from being obscured by the galactic star fields. This is where a monochrome CCD camera is useful. If a sufficient number of H-alpha subs are taken (which suppress the intensity of the star light) and these are blended into the red channel of short exposure RGB subs then the nebulosity can be made to really stand out from the Milky Way.



Fig. 2.1 Gum Nebula (south-west is up).

Technical Information – Fig. 2.1

Camera Lens:	Canon 18–55 mm at 18 mm
F-stop:	f/4.5
Camera:	QSI 683wsg Mono
Exposures:	6 × 3 min R
	6 × 3 min G
	6 × 3 min B
	15 × 15 min H-alpha (blended with the red)
	(All unbinned)
Field Size:	50° × 40°

Gum 15 — RCW 32

Constellation	Vela
RA	8 h 44 min 54 s
Dec	−41° 17′ 11″

Gum 15 is a fine object in a moderate sized telescope. An ultra high contrast (UHC) filter brings out the dark-lane and the slightly irregular outline of an otherwise circular appearance.

Fig. 2.2 reveals the dark-lane well along with the bright, shockwave feature left of center, and there is a sense that this is another Triffid Nebula in the making. The sparse open cluster Cr 197 makes up most of the stars in the northern half of the nebula.

Imaging

Without the Gum or RCW catalogue available the above RA and Dec coordinates can be used to locate this object. Alternatively, aim for the open cluster NGC 2671 and slowly move the camera a few fields north. Due to its small size, Gum 15 is only really suited to a medium to long focal length telescope. This image was taken at 2,010 mm and would have benefited from a larger field of view. It is bright enough to be a good target for DSLR and OSC, although it would still require extensive exposure.

With a wider field, Gum 15 can be imaged along with the much larger Gum 14 (RCW 27) and the reflection nebula NGC 2626 which lie to the north-west. Alternatively, it could be imaged with Gum 17 and the open cluster NGC 2671 to the south-east.



Fig. 2.2 Gum 15 (north is left).

Technical Information – Fig. 2.2

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min L 8 × 5 min R 8 × 5 min G 8 × 5 min B (All unbinned)
Field Size:	46' × 36'

Gum 20 — RCW 36

Constellation	Vela
RA	8 h 59 min 21 s
Dec	−43° 44′ 10″

Gum 20 is a curious star forming nebula with brilliant young stars deeply embedded amongst the dark and light nebulosity. Despite its appearance in photographs it is still a very dim object even in large telescopes.

Imaging

When trying to frame Gum 20 look out for the four brighter patches (reminiscent of the Cat's Paw Nebula, Fig. 6.9) and bring them to the center of the field. Without the catalogues and with an inaccurate mount it might be difficult to locate this object. Moving from the star Lambda Velorum is an option. There is actually a substantial amount of extremely faint nebulosity surrounding Gum 20 that might be captured with very long exposure time. However, a more pleasing appearance is achieved without capturing this nebulosity or by reducing its prominence during processing.

A much larger field will capture Gum 20 along with the Spiral Flame Nebula (Fig. 2.11).



Fig. 2.3 Gum 20.

Technical Information – Fig. 2.3

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min L 7 × 5 min R 7 × 5 min G 7 × 5 min B (All unbinned)
Field Size:	35' × 26'

Vela Supernova Remnant

Constellation	Vela
RA	8 h 59 min 47.2 s
Dec	−47° 31′ 57″

The Vela SNR is a large, somewhat enticing object for large aperture telescope users and astroimagers alike. In area the Vela SNR covers thirty square degrees. This size makes it one of the largest single objects that an observer can view through a telescope. In saying that, it takes a large aperture telescope with an O-III filter on a dark, transparent night to see this complex at its best.

When you have seen the whole of the Vela SNR through a telescope you get the feeling of travelling along a road or highway, such is the vast size of this much extended object. The names of some of the features therefore reflect these engineering similarities. Crossing a ‘bridge’ here, taking the short-cut along the ‘bypass,’ a wrong turn up to a dead end on the ‘spur’ or climbing to the ‘crest’, a journey along this oxygen-filled road is one never to be forgotten.

The supernova explosion that has left us with these amazing features occurred between 11,000 and 12,300 years ago at a distance of 800 light years.

Imaging

The Vela SNR is an astroimager’s paradise. There are countless different areas to image of all field sizes.

Using a camera lens enables you to capture the entire object in one field. Fig. 2.4 was taken using an 80 mm camera lens. In it you can see most of the Vela SNR in the foreground, with its filaments of green and blue shock waves, superimposed upon the background Gum SNR – two colossal explosions in one small field of view!

When it comes to imaging at prime focus the world really is your oyster. The various parts of the Vela SNR suit the whole range of cameras, telescopes and imaging techniques. Parts of it are very bright so will show up well with OSC and DSLR. For the fainter wispy bits a monochrome CCD will gather the data much faster and probably result in a richer field.

While LRGB will yield great results the Vela SNR is a real treat for narrowband imaging. The use of an H-alpha filter really helps to pick up the fainter wisps but when used in conjunction with an OIII filter the effect is magical. The shockwaves from the explosion contain a lot of OIII so the mix of H-alpha and OIII produces a great criss-crossing effect of green, red and blue. Both LRGB and narrowband have been used in the images in this chapter.

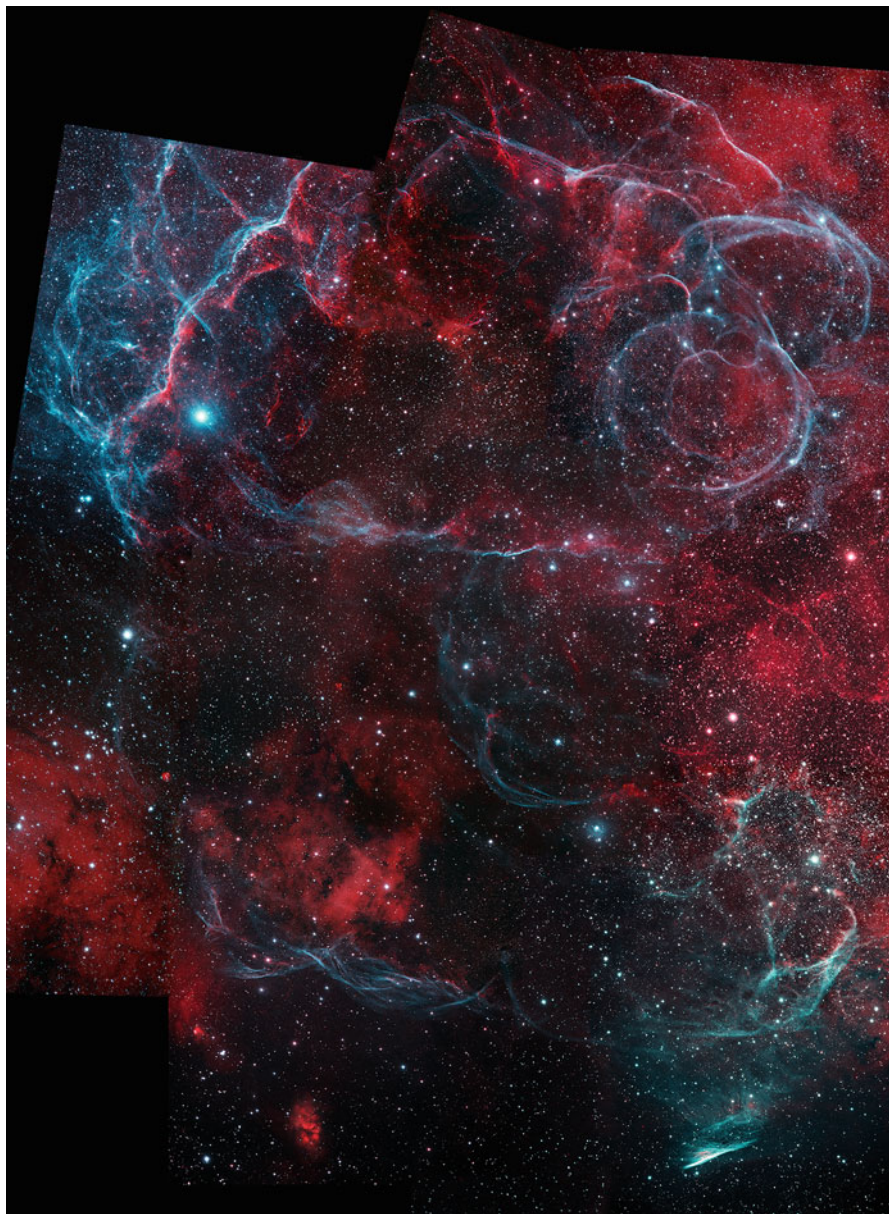


Fig. 2.4 Vela Supernova Remnant (north is left).

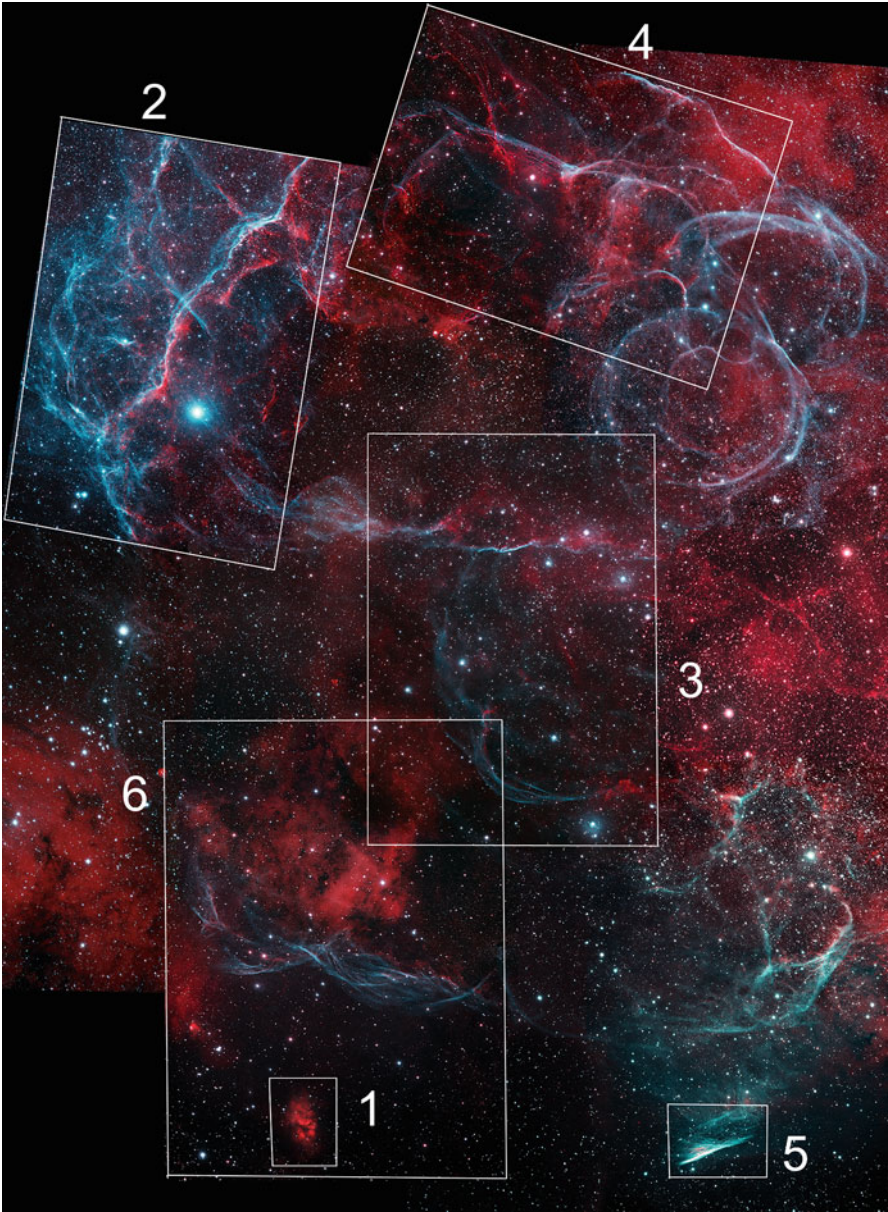


Fig. 2.5 Vela SNR reference chart.

Technical Information – Figs. 2.4 and 2.5

Camera Lens:	Canon 80 mm
F-stop:	f4.5
Camera:	QSI 683wsg Mono
Exposures:	6 × 3 min R
	6 × 3 min G
	6 × 3 min B
	15 × 15 min H-alpha (blended with the red)
	15 × 15 min OIII (blended with green and blue)
	(All unbinned)
Field Size:	6.4° × 4.9°

Vela SNR Reference Chart

There follows in this chapter a selection of fields from the Vela SNR. There are few specific catalogue numbers associated with the Vela SNR so you may have to rely on RA and Dec coordinates and a reliable star atlas/planetarium to find your way around. Fig. 2.5 shows where some of the fields in this chapter are in relation to each other. However, a lot of fun can be had choosing and composing your own unique fields that fit the particular telescope and camera that you have.

1. Gum 20 (Fig. 2.3)
2. Crest and the Bridge (Fig. 2.6)
3. Twin Crescents and the Bypass (Fig. 2.7)
4. Highway and the Spur (Fig. 2.8)
5. Pencil Nebula (Fig. 2.9)
6. Spiral Flame Nebula (Fig. 2.11)

Crest and the Bridge

Constellation	Vela
RA	8 h 37 min 38.6 s
Dec	-42° 59' 20.8"

The Crest comes from the region around the fourth magnitude star ϵ Velorum. Apart from the Pencil Nebula, (Fig. 2.9), this is the brightest section of the Vela SNR. In images with north at the top the highway appears to have reached a crest before turning north and then west to trail away in a plume-like spur. Back along the highway (top right corner in the image) we find a bright bifurcated section reminiscent of the symbol for a bridge in civil engineering drawings with a short spur line running underneath the bridge.

Imaging

This field is fairly easy to find due to the presence of the bright star ϵ Velorum (SAO 220204). The short tube refractor (446 mm) was used here in order to capture both the Crest and the Bridge. A longer focal length could be used if you wanted to just capture one or the other but the two combined make an impressive pair. The presence of ϵ Velorum can cause some trouble here as many of the filaments are very faint in comparison. So you might have to cut back on the exposure lengths to prevent saturation. To increase the intensity of the green/blue filaments a series of OIII subs can be taken and combined with the green and blue channel.

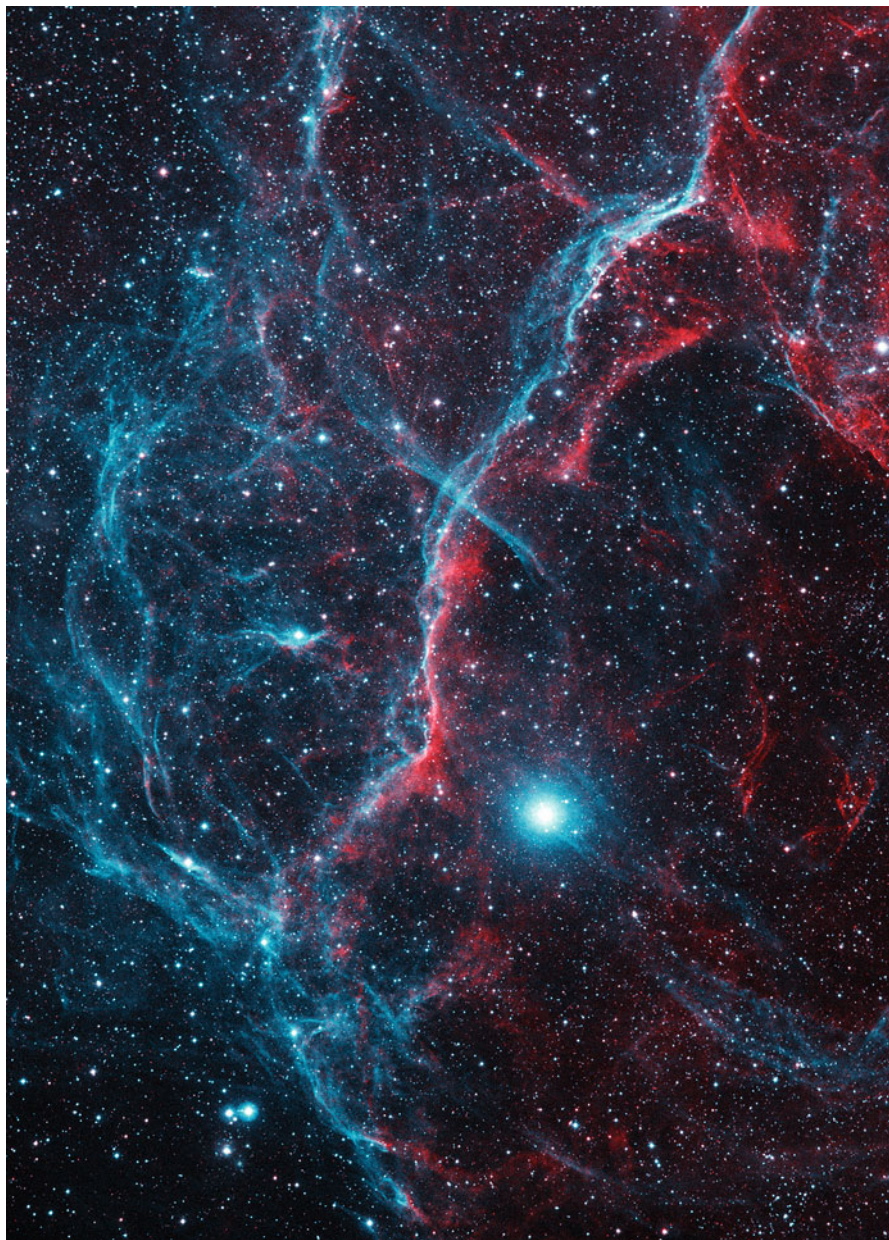


Fig. 2.6 Crest and the bridge (north is left).

Technical Information – Fig. 2.6

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	20 × 10 min L
	10 × 10 min R
	10 × 10 min G
	10 × 10 min B
	5 × 15 min OIII (blended with the green and blue)
	(All unbinned)
Field Size:	2.1° × 1.7°

Twin Crescents and the Bypass

Constellation	Vela
RA	8 h 44 min 0.37 s
Dec	−44° 56′ 19″

This pair of beautiful crescent-shaped shockwaves lies apart from the road network to the west but is well worth the detour to visit. The sparse open cluster NGC 2659 can be seen just above centre in the photo. Above that again is the north–south running section of the Highway we call the Bypass. The Bypass connects the southern section to the Crest and e Velorum.

In large amateur telescopes with a narrowband filter, the south-eastern crescent stands out the most. The north-western crescent is more diffuse. The most discrete part of the Bypass can be seen in this picture.

Imaging

In order to capture both of the interwoven crescents in one frame it is necessary to use a fairly short focal length. An identical set-up was used in Fig. 2.7 as with Fig. 2.6. This field is slightly more difficult to find as the filaments are fairly faint and there are few bright obvious stars. For those with accurate GOTOs the provided coordinates will situate you in the right area. It is then simply a case of choosing the best field that suits your set-up. However, if your mount is not particularly accurate you might have to star hop from the star g Velorum (SAO 220540).

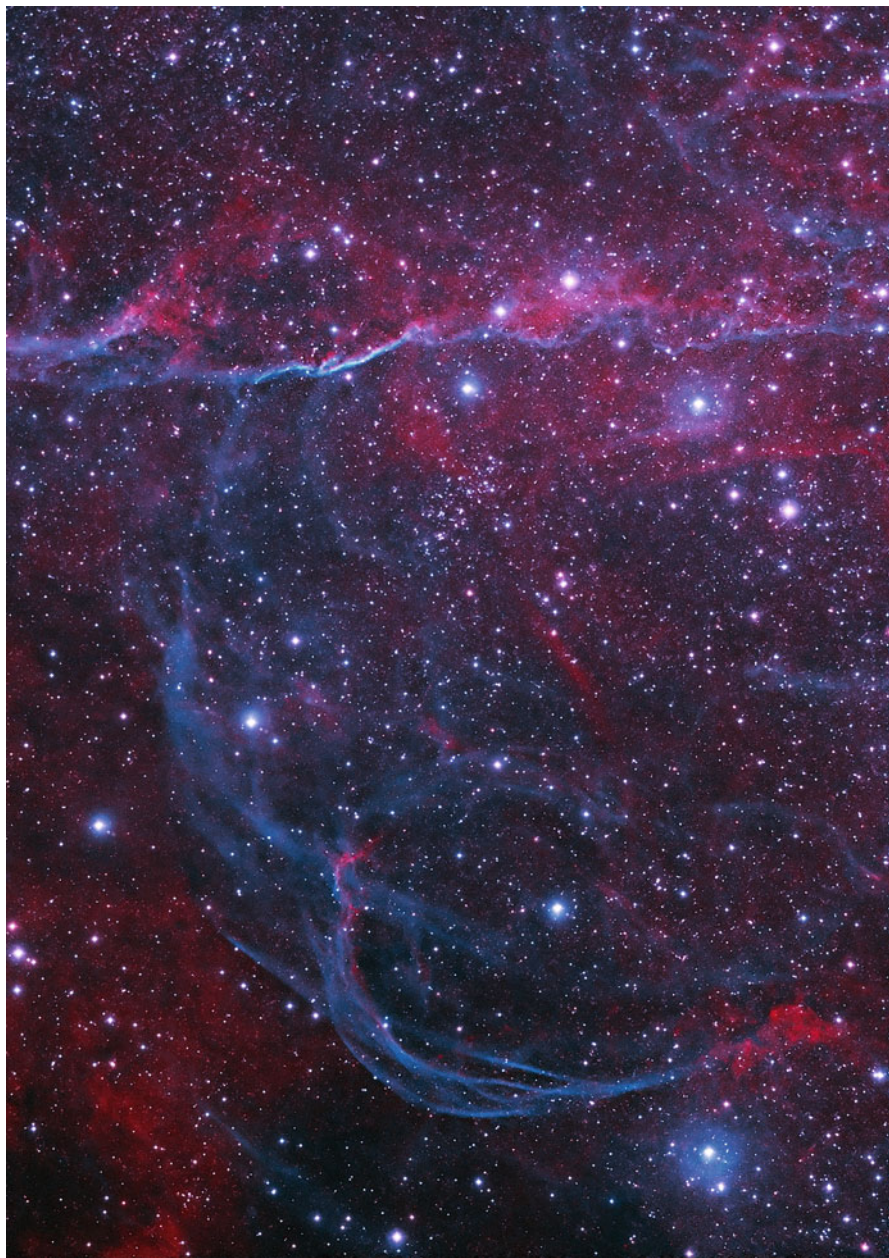


Fig. 2.7 Twin crescents and the bypass (north is left).

Technical Information – Fig. 2.7

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	25 × 10 min L 10 × 10 min R 10 × 10 min G 10 × 10 min B 5 × 15 min OIII (blended with the green and blue) (All unbinned)
Field Size:	2.1° × 1.7°

Highway and the Spur

Constellation	Vela
RA	8 h 30 min 0.0 s
Dec	-44° 58' 18"

Fig. 2.8 includes the field made famous by David Malin at the Anglo-Australian Observatory in the 1980s. The section of the Highway, next to SAO 219995 is one of the brightest visually and can be a good starting point for a grand tour of the Vela SNR itself. Further south (to the bottom in this image) we have the Fork, where the highway splits off to the incredibly thin Spur. The image shows the thread-like nature of the Spur very well. In the telescope with an OIII filter the discrete line of the Spur comes to an abrupt end.

Imaging

The Highway is the bright straight filaments in Fig. 2.8 running vertical so to do this field justice you really need to rotate your camera ninety degrees and image west-up. With a relatively accurate GOTO system this field is fairly easy to locate due to the presence of the star SAO 219995 right in the middle. However, if your mount is not as accurate you might have to star hop from ϵ velorum to SAO 219995. This field is probably the best one to choose if you are using a DSLR or OSC camera. While not bright, the filaments should show up clearly in these cameras. With a monochrome CCD camera remember to take extra exposures of OIII to help accentuate the supernova shockwaves.

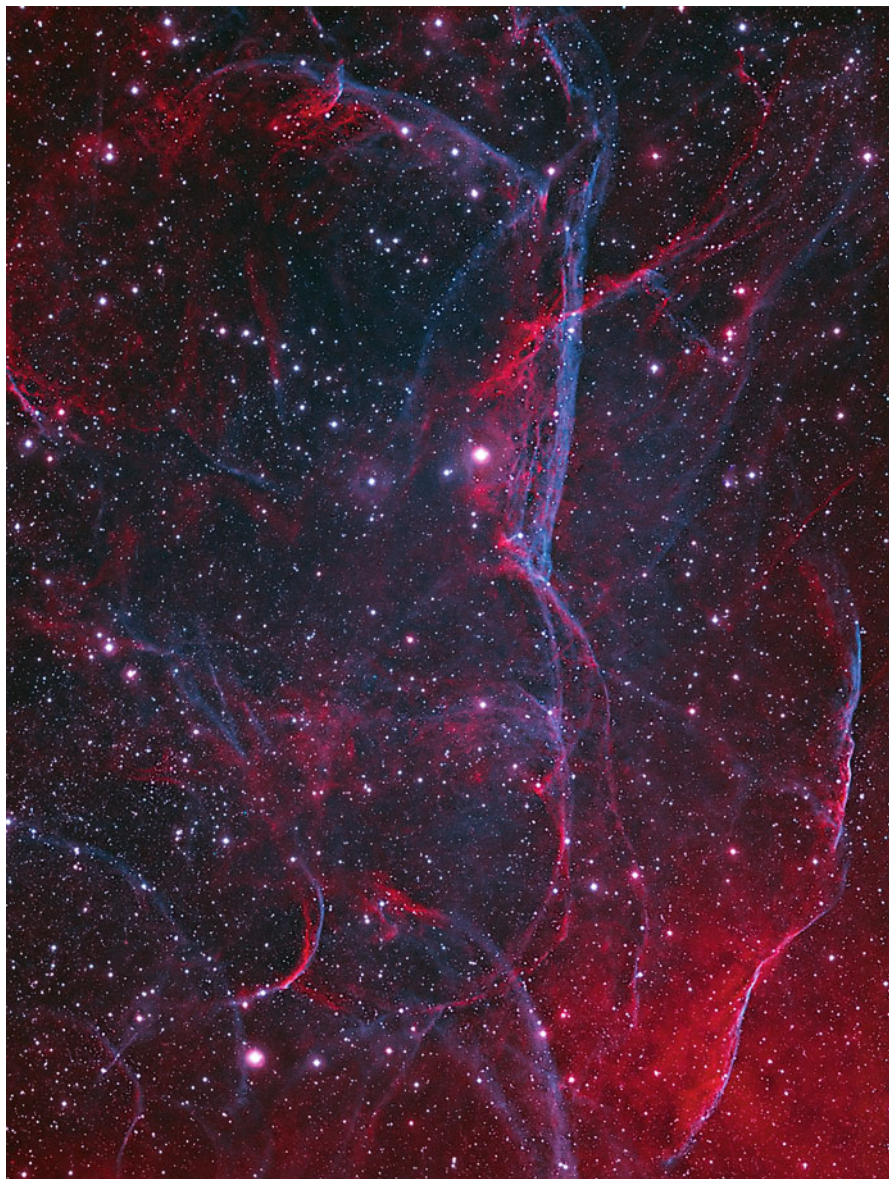


Fig. 2.8 Highway and the Spur.

Technical Information – Fig. 2.8

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	25 × 10 min L
	10 × 10 min R
	10 × 10 min G
	10 × 10 min B
	5 × 15 min OIII (blended with the green and blue)
	(All unbinned)
Field Size:	2.1° × 1.7°

Pencil Nebula — NGC 2736

Constellation	Vela
RA	9 h 00 min 0.0 s
Dec	−45° 56′ 30″

Discovered by Sir John Herschel during the early nineteenth century in his time at the Cape of Good Hope, South Africa, NGC 2736 is actually the brightest piece of the Vela SNR. Moderate sized amateur telescopes will pick it up, but like all sections of this vast complex a combination of non-light polluted skies, large aperture and a narrowband filter is best suited to showing these delicate threads properly.

The Pencil Nebula marks the eastern extremity of the Vela SNR and lies in a sparse field between ϵ Velorum and SAO 220664. Fig. 2.9 shows it to be more than just a straight line. The filamentary strands appear braided and about to twist ribbon-fashion like the Spiral Flame further north-west (Fig. 2.11).

Imaging

The Pencil Nebula is a different kettle of fish from the previous three images. It is only $20' \times 3'$ so requires a much longer focal length to do it justice. It is also a low contrast object so will require a fairly long exposure time to be effective. It emits very strongly in OIII hence the level of green in the image. It should be fairly easy to find as it has a designated catalogue number.

A wider field, of about $2^\circ \times 1^\circ$ will enable you to capture both the Pencil Nebula and another area of filaments, which is only 1° away to the south-west.



Fig. 2.9 Pencil Nebula (north is right).

Technical Information – Fig. 2.9

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 20 min H-alpha 7 × 20 min OIII 5 × 15 min H-beta (All unbinned)
Field Size:	27' × 19'

Gum 22–23 — RCW 38

Constellation	Vela
RA	8 h 59 min 47.2 s
Dec	−47° 31' 57"

Gum 22 and 23 are a slightly brighter group of nebulous patches in the telescope. The camera reveals them much better as a bright group on the edge of a large, homogenous red nebula. This too is a star-forming area with young stars deeply embedded in the nebulosity.

Fig. 2.10 shows parts of the Vela SNR quite obvious against the background of the much further away Gum SNR. The green shockwaves are from the Vela SNR and are amongst the furthest from the site of the original explosion.

Imaging

Gum 22 and 23 are actually just the part of this image towards the top left. There are therefore many different possibilities for framing these objects. Using a longer focal length will produce a pleasing result. However, in this image a much larger field of view was chosen in order to capture some of the shockwaves from the Vela SNR. It is unlikely that an OSC or DSLR will pick these shockwaves up so if using such a camera it may pay just to concentrate on Gum 22 and 23 rather than aiming for such a wide field. This image was taken using narrowband filters and this has helped to bring out the shockwaves which are rich in OIII.

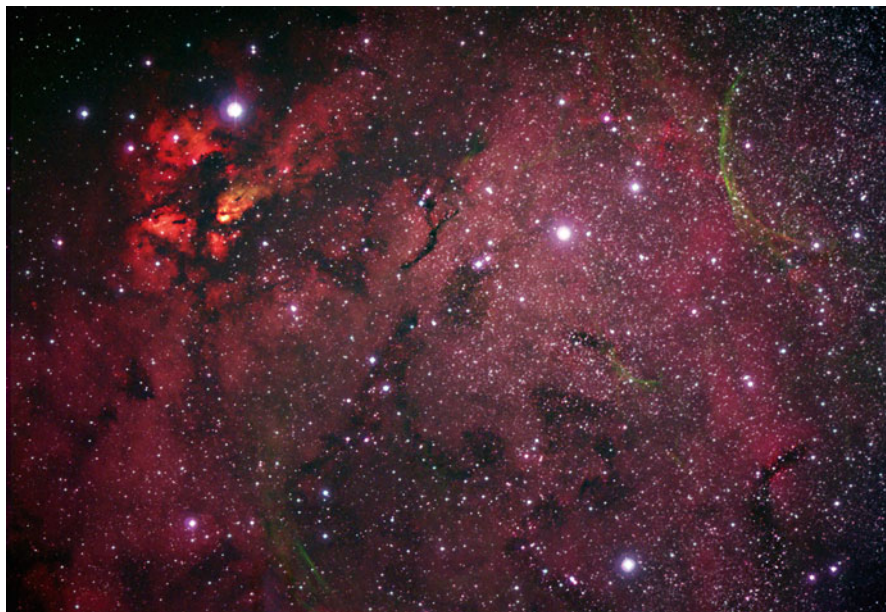


Fig. 2.10 Gum 22 and 23.

Technical Information – Fig. 2.10

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	9 × 20 min H-alpha 7 × 20 min OIII 5 × 10 min H-beta (All unbinned)
Field Size:	2.1° × 1.6°

Spiral Flame Nebula

Constellation	Vela
RA	8 h 54 min 21.0 s
Dec	−43° 50′ 43″

The last section of the amazing Vela SNR is the Spiral Flame Nebula. Fig. 2.11 reveals the helixial nature of this delicate, twisting series of filaments. The Spiral Flame is not bright and therefore is a challenge for the visual observer. Large aperture reflectors (upwards of 17.5") with narrow band filters and ideal conditions are required to get the best from this object.

The Spiral Flame Nebula finishes off the largest discernable object available to any visual telescopes. In an area covering $8.7^\circ \times 5.4^\circ$ we have examined a variety of forms brought about by a catastrophic event approximately 11,000 years ago from our own backyard!

Imaging

The Spiral Flame Nebula can be a challenge to frame satisfactorily. The most prominent part of Fig. 2.11 is actually Gum 20 (Fig. 2.3), the separate nebula towards the bottom of the image. Once this is in the field of view it is a matter of exposing until the faint wisps of filaments appear and then centering the object as desired. The turquoise flame actually carries on further south for a few more minutes so another pleasing orientation is to rotate the camera 90° to capture the full length of the flame. Capturing some OIII subs will help to bring out the flame when processing exposures.



Fig. 2.11 Spiral Flame Nebula (north is left).

Technical Information – Fig. 2.11

Telescope:	TS Super Apo Refractor with 0.8× flattener/reducer
Focal Length:	380 mm
F-ratio:	f/4.8
Camera:	QSI 683wsg Mono
Exposures:	20 × 10 min L
	10 × 10 min R
	10 × 10 min G
	10 × 10 min B
	5 × 15 min OIII (blended with the green and blue)
	(All unbinned)
Field Size:	2.5° × 2°

Chapter Three



The Ship of Argo

Carina
Centaurus
Puppis
Vela

The ancient constellation of Argo Navis, the Ship of Argo, was split up by astronomers at the end of the nineteenth century into Puppis, the Poop Deck, Vela, the Sail, and Carina, the Keel. These three constellations straddle a very rich piece of the Milky Way.

This section of the Milky Way is where things become bright. Very bright! For a start we have the sky's second brightest star Canopus sitting off to the south side as a marker for the whole region. The bright band of second magnitude stars that are a part of Gould's Belt continue through here and include the familiar southern asterisms the False and Diamond Crosses.

This area of the Milky Way is an astroimager's treasure trove, littered with objects of all kinds, sizes, and magnitudes. There is something for everyone here. It contains arguably the most famous and brightest emission nebula in the sky – the Eta Carinae Nebula. At the other extreme there are tiny, brightly colored planetary nebulae to delight the imager. Add to this the spectacular globular and open clusters, especially the huge naked-eye clusters that require very wide fields of view, and the astroimager is kept very busy whilst the Ship of Argo sails overhead.

NGC 2467

Constellation	Puppis
RA	7 h 52 min 30 s
Dec	-26° 24' 00"

This emission nebula is a true birth place of stars. In the bright red oval nebula just left of center, an embryonic star is emerging from its cocoon. Hidden behind the branches of dark-lanes crossing the face of the nebula are possibly more young stars being born.

This is a fairly bright nebula at photographic magnitude of 7.1 spread over an area of more than 25', though small telescopes show an area of only 4' × 3'. The nebula lies at 17,000 light years from Earth.

Imaging

Whilst this is an excellent object for all cameras, a DSLR might struggle to capture the fainter areas. If this is the case then a smaller field of view, about 25' × 20', could be used in order to concentrate on the area towards the top of this image. If extensive exposure is undertaken it is a good idea to consider imaging with a wider field – up to 2° × 1°. This will place the object in the context of the rich star field in which it is found. Due to the abundance of both H-alpha and OIII in the object it is a great choice for narrowband imaging.

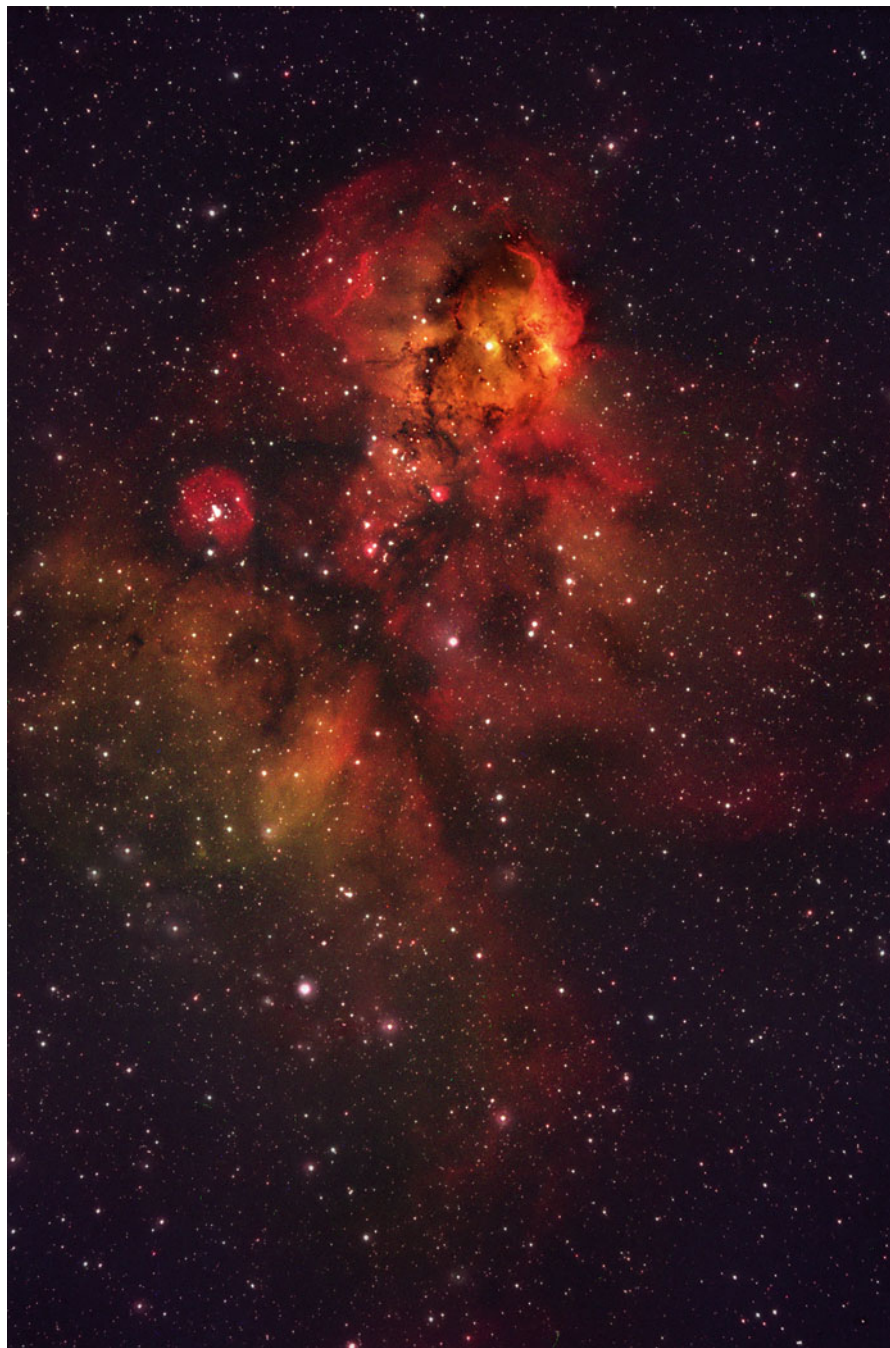


Fig. 3.1 NGC 2467 (north is left).

Technical Information – Fig. 3.1

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	6 × 20 min H-alpha
	6 × 20 min OIII
	3 × 20 min H-beta
	(All unbinned)
Field Size:	45' × 30'

NGC 3766

Constellation	Centaurus
RA	11 h 36 min 18 s
Dec	-61° 37' 00"

Lying at the eastern end of the Ship of Argo in Centaurus, NGC 3766 is a beautiful conglomeration of brilliant blue/white stars. Thrown into the mix are two red giants that offer fine color contrast to this dazzling cluster.

About 130 stars fill an area of about 15' and shine at magnitude 5.3, making this cluster just visible to the naked eye as a fuzzy spot. The cluster sits at 5,500 light years from us.

Imaging

This is a straightforward object to image, suited to all cameras. Due to its high magnitude it only requires short exposures so is a good target for light polluted skies even without a filter. A field size of at least 45' × 30' is required to frame the object effectively. A wider field can also be used but note that anything larger than 1.5° × 1.0° will make the colorful cluster begin to lose its impact.

Technical Information – Fig. 3.2

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 3 min R
	8 × 3 min G
	8 × 3 min B
	(All unbinned)
Field Size:	45' × 30'



Fig. 3.2 NGC 3766.



Fig. 3.3 NGC 3201.

NGC 3201

Constellation	Vela
RA	10 h 17 min 36 s
Dec	−46° 25′ 00″

Like a smaller version of Omega Centauri in appearance, this rich, evenly luminous globular cluster covers 20' and shines at magnitude 6.9. This cluster is slightly less condensed than the famous Omega Centauri though it is a Class X compared to the latter's Class VIII.

NGC 3201 lies at the relatively close distance of 15,000 light years.

Imaging

A glorious object suited to any camera although for good image scale a field of view no larger than about 1° × 1° is required. Keeping exposures short will ensure that the core does not burn out. However, if the core does burn out before the fainter stars have registered then it might be worth collecting some longer exposures and also a set of short exposures and then layer them together. Saturation must be avoided as there is great color contrast in the stars in this region. Acquiring luminance data is unnecessary due to the object's brightness.

Technical Information – Fig. 3.3

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 2 min R 7 × 2 min G 7 × 2 min B (All unbinned)
Field Size:	26' × 20'

Flying Jaw Nebula — NGC 2899

Constellation	Vela
RA	9 h 27 min 06 s
Dec	−56° 06′ 00″

Situated near the top of the False Cross in rich Milky Way fields, the Flying Jaw Nebula is well worth hunting down with moderate to large apertures at high powers. The gaping jaw-like feature is very evident from 150× upwards even without filters. For a planetary this one is a good size at 117″. At only magnitude 11.8, however, the surface brightness is not brilliant. The Flying Jaw resides at 6,500 light years away.

Imaging

Even though in comparison to other planetaries in this book it is fairly large, it still requires the longest focal length that conditions will allow for in order for any detail to be attained. This means it should only be attempted on nights of exceptional seeing, and if the mount can provide excellent guiding. If the smallest field size that can be achieved with a scope/camera combination is much larger than 30′ × 20′ then another target is perhaps a better option. Whilst this is an excellent choice for color cameras and LRGB, narrowband imaging will also produce good results.

Technical Information – Fig. 3.4

Telescope:	10″ Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	11 × 3 min L 5 × 3 min R 5 × 3 min G 5 × 3 min B (All unbinned)
Field Size:	7.2′ × 6.1′



Fig. 3.4 Flying Jaw Nebula.



Fig. 3.5 Eight Burst Nebula.



Fig. 3.6 Toby Jug Nebula (north is left).

Eight Burst Nebula — NGC 3132

Constellation	Vela
RA	10 h 07 min 00 s
Dec	−40° 26′ 00″

Statistically the Eight Burst Nebula is almost a twin of perhaps the most famous planetary nebula in the sky, the Ring Nebula, M 57 in Lyra. Covering 88" and shining at magnitude 8.2 you would expect this object to be better known, especially in the southern hemisphere. Whereas the Ring Nebula sits halfway between two bright stars making it very easy to find, the Eight Burst is situated in a nondescript part of the sky lacking bright stars to make star-hopping an easy option. GOTO telescopes certainly earn their keep here.

So bright that it doesn't need a filter or large aperture to be seen well, the bright oval ring is easily resolved at 150 powers. The bright star at the center is not the true central star. The term 'Eight Burst' comes from the apparent number of shells cast off the central star. NGC 3132 lies at a distance of only 2,000 light years.

Imaging

Due to its high magnitude this is an excellent target for all cameras. It requires a long focal length and exceptional seeing conditions if any detail is to be revealed. If the smallest field size that can be achieved with a scope/camera combination is much larger than 30' × 20' then another target is perhaps a better choice. Although the main structure of the nebula is bright, the outer shells are quite faint and so will require deeper exposing to capture them. This is a great object for a Moonlit night using narrowband filters.

Technical Information – Fig. 3.5

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 5 min L 3 × 5 min R 3 × 5 min G 3 × 5 min B (All unbinned)
Field Size:	7.7' × 6.2'

Toby Jug Nebula — IC 2220

Constellation	Carina
RA	7 h 56 min 48 s
Dec	−59° 08′ 00″

Not many deep-sky objects show their true colors so readily as the Toby Jug Nebula. This reflection nebula surrounds the bright orange star HR 65750. The dust that we see is believed to be the outflow of HR 65750 with that dust reflecting the stars’ color. This bright orange stands out in the field and is easy to see in modest apertures.

The nebula is not only bipolar but also biconical in nature. The Toby Jug lies at 300 light years from us.

Imaging

One of the most beautiful objects in the sky, the Toby Jug is bright and a great target for all cameras. Excellent seeing will enable more detail to be resolved in the core. In order to achieve a rich yellow color you might like to consider collecting some extra color subs. A field size of about 30′ × 15′ is perfect for this object although, due to its distinctive color, it will still look appealing in a wider field of view. As it is a reflection nebula it is not suitable for narrowband imaging.

Technical Information – Fig. 3.6

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	11 × 5 min L 6 × 5 min R 6 × 5 min G 6 × 5 min B (All unbinned)
Field Size:	13.9′ × 12.2′

NGC 2808

Constellation	Carina
RA	9 h 12 min 0 s
Dec	-64° 52' 00"

The Ship of Argo has only two globular clusters of significance. The beautiful cluster NGC 2808 sits in between the False Cross and the Diamond Cross.

A stunning sight even in the smallest of apertures, NGC 2808 turns out to be an unusual cluster. It has long been believed that there could only ever be one population of stars in a globular cluster, i.e. that the stars were all formed at the same time. Studies over the past decade show however that NGC 2808 has three generations. One theory has it that the gravitational influence of the cluster had bound enough of the original nebulosity to enable two more star forming periods since the cluster's birth. Another view is that once again we are seeing the remains of a dwarf galaxy swallowed up by the Milky Way! It has an age of 12.5 billion years.

This massive cluster lies at a distance of 31,300 light years and contains over 1,000,000 stars!

Imaging

A glorious object suited to any camera although for good image scale a field of view no larger than about $1^{\circ} \times 1^{\circ}$ is required. Keeping exposures short will ensure that the core does not burn out. However, if the core does burn out before the fainter stars have registered then it might be worth collecting some longer exposures and also a set of short exposures and then layer them together. Saturation must be avoided as there is great color contrast in the stars in this region. Acquiring luminance data is unnecessary due to the object's brightness.

Technical Information – Fig. 3.7

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 2 min R 7 × 2 min G 7 × 2 min B (All unbinned)
Field Size:	35' × 28'



Fig. 3.7 NGC 2808.



Fig. 3.8 M 93.

M 93 — NGC 2447

Constellation	Puppis
RA	7 h 44 min 36 s
Dec	−23° 52′ 00″

A medium sized galactic cluster at 22' across. The cluster is full of eighth magnitude stars that are easily resolved in small telescopes. The whole cluster shines at magnitude 6.2. This cluster is part of a busy region of Puppis that includes NGC 2467 and lies at around 3,500 light years from us.

Imaging

M 93 is a great target for all cameras. Keep exposures short to maintain star coloration. It is a small cluster so requires a field size of less than 1° × 1° in order to get the best out of it. This is a good target for the end of an imaging session or for gaps between banks of clouds.

Technical Information – Fig. 3.8

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 3 min R 8 × 3 min G 8 × 3 min B (All unbinned)
Field Size:	27' × 21'

The Sprinter — NGC 2516

Constellation	Carina
RA	7 h 58 min 0 s
Dec	−60° 45′ 00″

This huge naked eye cluster is one of the treasures of the southern sky. Situated well off the plane of the Milky Way, at the base of the long axis of the False Cross, the Sprinter is easily seen as a fuzzy patch to the unaided eye, and resolved into stars with binoculars.

Through any telescope with south at the top, and a low magnification, the cluster is revealed to be a conglomeration of bright white stars around the head and shoulders of the Sprinter. From the shoulders looping chains of stars delineate the strident arms, and from the lower torso we can see the legs akimbo replete with a pair of golden running shoes made of red giant stars! There is a gold medal on the chest of the Sprinter as well.

NGC 2516 sits at 1,300 light years from Earth.

Imaging

A beautiful cluster comprising very bright stars. It is most important here to avoid saturating any of the stars, otherwise the distinctive colors will not be present in the final image. It is an excellent target for any camera/scope combination that provides a field of at least 40′ × 30′. As short exposures are required it is a good object to leave for nights of intermittent cloud. If a scope/camera combination provides a field size of about 2.5° × 1.5° an image can be framed which includes both the Sprinter and the Toby Jug Nebula (Fig. 3.6).

Technical Information – Fig. 3.9

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	5 × 2 min R 5 × 2 min G 5 × 2 min B (All unbinned)
Field Size:	42′ × 33′



Fig. 3.9 The Sprinter (north is right).



Fig. 3.10 RCW 58 (north is left).

RCW 58

Constellation	Carina
RA	11 h 06 min 17 s
Dec	−65° 30′ 35″

The two dimensional oval-ring structure we see in Fig. 3.10 is actually part of a three dimensional bubble of ionized gas being blown out from the central Wolf-Rayet star, WR 40. This is typical of similar structures seen in the likes of the Banana Nebula, NGC 3199 (Fig. 3.12). Extremely faint even with filters in the largest amateur telescopes available, RCW 58 lies some 1,300 light years from Earth.

Imaging

RCW 58 is a real challenge to image. DSLR and OSC may struggle to do so, in which case you might prefer to attempt another object. With a monochrome CCD camera little nebulosity will be seen in exposures less than a few minutes long. Therefore, the object can be quite a challenge to locate and frame as many mounts/planetariums do not hold the RCW catalogue. With an accurate GOTO mount the RA and Dec coordinates provided should make RCW 58 fairly easy to find. A field size of at least 25' × 20' is required to frame the object. Larger fields, up to about 1.5° × 1°, will also do justice to the object. The key to a good image here is – keep on exposing.

Technical Information – Fig. 3.10

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QHY9 Mono
Exposures:	20 × 10 min L 10 × 10 min R 10 × 10 min G 10 × 10 min B (All unbinned)
Field Size:	25' × 17'

The Eta Carinae Area

The bright star clouds around the Great Eta Carinae Nebula are full of deep-sky treasures. From some of the best naked-eye clusters in the whole sky to numerous interesting nebula complexes and stars in their death throes this region has more than its fair share of stunning objects to enjoy. Fig. 3.11 is a reference chart showing the objects in the list below.

1. Banana Nebula (NGC 3199)
2. Whirling Dervish Nebula (NGC 3247)
3. Pendant (NGC 3293)
4. Gabriela Mistral Nebula (NGC 3324)
5. Eta Carinae Nebula (NGC 3272)
6. Southern Pleiades (IC 2602)
7. Black Arrow Cluster (NGC 3532)
8. NGC 3576 and NGC 3603
9. Running Chicken Nebula (Wide) (IC 2944-48)
10. NGC 3766
11. RCW 58

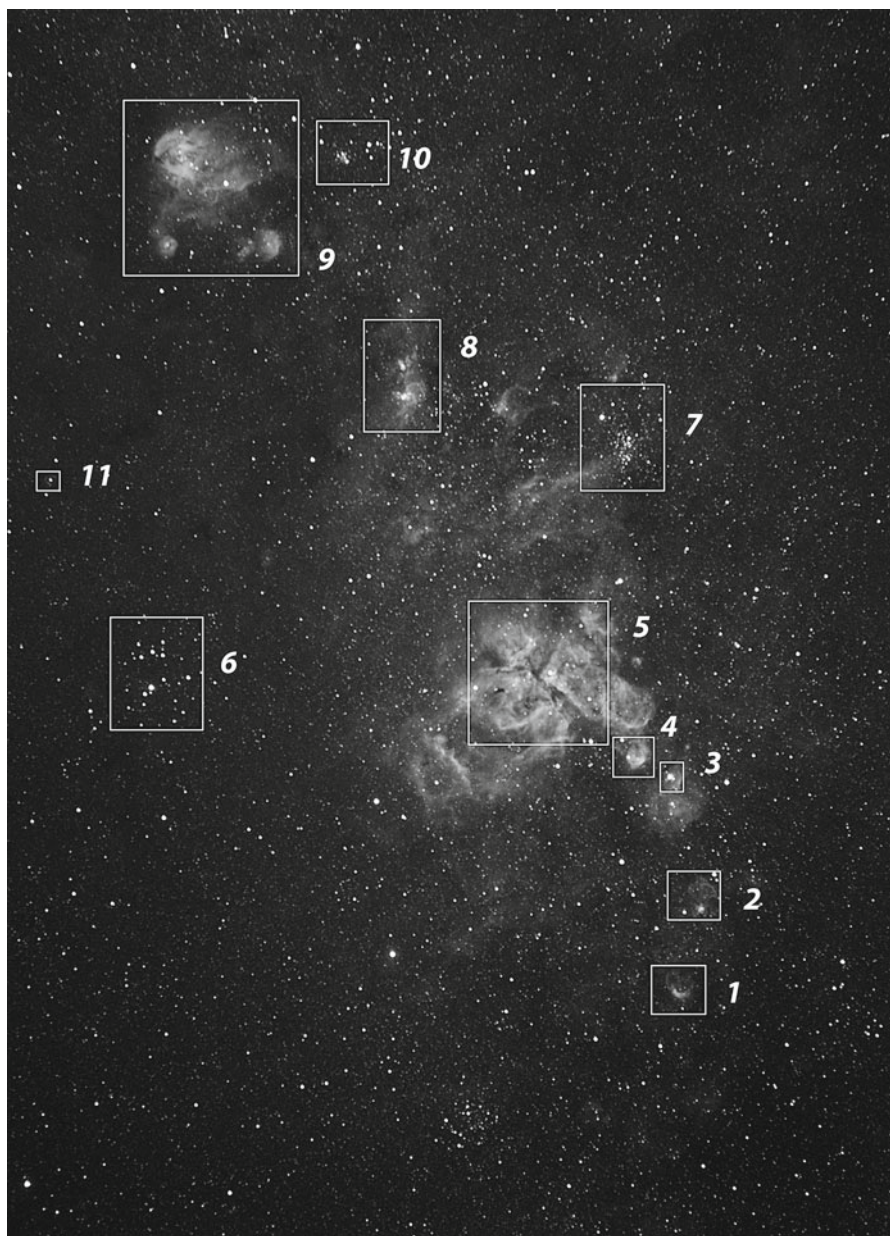


Fig. 3.11 Eta Carinae Area reference chart.

Banana Nebula — NGC 3199

Constellation	Carina
RA	10 h 16 min 48 s
Dec	−57° 57′ 00″

Through most telescopes we only see the Banana shape. Photographs, however, reveal this bright crescent to be the strongest part of an almost complete ring of nebulosity being blown into this shape by a very active Wolf-Rayet star near the center of this emission nebula.

The Banana Nebula covers 20' × 15' and is situated 11,736 light years away.

Imaging

The brightest part of this nebula is easily imaged with any camera. However, the rest of the object has a much fainter surface brightness and so requires extensive exposing. Due to the high level of OIII and H-alpha in this image it is a very good choice for narrowband imaging. Depending upon how the colors are mapped the Banana will be yellow, green or blue.

In order to frame the Banana Nebula on its own a field of at least 35' × 30' is required. However, if a larger field of view is available then it may be possible to frame it alongside NGC 3247 (Fig. 3.13) less than 1.2° away.

Technical Information – Fig. 3.12

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QHY9 Mono
Exposures:	13 × 15 min H-alpha 8 × 15 min OIII 6 × 15 min H-beta (All unbinned)
Field Size:	35' × 26'



Fig. 3.12 Banana Nebula.



Fig. 3.13 Whirling Dervish Nebula (north is left).

Whirling Dervish Nebula — NGC 3247

Constellation	Carina
RA	10 h 23 min 54 s
Dec	−57° 45′ 00″

NGC 3247 is a vast star forming region that is connected with the massive open cluster Westerlund 2 and several other concentrations in this area. The brighter asymmetrical area is well seen in telescopes, and the cluster appears as a very tight knot of stars.

This nebula sits at 26,000 light years away.

Imaging

The body and skirt of the dancer are easily imaged by any camera. However, deeper exposure will be needed in order to capture the rest of the nebulosity. In order to frame the Whirling Dervish Nebula on its own a field of at least 50' × 40' is required. However, if a larger field of view is available, of about 2° × 1.2°, then it can be framed alongside the Banana Nebula (Fig. 3.12), less than 1.2° away. Whilst these two areas of nebulosity are not actually connected they make an attractive line of sight pair when in the same field.

Technical Information – Fig. 3.13

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	14 × 10 min L 6 × 10 min R 6 × 10 min G 6 × 10 min B (All unbinned)
Field Size:	42' × 35'

The Pendant — NGC 3293

Constellation	Carina
RA	10 h 35 min 48 s
Dec	−58° 14′ 00″

NGC 3293 is a rival for the Jewel Box (Fig. 5.5) as one of the most resplendent open clusters in the southern sky. The Pendant has the same beautiful color contrast evident in the Jewel Box. It does however have the added bonus of bright and dark nebulosity being involved with the cluster, the brightest portion being to the north-west.

The cluster contains a pattern similar to the letters S and X superimposed upon each other. This figure consists mainly of young blue super-giant stars, except for the south-western corner of this figure where a red giant provides the color contrast. NGC 3293 consists of about 85 stars at a distance of 8,400 light years.

Imaging

The stars in this cluster are fairly bright and thus care must be taken to avoid saturation. It is worth spending more time imaging this object than would be the case for most clusters of this magnitude. The surrounding area of red nebulosity as well as the blue reflection nebula surrounding the Pendant itself really set this cluster off. The more time spent exposing the more of this nebulosity will be revealed.

If an image is desired that only contains the Pendant then a field no larger than 30' × 25' should be used. However, if the camera/scope combination provides a field larger than 1.5° × 1° then the Pendant can be framed alongside the Gabriela Mistral Nebula (Fig. 3.15).



Fig. 3.14 The Pendant (north is left).

Technical Information – Fig. 3.14

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	9 × 5 min R
	9 × 5 min G
	9 × 5 min B
	(All unbinned)
Field Size:	28' × 20'

Gabriela Mistral Nebula — NGC 3324

Constellation	Carina
RA	10 h 37 min 18 s
Dec	−58° 40′ 00″

This bright, circular emission nebula seems to be a part of the greater Eta Carinae Nebula to the south-east, but has been given its own NGC number. Small telescopes easily reveal its nature. Larger apertures, especially with an OIII filter or similar, reveal the well-defined western edge, which appears to be the shock front from the energy emitted by the young stars forming in this region.

That western edge also leads to the descriptive name for this nebula. There is a strong resemblance of the outline seen in a famous photo of the Nobel Prize winning Chilean poet, Gabriela Mistral. Gabriela was born and raised in the Elqui region, where the professional observatories of Cerro Tololo, Cerro Pachon and Cerro Morado reside.

NGC 3324 sits at a distance of 7,200 light years away.

Imaging

This is a very easy, satisfying image to take. In order for the ‘face’ to be framed a field of view as small as $25' \times 20'$ should be used. However, this whole area of the sky consists of nebulosity and so any field of view is capable of producing an excellent image. Not only is it an excellent target for LRGB and OSC it is also a great choice for narrowband imaging if equipment allows. The image presented in Fig. 3.15 has been taken through narrowband filters on a night of full Moon.



Fig. 3.15 Gabriela Mistral Nebula.

Technical Information – Fig. 3.15

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI583wsg Mono
Exposures:	10 × 15 min H-alpha
	10 × 15 min OIII
	6 × 10 min H-beta
	(All unbinned)
Field Size:	34' × 21'

Eta Carinae Nebula — NGC 3372

Constellation	Carina
RA	10 h 43 min 48 s
Dec	−59° 52′ 00″

The brightest nebula in the sky, NGC 3372, sometimes referred to as the Great Nebula in Carina, appears as a bright star when you hold an OIII filter up to the sky by hand! The Carina arm of the Milky Way contains a plethora of deep-sky objects, including some amazingly large and bright open clusters, but the Eta Carinae Nebula is the kingpin for sure.

Any pair of binoculars will show the overall shape and structure of the nebulosity and hint at the numerous small open clusters involved. With any telescope used, the widest possible field available is recommended until the observer has become familiar with the layout of this large ($2.7^\circ \times 1.9^\circ$) nebula complex.

The brightest portion around the star that the nebula is named after, Eta Carinae, is bounded on two sides by strong dark-lanes. This strong delta shape is then bounded to the south from west through to east by three bright wings of nebulosity appearing to stream away from the dark-lanes in the middle. This shows us the nebula for what it is, a bi-polar H II region on its way to becoming a superbubble like those we see in the Magellanic Clouds. The whole nebula is currently 326 light years across.

In the delta region we find the distinctive Keyhole Nebula next to Eta Carinae. At magnifications over 150 times modest telescopes will start to reveal the famous bi-polar nebula, the Homunculus, which surrounds the famous eruptive star. Two bright orange lobes, the results of the explosion of 1843 that made Eta Carinae the second brightest star in the sky for a while, are revealed to have delicate structures in large apertures. Observers can take a tour up along the hard edge of the delta dark-lanes and visit vistas made famous now by the HST like those of the Herbig – Haro object HH 901/902 just north of the brilliant cluster Tr 14.

NGC 3372 lies at a distance of 7,200 light years from Earth.

Imaging

The world really is your oyster when it comes to imaging this object. Any camera, scope and lens can be used here with great results. As it is so bright it is a great deep-sky object for those with unguided mounts to try their hand at astroimaging, as even exposures of a few seconds will reveal interesting features.

It is also an excellent object for narrowband or hybrid imaging as has been done here. Narrowband imaging actually has the advantage of cutting back the star light so the nebula shines through more clearly than when using RGB. Even black and white images taken with an H-alpha filter are impressive.

Imaging the Homunculus Nebula is extremely challenging. As it surrounds the bright star Eta Carinae it requires very short exposures to prevent the star from overpowering the nebulosity. One method is to use a video camera and then stack the frames and process it as you would a planet.

If a long focal length is used that provides a field size no greater than $20' \times 15'$ then a detailed image of the Keyhole can be produced. Using H-alpha here can really help to bring out the detail.

A camera/scope combination that provides a field of $1^\circ \times 1^\circ$ can frame the delta shape of the nebula perfectly.

Beyond that, any field size will result in a great image. Fig. 3.16 has a field size of nearly $2.3^\circ \times 1.8^\circ$ but there is plenty more nebulosity in the surrounding area to be captured. An 80 mm camera lens would also be useful to capture all the objects presented in this book that are in the wider Eta Carinae area.

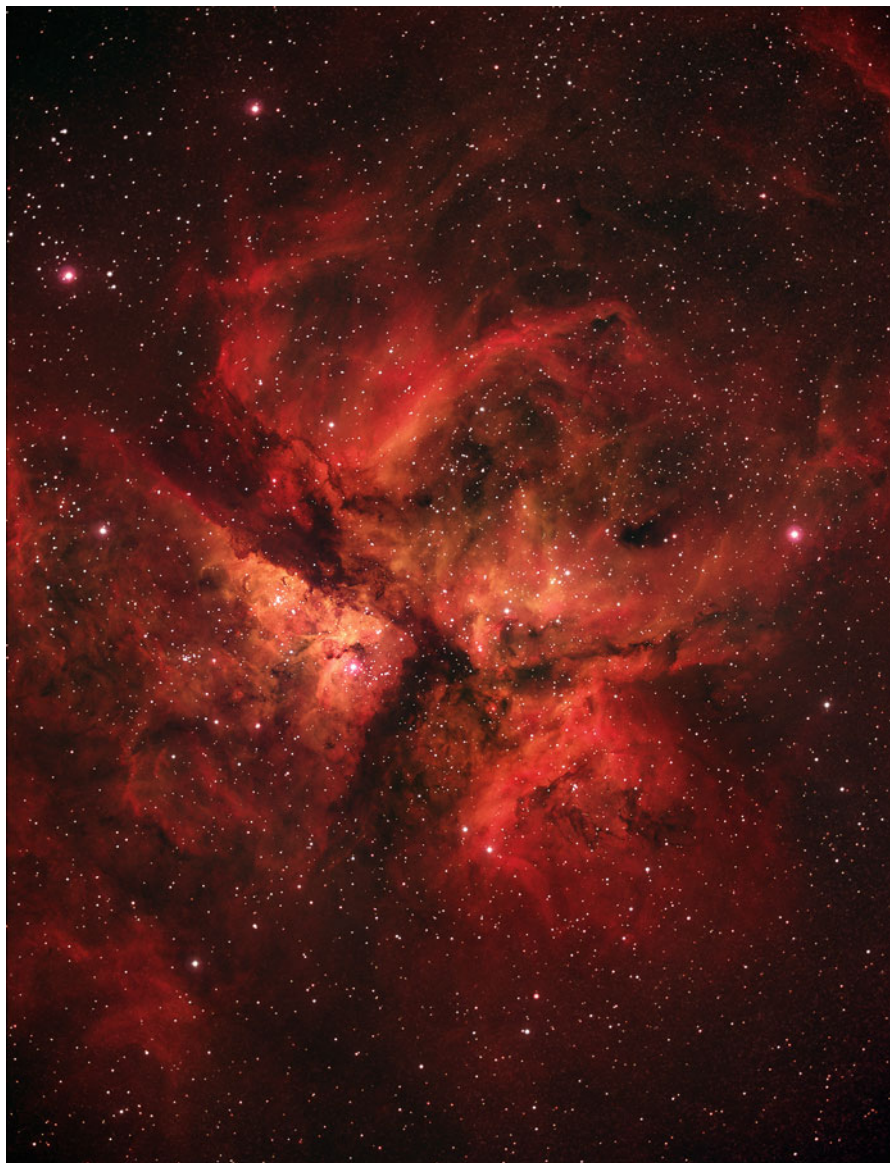


Fig. 3.16 Eta Carinae Nebula (north is left).

Technical Information – Fig. 3.16

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	10 × 15 min H-alpha
	8 × 15 min OIII
	8 × 15 min H-beta
	(All unbinned)
Field Size:	2.3° × 1.8°

The South Pillars

Constellation	Carina
RA	10 h 45 min 42 s
Dec	−60° 02′ 21″

It would seem the obvious thing to assume that such a vast nebulous region would be teeming with signs of star formation but that wasn’t the case initially. It became apparent that the presence of a large number of O-type stars including some of the rare O3-types, the monster O2 If* star HD 931129A and last but not least the blue super-giant Eta Carinae meant that the whole region was being bathed in high amounts of ultraviolet radiation. The energy from all of these super massive stars was clearing out the remaining early nebula material that stars form from and cutting short the proto stars (proplyds) before they could properly mature by the process of scalding photo evaporation.

It took a while before an army of telescopes around the world and in space, all working at different wavelengths, were able to find signs of new stellar life coming into existence in the Great Nebula. The first area to prove most fruitful was named by the professionals as the ‘South Pillars.’ Situated south of the big ‘V’ shaped dust lane the pillars are a series of globules, pillars and elephant trunks. There are no stars in birth to be seen visually but via the Infrared band we are able to detect clumps and individual sources of stellar birth.

Another indicator of such stellar activity was the discovery of bi-polar jets emanating from a rotating accretion disc. The best example of this is the infamous HH 666, nicknamed, ‘The Axis of Evil’! The jets with their bow shock waves are the longest known for such objects at 13 light years in length. Fig. 3.18 shows the heart of HH 666 as a red circular patch at the top left of the frame. Numerous other dark pillars fill this most interesting field. Many of the pillars are pointing back towards the cluster Tr 16 and Eta Carinae itself indicating in reverse just where the strong stellar winds are coming from. In this respect the Great Carina Nebula is more akin to NGC 2070 (Fig. 8.18) the Tarantula Nebula in the LMC than the well known Pillars of Creation in the Eagle Nebula, M 16 (Fig. 6.20). The mechanism for star birth now in NGC 3272 and NGC 2070 appears to be compression caused by the power of the nearby super-giants’ wind.

Imaging

The South Pillars require a field size of at least 30’ × 20’ in order to capture all the pillars in the area. However, larger fields will also produce good results but any field size over about 50’ × 30’ will begin to include parts of the area around the Keyhole Nebula and this may spoil the effect. For other tips on imaging the South Pillars see the information provided for Fig. 3.16.

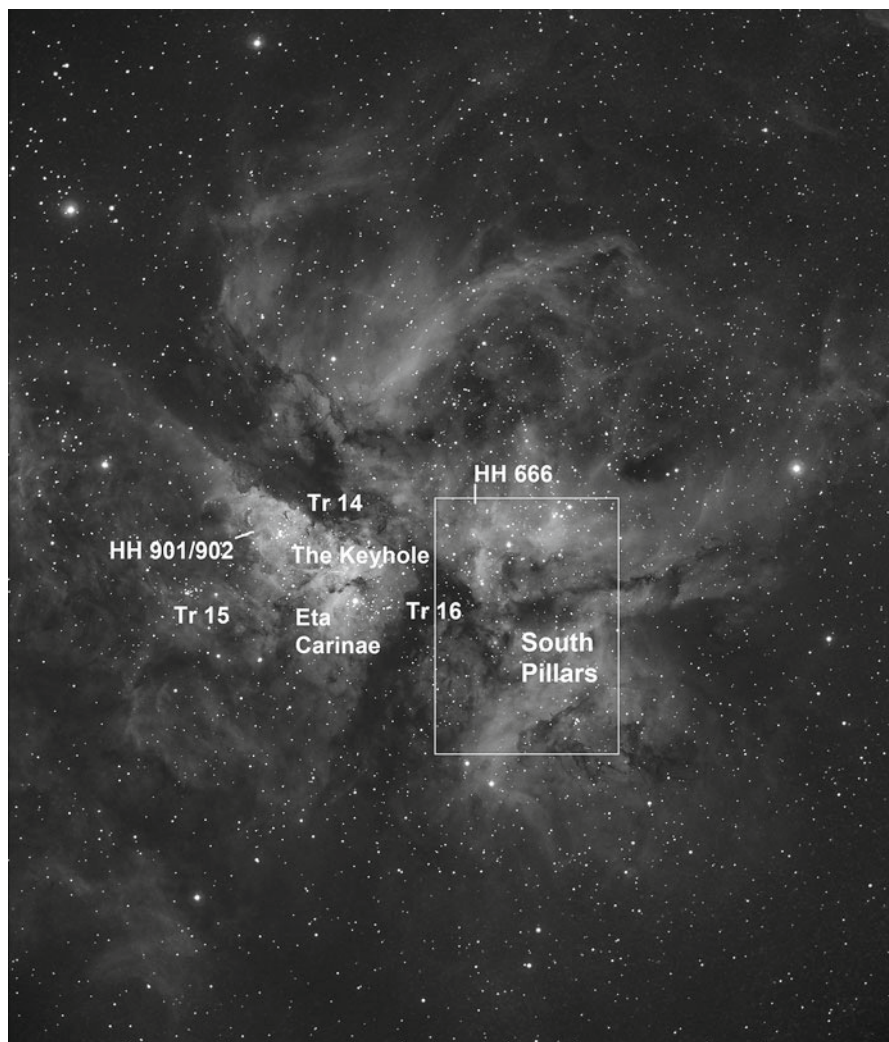


Fig. 3.17 Shows the ‘South Pillars’ area of the Eta Carinae Nebula along with the positions of the objects discussed above.

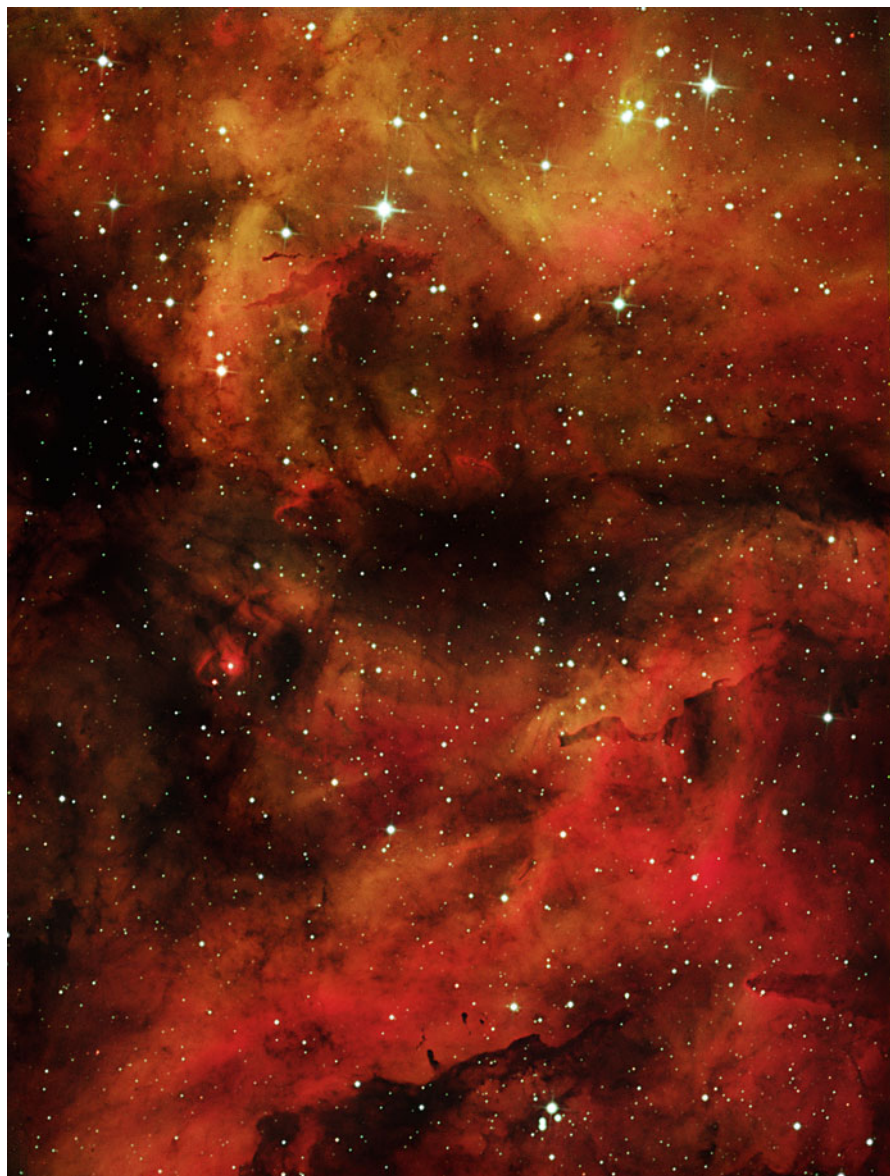


Fig. 3.18 South Pillars (north is left).

Technical Information – Fig. 3.18

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	8 × 10 min H-alpha
	6 × 10 min OIII
	5 × 10 min H-beta
	(All unbinned)
Field Size:	29' × 21'

Southern Pleiades — IC 2602

Constellation	Carina
RA	10 h 42 min 54 s
Dec	−64° 24′ 00″

This large, dazzling cluster at the top of the Diamond Cross is readily visible as a cluster to the naked-eye, and includes third magnitude Theta Carinae. It is given the descriptive name of the Southern Pleiades, due to the obvious similarity. Both are nearby, young clusters composed of brilliant blue/white giant stars. There is however a subtle difference between the two. The renowned blue reflection nebulosity in the Pleiades is absent in IC 2602. The blooming effect caused by moisture on eyepieces and as an artefact on some camera lenses is not a reflection nebula!

Given the dimensions of 100' this cluster requires the widest field possible to get it all in, making it highly suitable for binoculars. The photo here also contains the more distant cluster Melotte 101. IC 2602 is situated 479 light years away.

Imaging

Exposure times must be kept short in order to prevent the saturation of brightest stars in the cluster and the introduction of the false bluish color around them. Luminance layering is unnecessary here. Due to its size a very large field is required to frame the object – at least 2.3° × 1.8°. You should consider saving this target for a night of average seeing with passing clouds.

Technical Information – Fig. 3.19

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI583wsg Mono
Exposures:	8 × 3 min R 8 × 3 min G 8 × 3 min B (All unbinned)
Field Size:	2.3° × 1.8°



Fig. 3.19 Southern Pleiades (north is right).



Fig. 3.20 Black Arrow Cluster (north is left).

Black Arrow Cluster — NGC 3532

Constellation	Carina
RA	11 h 05 min 30 s
Dec	−58° 44′ 00″

This cluster was rated by Sir John Herschel as “The most brilliant object of its kind I have ever seen”. It is hard to argue with one of the few people to have observed the whole sky in such detail. There are about 150 evenly bright stars around magnitude 7 in an elongated shape covering 60′ × 30′. Readily visible to the unaided eye, NGC 3532 is a delight in small telescopes, but gobsmacking in larger apertures.

Sometimes described as a pin cushion, or the coins at the bottom of a wishing well, the name given here refers to an apparently random feature that runs east–west along the cluster near the center of the long axis. There appears to be an area devoid of stars that is bounded by two parallel rows of stars that form a shaft that then terminates in a large, flat, delta shaped arrow head pointing to the west. NGC 3532 lies at just over 1,300 light years away from us.

Imaging

To frame the Arrow itself requires a field of at least 70′ × 35′. However, due to its position amongst the red nebulosity of the Eta Carinae region a larger field of view can still be used to great effect. Any camera will capture the Arrow well although deeper exposure will be needed in order to bring the surrounding nebulosity to the fore. A hybrid image is possible here, using RGB for the star colors and adding in some H-alpha to enhance the nebulosity.

Technical Information – Fig. 3.20

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	10 × 5 min R 10 × 5 min G 10 × 5 min B (All unbinned)
Field Size:	2.2° × 1.5°

Torch Bearer Nebula (NGC 3576) — and NGC 3603

Constellation	Carina
RA	11 h 13 min 30 s
Dec	−61° 15′ 00″

What at first appears to be two nebulae in contact turns out to be a fairly small, but close nebula in front of a much larger, but far more distant nebula complex. The delicate, looping whirls of the NGC 3576 group are only 9,000 light years away and are about 100 light years wide. NGC 3603 on the other hand sits at 20,000 light years away and is the largest nebula in the Milky Way!

The standout loops of NGC 3576 are the result of the stellar winds of numerous young stars forming in that region. As good as they look in images, the loops are almost impossible to detect with even the largest amateur telescopes. The brighter portions at the southern end (the torso of the Torch Bearer) are easily seen in modest telescopes however. The form of the Torch Bearer is best seen with north up. The dark-lanes in Fig. 3.19 south of the brightest parts are the stretched out legs of the runner, while the other prominent dark-lanes to the north form the head and upraised arm carrying the torch. This dark nebula has also been referred to as the Statue of Liberty Nebula.

NGC 3603 has been heavily studied over the past century when it was realized that this is a strong star-forming region. The compact cluster at the heart of the nebula has the densest concentration of super-massive stars in the Milky Way. Inside the cluster have been found three Wolf-Rayet stars. One of these stars, NGC 3603-A1 is believed to be a pair of stars with a mass 200 times that of the Sun, yet incredibly they orbit a common center of gravity in 3.77 days! NGC 3603-A1a with a mass of 116 Suns is the largest star in our galaxy.

Imaging

These objects are ideal for all cameras. LRGB works well and they are particularly receptive to narrowband imaging. The two objects can be imaged either together or separately. In order to frame both of them a field of at least $1.1^\circ \times 1^\circ$ should be used. With a slightly larger field much of the surrounding nebulosity can also be included, as in Fig. 3.19. In order to image them separately a field size of about $40' \times 30'$ is ideal. Both objects make beautiful images separately.



Fig. 3.21 NGC 3576 and NGC 3603 (north is left).

Technical Information – Fig. 3.21

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI583wsg Mono
Exposures:	10 × 15 min H-alpha
	8 × 15 min OIII
	8 × 15 min H-beta
	(All unbinned)
Field Size:	1.6° × 1.0°

Running Chicken Nebula — IC 2944-48

Constellation	Centaurus
RA	11 h 37 min 18 s
Dec	−63° 11′ 00″

The open cluster, IC 2944, and the emission/reflection nebula IC 2948, are also known as the Lambda Centauri Nebula, which is the bright star on the western edge of the nebula. This very large object covers $75' \times 50'$ so needs a very wide-angle field of view to be seen properly. Being a low surface object there is a need for very transparent skies, or the use of large aperture with H-beta or OIII filters to see the nebulosity well. Close inspection of the image reveals the presence of Bok Globules imbedded in the nebula. The globules are believed to be areas of cold, pre-stellar birth condensations which will one day ignite into hot, young stars.

IC 2944-48 lies at a distance of 6,500 light years.

Imaging

A wonderful object for all cameras and scopes. In order to frame the entire area of nebulosity a large field is required, of at least $2.2^\circ \times 1.9^\circ$, as can be seen in Fig. 3.22. However, if the camera/scope combination gives a smaller field then there are plenty of interesting fields within the nebula that can be chosen. It is an object well suited to LRGB or narrowband. Narrowband imaging has the advantage of reducing the intensity of the stars which are present in abundance in this part of the Milky Way, allowing the nebulosity to shine through more. Fig. 3.23 shows the area just around the head of the Running Chicken. Longer focal lengths help to accentuate the Bok Globules.



Fig. 3.22 Running Chicken Nebula (north is right).

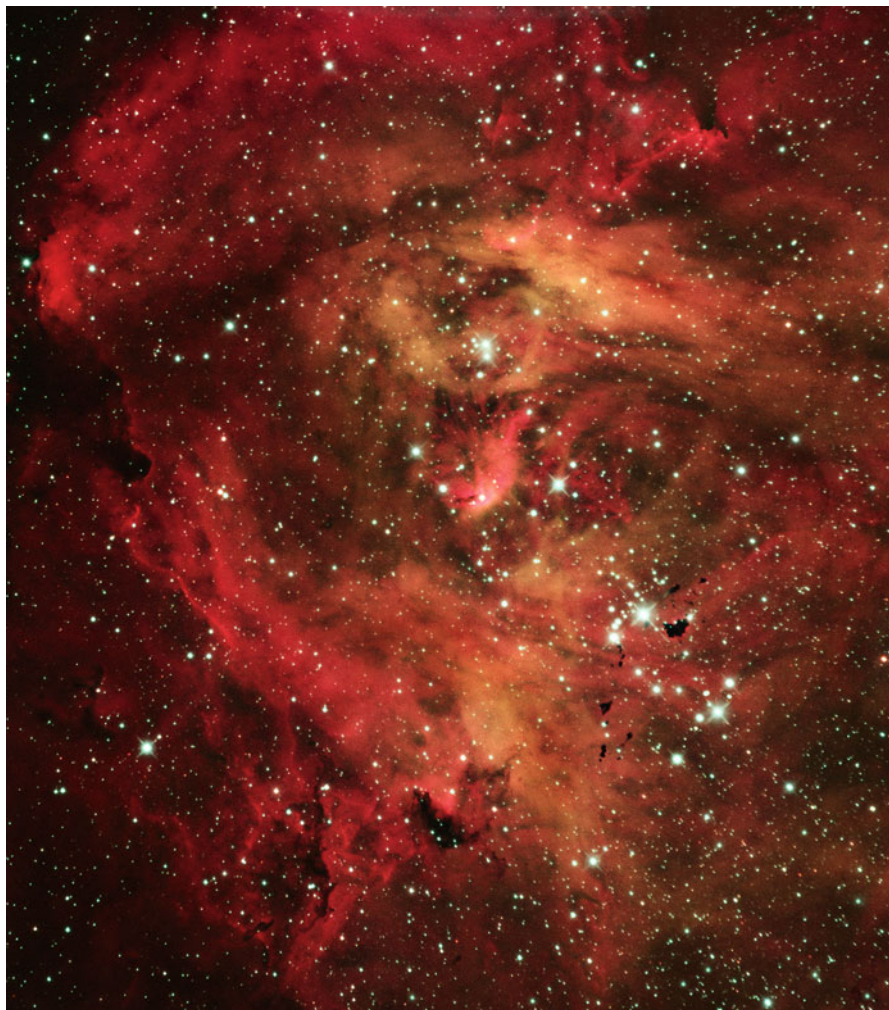


Fig. 3.23 Running Chicken Nebula (north is right).

Technical Information – Fig. 3.22

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	10 × 10 min L 5 × 10 min R 5 × 10 min G 5 × 10 min B (All unbinned)
Field Size:	2.2° × 1.65°

Technical Information – Fig. 3.23

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	8 × 10 min H-alpha 6 × 10 min OIII 5 × 10 min H-beta (All unbinned)
Field Size:	38' × 33'

Chapter Four



On the Serpent's Back

Antlia
Centaurus
Corvus
Hydra
Virgo

As the southern summer Milky Way closes for a rendezvous with the Sun, in the region between the Milky Way and the celestial equator can be found the largest constellation of them all, Hydra, the multi-headed serpent. Sprawled out along the length of this huge celestial serpent we find many beautiful examples of different types of galaxies, which together make up the southern autumn galaxies.

The galaxies belong to an array of extended galaxy clusters in Antlia, Hydra and Centaurus with a few from southern Virgo thrown into the mix as well.

While a few of the brighter galaxies in this region are possible to image from an urban location, a dark site is really what is required to make the most of the objects in this chapter.

NGC 2992-3 — Arp 245

Constellation	Hydra
RA	9 h 45 min 42 s
Dec	−14° 22′ 06″

This peculiar pair of interacting galaxies needs a large amateur telescope to be seen well. It requires the photograph to reveal the interplay between the galaxies to its true extent, clearly showing the tidal tails stretching away from the main components as well as the connecting bridge. The very thin galaxy nearby is FGC 938/RFGC 1621. FGC refers to the Flat Galaxy Catalogue. The three galaxies lie approximately 125 million light years away.

Imaging

Due to its low magnitude these galaxies would be a challenge for a DSLR and OSC CCD. Extensive exposure is required to reveal the tidal tails. It will be difficult to reveal them from light polluted sky. Using a medium to long focal length is necessary, with a field of view of no more than about 50' × 50', in order to resolve any of the structure in the cores of the galaxies.

Technical Information – Fig. 4.1

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	13 × 10 min L 4 × 10 min R 4 × 10 min G 4 × 10 min B (All unbinned)
Field Size:	25' × 19'



Fig. 4.1 NGC 2992-3 (north is right).



Fig. 4.2 Sombrero galaxy.

Sombrero Galaxy — M 104 — NGC 4594

Constellation	Virgo
RA	12 h 39 min 59 s
Dec	-11° 37' 24

One of the most succinct galactic dark-lanes that you can view cuts across the face of the dazzling core of the Sombrero Galaxy. Visible in binoculars as a small streak, small telescopes will show the dark-lane at high power. In larger apertures observers become spellbound by the stark contrast as they contemplate the beautiful symmetry evident before them. M 104 resides some 50 million light-years from Earth.

Imaging

A beautiful target for all cameras, the stark contrast between the halo and the dark-lane is easily captured. Even though the object is a mere 9' × 4' it still makes an interesting image with a larger field of view due to this high contrast. However, in order to begin to resolve the detail in the rim of the Sombrero a medium to long focal length is required with a field of view of no more than about 30' × 20'. A good galaxy to try to image from a light polluted sky.

Technical Information – Fig. 4.2

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	15 × 5 min L 5 × 5 min R 10 × 5 min G 10 × 5 min B (All unbinned)
Field Size:	22' × 17'

NGC 2997

Constellation	Antlia
RA	9 h 45 min 41 s
Dec	-31° 11' 30"

One of the true gems of this region, NGC 2997 is a galaxy hunter's delight. A medium aperture telescope under dark conditions will reveal the spiral arms and with larger telescopes an increase in contrast defines these more clearly. Color images reveal twenty or more HII regions embedded along the line of the arms. NGC 2997 is 40 million light years away.

Imaging

This is an excellent target for all cameras, although the fainter ends of the outer arms may only be accessible to a monochrome CCD from a dark sky. It is best suited to a medium or long focal length scope and will look good with a field size no greater than $40' \times 30'$. Due to the many HII regions it is worth exposing some H-alpha subs if possible in order to blend with the red channel.



Fig. 4.3 NGC 2997.

Technical Information – Fig. 4.3

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	13 × 10 min L
	6 × 10 min R
	6 × 10 min G
	6 × 10 min B
	3 × 15 min H-alpha (blended with the red)
	(All unbinned)
Field Size:	20' × 14'

NGC 3621

Constellation	Hydra
RA	11 h 18 min 18 s
Dec	-32° 48' 48"

Fig. 4.4 reveals this galaxy to be much larger than it seems at first glance. Even through large telescopes the galaxy appears to lie within the confines of the three bright stars. Deep images show that there is a spider web of delicate arms wrapped around the broad central region which nearly fills the frame! This is an example of a late (young) type Sc spiral galaxy lying some 21.8 million light years away.

Imaging

The brighter core of this galaxy is accessible to all cameras even from the suburbs but the fainter arms may be beyond the capability of a DSLR. Even with a mono-chrome CCD extensive exposure is required to show the full extent of the arms, which stretch far beyond what is revealed in Fig. 4.4. While this image has been taken using a long focal length scope, if a truly deep image were taken, a larger field of view of at least 40' × 30' would be required to frame the complete galaxy with its extended arms.

Technical Information – Fig. 4.4

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 10 min L 3 × 10 min R 3 × 10 min G 3 × 10 min B (All unbinned)
Field Size:	20' × 15'



Fig. 4.4 NGC 3621 (north is right).



Fig. 4.5 NGC 5247.

NGC 5247

Constellation	Virgo
RA	13 h 38 min 01 s
Dec	-17° 52' 54"

NGC 5247 is a galaxy hunter’s delight. Although not overly bright NGC 5247 yields up its multiple spiral arms to medium sized telescopes (10”) in good conditions. Spotting the third arm in the south-west (bottom right) is a sign of excellent sky transparency, which makes it ideal for deep-sky observing.

Imaging

An easy target for all cameras and a long focal length scope that provides a field of view of about 30’ × 20’ or less. This is best imaged away from bright city lights.

Technical Information – Fig. 4.5

Telescope:	10” Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 10 min L
	5 × 5 min R
	5 × 5 min G
	5 × 5 min B
	(All unbinned)
Field Size:	26’ × 21’

Antennae Galaxies — NGC 4038-39

Constellation	Corvus
RA	12 h 01 min 54 s
Dec	−18° 51′ 54″

Already famous in astronomy circles, the Antennae Galaxies were made world famous thanks to a Hubble Space Telescope image. Modest to large telescopes reveal the strange, fetal nature of this interacting pair. However, deep imaging is required to show the renowned tails that are being spun off as the result of the cosmic dance that we have a snapshot of. The bristling star-burst regions around the cores show up well also as an irregular string of pink beads. The distance to the Antennae is 70 million light years.

Imaging

While the cores of the pair are easily captured with any camera, the tails are much fainter and more challenging and so it is likely that they will be overpowered by sky glow unless they are imaged from a dark sky location. The tails still look impressive even if insufficient color has been captured to colorize them. So if using a monochrome CCD it might be worth spending extra time exposing luminance subs, in order to strengthen the brightness of the tails, and gather only sufficient RGB to bring out the color in the core of the galaxies.

Accurate flats are required when imaging this object to ensure that all gradients are removed in order to successfully bring out the faint galactic tails.

Technical Information – Fig. 4.6

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	13 × 5 min L 5 × 5 min R 5 × 5 min G 5 × 5 min B (All unbinned)
Field Size:	28' × 22'



Fig. 4.6 Antennae galaxies.



Fig. 4.7 NGC 2835.

NGC 2835

Constellation	Hydra
RA	9 h 17 min 54 s
Dec	−22° 21′ 18″

This delicate, multi-armed, face-on spiral galaxy could easily be overlooked in a region with so many similar objects to choose from, but that would be a mistake. Lying in a barren region between the great serpent and the innocuous air pump of Antlia, NGC 2835 is well worth the visit, visually and photographically. NGC 2835 is 30 million light years distant.

Imaging

A good target for a DSLR and a scope that provides a field of view of no more than 50' × 40', otherwise little detail will be revealed. The arms are well pronounced and easily captured.

Technical Information – Fig. 4.7

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 10 min L 3 × 10 min R 3 × 10 min G 3 × 10 min B (All unbinned)
Field Size:	27' × 22'

Cigar Galaxy — NGC 4945

Constellation	Centaurus
RA	13 h 05 min 25 s
Dec	−49° 28′ 18″

The Cigar Galaxy in Centaurus lies less than 15° from the plane of the Milky Way, and therefore sits in a field sown with stars. Just visible through 10×50 binoculars, modest telescopes show the dark-lanes well and hint at the nearside spiral arm at lower right in Fig. 4.8. This is a low surface brightness object with a length equal to half the Moon's diameter. NGC 4945 has great image scale, but an apparent faintness belies its given magnitude. The Cigar galaxy is a member of the nearby Centaurus Galaxy Cluster, with an average distance of 14 million light years.

Imaging

Due to its large size the Cigar Galaxy is one of the few that really works well imaged with a short focal length scope. Even with a field of view of $2^\circ \times 1^\circ$ detail will be captured. While this image is taken with a long focal length the galaxy looks great sitting smaller in the center of the surrounding star field. Although it has a low surface brightness it still makes an excellent choice for all cameras and even from moderately light polluted skies. Care needs to be taken not to saturate the core as all color will be lost.



Fig. 4.8 Cigar galaxy.

Technical Information – Fig. 4.8

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	5 × 10 min L
	3 × 10 min R
	3 × 10 min G
	3 × 10 min B
	(All unbinned)
Field Size:	22' × 16.5'

Centaurus A — NGC 5128

Constellation	Centaurus
RA	13 h 25 min 29 s
Dec	−43° 01' 00"

Probably the easiest galactic dark-lanes you will ever see split this unusual giant galaxy. Readily seen in 7×50 binoculars, even small amateur telescopes show the inky bifurcation of this radio emitting galaxy. Modest apertures (8") show the bright starburst region that runs along the center of the dark-lane. The visual image is of course only a small fraction of this galaxy seen in the radio frequencies. Believed to be a giant galaxy that has cannibalized many smaller galaxies in its vicinity, NGC 5128 is also one of the nearest galaxies to us outside of the Local Group at approximately 12.5 million light years distant.

Imaging

A fantastic object to image with any camera or scope and from any geographical location in which it can be seen. Both bright and large, it is really a matter of choosing how to present the object. With more luminance subs the galaxy would appear much larger than is presented in Fig. 4.9. Therefore if a huge number of subs are taken it is better to use a shorter focal length, that provides a field of view of at least $50' \times 40'$, in order to leave sufficient space around the galaxy. Due to the natural gradient present in the halo it is particularly important that accurate flats are taken.



Fig. 4.9 Centaurus A (north is left).

Technical Information – Fig. 4.9

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QHY9 Mono
Exposures:	11 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	26' × 21'

Southern Pinwheel Galaxy — M 83 — NGC 5236

Constellation	Hydra
RA	13 h 37 min 01 s
Dec	-29° 52' 06"

Without a doubt the southern sky's most impressive face-on spiral galaxy, the Southern Pinwheel Galaxy greatly rewards observer and astroimager alike. Easily seen through 7×50 binoculars, modest apertures reveal the main arms in good observing conditions. Large telescopes show star clouds as mottled clumps along the arms and bar.

Four supernovae were recorded in this galaxy during the twentieth century making M 83 one of the most active galaxies for supernovae.

Imaging

The size, and brightness, of M 83 make it one of the most accessible galaxies in this book. Great detail can be achieved using a DSLR or OSC and a short focal length scope with relatively short exposures. It is therefore one of the few galaxies that is an ideal target for a less than average mount and from light polluted skies. Longer focal lengths will resolve more of the HII regions and the abundance of these regions makes it an ideal object for extra H-alpha subs to be taken if possible.

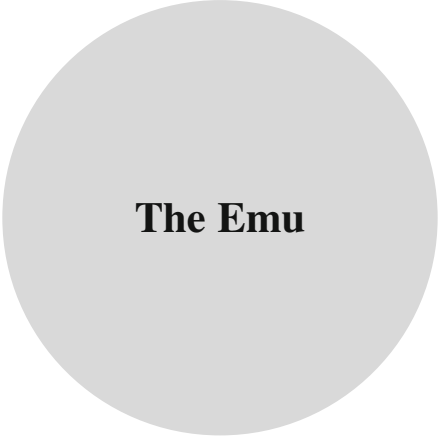


Fig. 4.10 Southern Pinwheel galaxy (south is up).

Technical Information – Fig. 4.10

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 10 min L
	4 × 10 min R
	4 × 10 min G
	4 × 10 min B
	(All unbinned)
Field Size:	24' × 17'

Chapter Five



The Emu

Ara

Centaurus

Circinus

Crux

Lupus

Musca

Norma

Scorpius

Triangulum Australe

For anyone having their first decent view of the southern Milky Way during winter when the center of our galaxy straddles the zenith, they can't help but be amazed by the dazzling star clouds stretching across the sky. The new observer will then be further amazed by the myriad of dark-lanes criss-crossing the bright starry background.

For the ancient people of South America and the indigenous people of Australia, these dark-lanes and patches are as much constellations as are the brilliant stars of the southern sky.

In an interesting coincidence the Aboriginal people saw a giant manifestation of their largest bird along the Milky Way, while the first Europeans to settle in the southern hemisphere filled what to them were blank spaces with a plethora of southern bird constellations.

A very rich piece of sky, the imager can use all sorts of equipment to capture the objects on offer. From the widest camera lens to the longest focal length scope there is something for everyone. The body of the Emu is an area devoid of galaxies so it is the turn of the nebulae, supernova remnants, clusters and planetary nebulae to delight the imager.

The Emu's Body, Neck and Head

Constellation	Scorpius to Crux
RA	16 h 11 min 00 s
Dec	-53° 30' 00"

Perhaps the most famous of the 'dark constellations' in modern times is the Emu. The figure of the Emu is actually so large it covers nearly a third of the length of the Milky Way! Fig. 5.1 reveals just the body, neck and head. The head and neck of the Emu are seen rising in the south-east on southern autumn evenings. The head is very easy to see being none other than the famous Coal Sack Nebula (Fig. 5.3), next to the Southern Cross. The Coal Sack forms the bulbous head with the stubby beak pointing to the south.

The neck consists of the distinctively long dark-lane that starts just below Alpha Centauri, the brightest of the Southern Cross' pointer stars, and runs straight for 14° to the naked eye cluster NGC 6067 in Norma.

From there the neck evolves into the body via a series of branching dark-lanes that spread out as far as Antares in Scorpius, before returning to the plane of the Milky Way around the Lagoon Nebula in Sagittarius.

Imaging

Due to its extended field size the Emu is an object for a camera lens and is therefore an excellent target for a DSLR. A very wide angle lens might get the whole Emu in one field but there would be a loss of resolution and increased distortion. A better, although more complicated, alternative is to mosaic separate images. In the case of Fig. 5.1 an 18 mm lens was used orientated perpendicular to the Milky Way. This gives more dark space either side of the Milky Way thus increasing contrast. Ideally all the images should be taken on one night, when the object is highest in the sky, to ensure similar lighting as dealing with gradients in mosaics can be tricky. Ensure that there is a large overlap with each frame to ease stitching. Keep a close eye on focusing – if the different frames are focused differently this will be very evident in the final mosaic. Stopping down the lens may help reduce coma, although it will necessitate longer exposures.



Fig. 5.1 Emu's body, neck and head (north is left).

Technical Information – Fig. 5.1

Camera Lens:	Canon 18–55 mm at 18 mm
F-stop:	f/5.5
Camera:	QHY12 One Shot Color
Exposures:	3 Frame Mosaic
	6 × 10 min each frame
	(All unbinned)
Field Size:	70° × 48°

The Emu Reference Chart

Fig. 5.2 shows the positions of the objects presented in this chapter. While this won't help you to locate the objects it does put them into context and give some idea of the richness of this portion of the sky.

1. Coal Sack Fig. 5.3
2. Dark Doodad Fig. 5.4
3. Jewel Box Fig. 5.5
4. Bernes 145 Fig. 5.6
5. NGC 4372 Fig. 5.7
6. NGC 4833 Fig. 5.8
7. Omega Centauri Fig. 5.9
8. Spiral Planetary Fig. 5.10
9. NGC 5844 Fig. 5.11
10. Box Nebula Fig. 5.12
11. Shapley 1 Fig. 5.13
12. RCW 86 Fig. 5.14
13. RCW 103 Fig. 5.15
14. NGC 5822 Fig. 5.16
15. NGC 5617 Fig. 5.17
16. NGC 5367 Fig. 5.18
17. RCW 104 Fig. 5.19
18. RCW 106 Fig. 5.20
19. NGC 6188-93 Fig. 5.21
20. NGC 6164-65 Fig. 5.22
21. Blue Straggler Fig. 5.23
22. NGC 4103 Fig. 5.24
23. RCW 94 & 95 Fig. 5.25
24. RCW 120 Fig. 5.26
25. Coffee Bean Nebula Fig. 5.27
26. Menzel 1 Fig. 5.28
27. Menzel 2 Fig. 5.29

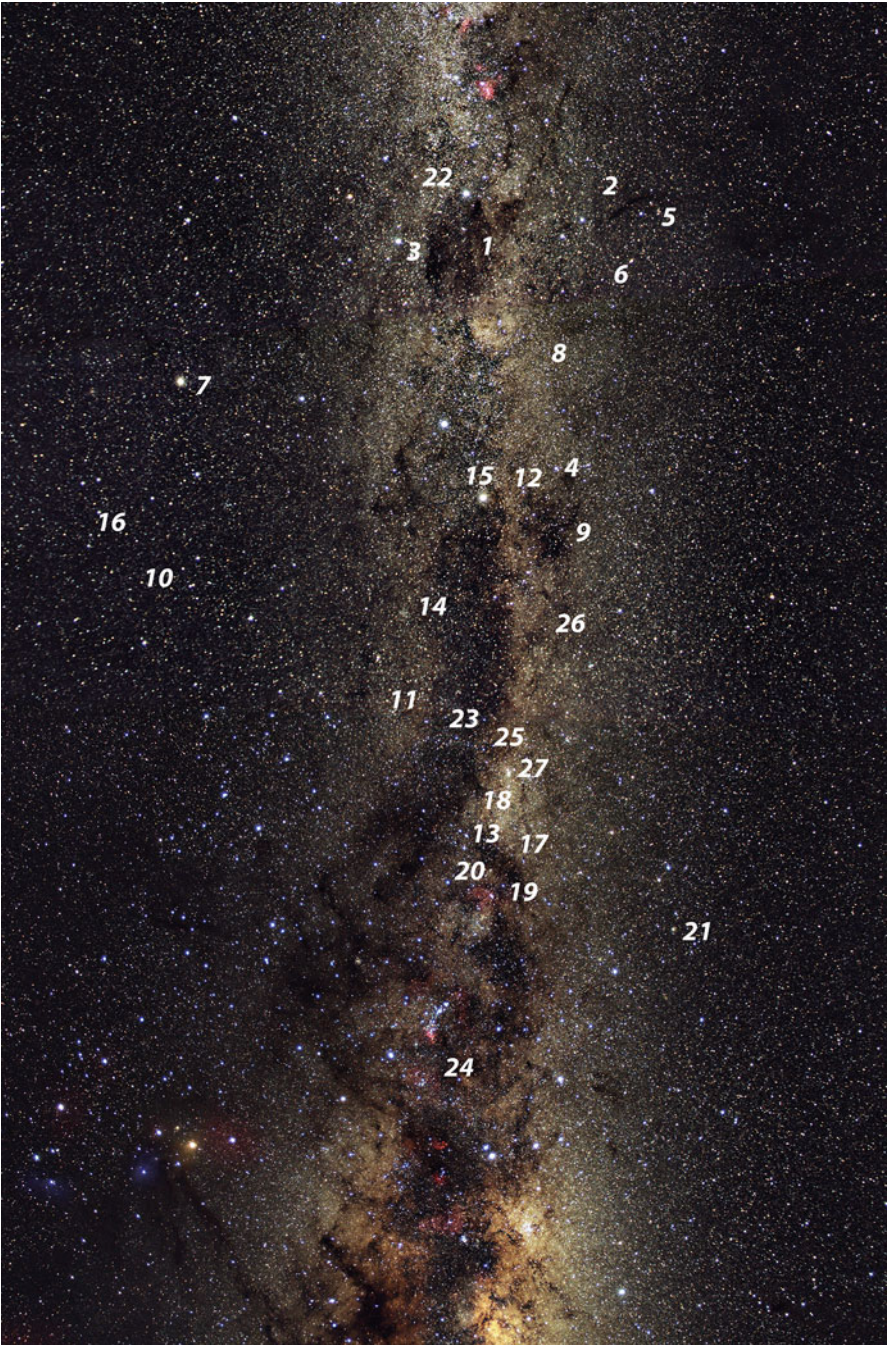


Fig. 5.2 Emu reference chart.

Coal Sack

Constellation	Crux/Musca
RA	12 h 53 min 00 s
Dec	-53° 00' 00"

The most famous naked eye dark nebula in the Milky Way, the Coal Sack stands out due to the bright star clouds of Crux that frame it well. Aboriginal culture saw it as the Emu’s head, while the seafaring Polynesians saw it as a flounder or fishing net. Binoculars give the best view, although a wide field eyepiece in any telescope allows for a grand tour of the region as well. The main oval shape covers 8° × 4° aligned with the beak of the Emu’s head. From the tip of the beak an observer can follow a chain of small dark nebulae that run up to the right of Fig. 5.3, like the tail of some dark, celestial kite!

Imaging

As with the Emu above, the Coal Sack is another extended object that requires the use of a camera lens to do it justice and is therefore an excellent object for a DSLR. If using a monochrome CCD luminance layering is unnecessary as it is bright enough for RGB to capture all the detail. Which lens is used will determine how much of the field of view is taken up by the Coal Sack itself. As the Coal Sack is basically just a dark nebula devoid of stars it only really has impact in a wider field rich with stars. Therefore you should frame the Coal Sack so it only takes up the central part of the field as shown in the image below. A field of this size has the advantage of including the Running Chicken area of nebulosity (towards the top of the image), which adds a little color to the image. (Stop down the lens to reduce coma.) If using a wide angle zoom lens the Coal Sack is easy to find. First locate the Pointers (Alpha and Beta Centauri) in the field of view and then zoom in on the Southern Cross. Once this is in the frame, the camera can be orientated to please.

Technical Information – Fig. 5.3

Camera Lens:	Canon 80–300 mm at 80 mm
F-stop:	f5.5
Camera:	QSI 583wsg Mono
Exposures:	6 × 2 min R 6 × 2 min G 6 × 2 min B (All unbinned)
Field Size:	22.4° × 16.0°

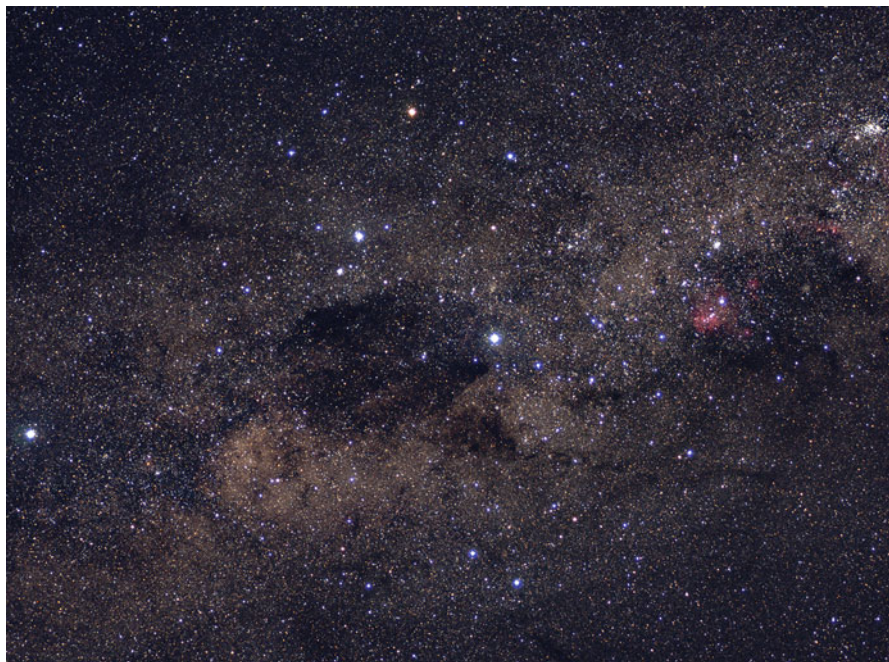


Fig. 5.3 Coal Sack.

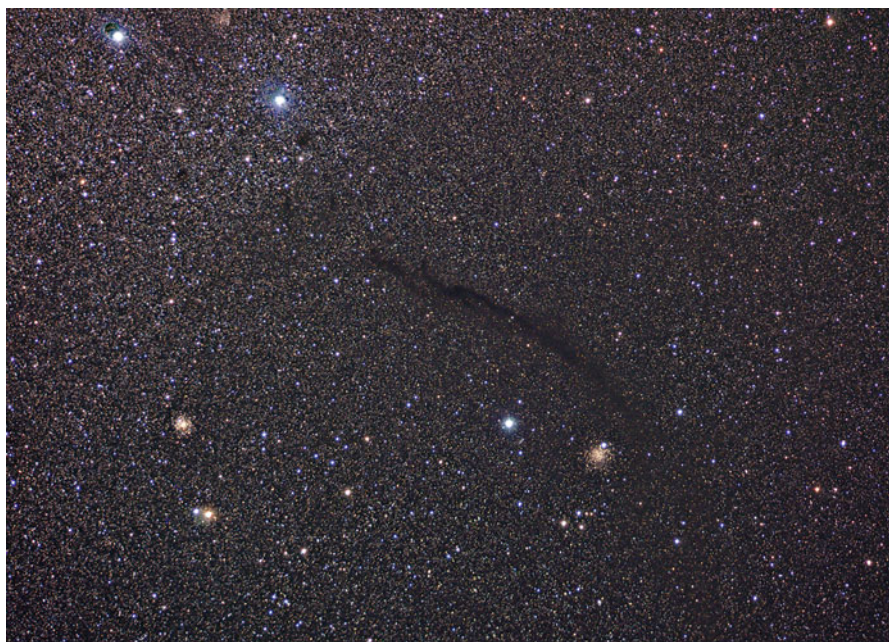


Fig. 5.4 Dark Doodad Nebula.

Dark Doodad Nebula — Sandqvist 149

Constellation	Musca
RA	12 h 28 min 50 s
Dec	−71° 22′ 00″

When visible to the unaided eye the Dark Doodad Nebula is a sign of a dark, transparent sky. Stretching just on 3° long, this dark nebula appears to be a connecting bridge between the plane of the Milky Way and the molecular clouds of nearby Chamaeleon mentioned in Chap. 7.

Binoculars show it well, while wide field views through any telescope will reveal its wiggly nature. The name Dark Doodad was bestowed by American astronomer Dennis Di Cicco on a trip to the southern hemisphere in 1988, and has since stuck!

Dr. Aage Sandqvist of the Observatory of the Stockholm University built up a list of optical components of dark nebulae for the European Southern Observatory in the 1970s.

Imaging

A camera lens is required to capture the full length of the Dark Doodad Nebula and it is a good target for the full range of cameras. If using a monochrome camera, luminance layering is unnecessary. RGB data is all that is required. While a much narrower field of view will also frame the object it is in such a rich star field that it works well in a larger field. A larger field will also enable the image to include the two globular clusters NGCs 4372 and 4833, vertical left of center, and the open cluster Harvard 6 on the far right. Keep exposure lengths short enough so that the globular clusters do not saturate as they will lose their beautiful golden coloring.

The Dark Doodad Nebula is unlikely to be in a GOTO catalogue. When trying to locate the object aim for NGC 4372 and the Dark Doodad will then be in the field of view – reposition the field as desired.

Technical Information – Fig. 5.4

Camera Lens:	Canon 80–300 mm at 125 mm
F-stop:	f/5.5
Camera:	QSI 583wsg Mono
Exposures:	10 × 5 min R 10 × 5 min G 10 × 5 min B (All unbinned)
Field Size:	7° × 5°

Jewel Box — NGC 4755

Constellation	Crux
RA	12 h 53 min 36 s
Dec	−60° 20′ 00″

A contender for the most well known deep-sky object in the southern hemisphere, just because it is so easy to find! Lying next to first magnitude Mimosa (Beta Crucis), the Jewel Box Cluster is aptly named thanks mainly to a brilliant red giant star set amidst the equally brilliant blue/white stars that make up the bulk of the cluster. The color contrast and compactness is only matched by the splendid Pendant Cluster (NGC 3293) in Carina (Fig. 3.14).

Covering approximately 10', the Jewel Box can stand high magnifications in any telescope. A favorite amongst amateurs sharing the night sky with the public, the Jewel Box never fails to wow onlookers even with city lights or bright Moonlight around.

Imaging

The Jewel Box makes a beautiful image in any focal length scope although the stars will be greater resolved with a field size of no more than 50' × 30'. Any sort of camera will produce great results. As with many clusters keep exposures short enough so that the brightest stars do not saturate, as the main attraction of this cluster is the variety of colors that will be lost if saturation occurs. Due to the short exposure times necessary the Jewel Box is an excellent target for those with low performance mounts or when imaging between banks of clouds.

Technical Information – Fig. 5.5

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	15 × 60 s R 15 × 60 s G 15 × 60 s B (All unbinned)
Field Size:	23' × 19'



Fig. 5.5 Jewel Box.



Fig. 5.6 Bernes 145.

Bernes 145

Constellation	Circinus
RA	14 h 48 min 29 s
Dec	-65° 15' 54"

This is a difficult object even with large aperture amateur telescopes. The small reflection nebula is only seen with averted vision. The dark nebula, which covers 12' × 5', is easily seen however against the rich starry background.

This is number 145 in the Catalogue of Bright Nebulosity of Opaque Dust Clouds compiled by Swedish astronomer C. Bernes in 1971.

Imaging

As it is a dark nebula it should be imaged with a generous amount of starry area around it, so a field size of at least 40' × 30' is required for a well framed image. (Fig. 5.6 has been cropped.) The reflection nebula is fairly dim so it is best suited to a monochrome camera with filters. Ensure that sufficient exposures have been obtained for both the dark nebula to stand out and for the reflection nebula to register.

This object can be difficult to locate. Many planetarium programs and catalogues will not have the Bernes numbers in them so RA and Dec coordinates might have to be used. With an accurate mount this won't be a problem but with a mount that is inaccurate or is not perfectly polar aligned then it might be difficult to tell whether or not the object is on the sensor. Long exposures might be necessary in order to tell whether or not you are in the right position.

Technical Information – Fig. 5.6

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	16 × 5 min L 8 × 5 min R 8 × 5 min G 8 × 5 min B (All unbinned)
Field Size:	39' × 23'

NGC 4372

Constellation	Musca
RA	12 h 25 min 48 s
Dec	-72° 40' 00"

NGC 4372 may appear as a dim patch in small telescopes but higher powers reveal a spread of evenly bright stars across the globe that covers 5'. This is the fainter of the pair of globulars in Musca, the Fly.

Imaging

This globular cluster is best imaged with a camera/scope set-up that provides a field of view of no more than 50' × 30', in order to adequately resolve the stars, and is a good target for any camera. The cluster will have no impact in a field larger than about 60' × 40'. Keep the exposures short so as not to saturate the bright star. If using a monochrome camera luminance layering is unnecessary, so only RGB data need be collected. Leave this globular for a night of excellent seeing.

Technical Information – Fig. 5.7

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 2 min R 10 × 2 min G 10 × 2 min B (All unbinned)
Field Size:	35' × 26'

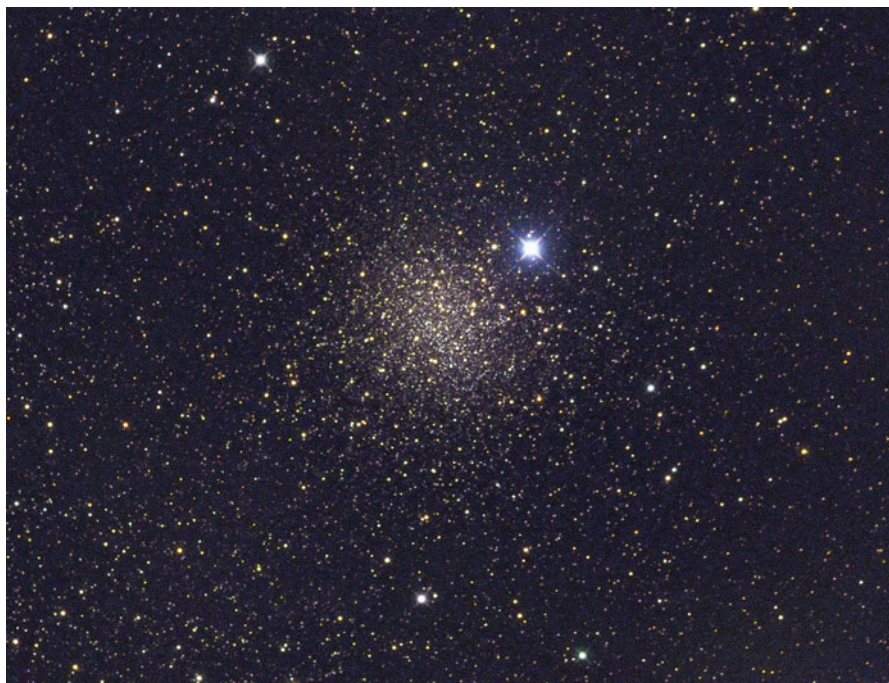


Fig. 5.7 NGC 4372.



Fig. 5.8 NGC 4833.

NGC 4833

Constellation	Musca
RA	12 h 59 min 34 s
Dec	-70° 52' 35"

NGC 4833 is a more condensed Class VIII globular compared to the looser Class XII of NGC 4372. Covering 14', this globular is a fine example of its kind even in small apertures. Binoculars show it as a discrete fuzzy spot.

Imaging

This Globular cluster is best imaged with a camera/scope set-up that provides a field of view of no more than 50' × 30', in order to adequately resolve the stars, and is a good target for any camera. The cluster will have no impact in a field larger than about 60' × 40'. Keep the exposures short so as not to saturate the bright star. If using a monochrome camera luminance layering is unnecessary, so only RGB data need be collected.

Technical Information – Fig. 5.8

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 3 min R
	10 × 3 min G
	10 × 3 min B
	(All unbinned)
Field Size:	23' × 20'

Omega Centauri — NGC 5139

Constellation	Centaurus
RA	13 h 26 min 48 s
Dec	−43° 01′ 00″

Known to the ancients as a star, Omega Centauri was first discovered to be a cluster by none other than Sir Edmund Halley during his time at St Helena in the South Atlantic Ocean.

Believed to be the remnant core of a captured dwarf galaxy, this may explain Omega's different appearance compared to the majority of Milky Way globulars. The first aspect that looks different is the oblate shape of the cluster compared to the roundness of the Milky Way majority! It should also be noted that this oblateness is similar to that of the globular clusters in the Magellanic Clouds.

Lying at just 16,000 light years, Omega Centauri is one of the closest globular clusters to us and contains somewhere in the order of 1,000,000 stars in an area covering 36', slightly larger than the Moon. Small telescopes resolve the brightest stars easily, while larger apertures produce jaw dropping results on first time viewers!

Omega Centauri's main rival for the status of being the best globular cluster in the sky is the equally astounding 47 Tucanae (Fig. 7.9). This has led to the unofficial setting up of two rival camps due to their apparent dissimilarities, highlighting the fickle nature of such a subjective topic!

Imaging

Due to its extensive size this is a perfect object for a short focal length scope that gives a field size of at least $2^\circ \times 1.5^\circ$. However, with a smaller field of view excellent images can be taken of only the core, similar to the image of 47 Tucanae (Fig. 7.9). It is extremely bright and so a great target for all cameras. The core of the cluster can quickly saturate while the stars at the edges of the cluster are extremely faint. It is therefore worth taking a set of short exposures and a set of long exposures that can be combined to produce an image that resolves all the stars from the center to the edge. Luminance layering is unnecessary so sets of RGB images are all that is required.



Fig. 5.9 Omega Centauri.

Technical Information – Fig. 5.9

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	12 × 10 min R
	12 × 10 min G
	12 × 10 min B
For the core:	6 × 2 min R
	6 × 2 min G
	6 × 2 min B
	(All unbinned)
Field Size:	2° × 1.3°

Spiral Planetary — NGC 5189

Constellation	Musca
RA	13 h 33 min 33 s
Dec	−65° 58′ 27″

NGC 5189 is a very unusual planetary nebula and astronomers are still working to find out the mechanism that generates this amazing spiral pattern.

Modest sized telescopes will reveal the nebula but larger telescopes with an OIII filter show the complex nature of this nebula well. At first glance it looks more like a barred spiral galaxy than a planetary nebula.

The nebula lies at approximately 3,000 light years and covers an area of 3′ × 2′.

Imaging

The Spiral Planetary is fairly small so requires a small field of view. It will be lost in any field larger than 30′ × 20′. It is, however, fairly bright and so is in range of any camera and with a monochrome CCD it may benefit from luminance layering. Exceptional seeing is necessary to capture the filaments of OIII found in the core.

Technical Information – Fig. 5.10

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 5 min L 6 × 5 min R 6 × 5 min G 6 × 5 min B (All unbinned)
Field Size:	8.7′ × 6.9′



Fig. 5.10 Spiral Planetary.



Fig. 5.11 NGC 5844.

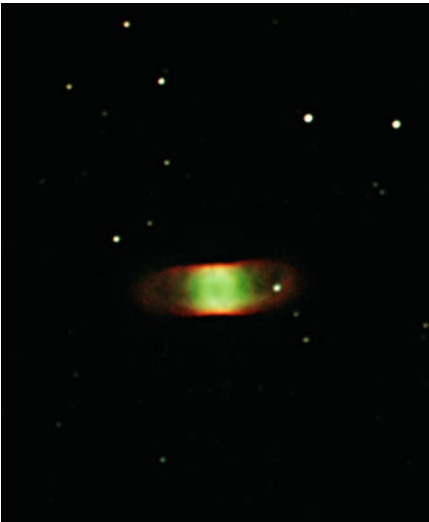


Fig. 5.12 Box Nebula.

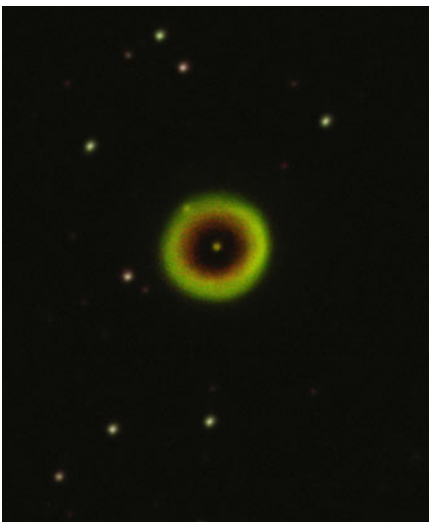


Fig. 5.13 Shapley 1.

NGC 5844

Constellation	Triangulum Australe
RA	15 h 10 min 41 s
Dec	-64° 40' 28"

This planetary nebula is a typical bi-polar example in the telescope under powers greater than 150x. Visually it is not unlike a mini version of the famous Dumbbell Nebula, M 27. There is an indication of that in the image here.

Imaging

NGC 5844 is one of the smallest planetary objects in the book and as such requires a small field of view, no more than 30' × 20' but ideally less, if seeing conditions and guiding capability allow. At magnitude 13.2 it is also not very bright but should be a possible target for DSLR and OSC cameras given enough data collected. It is also an excellent object for narrowband imaging on a Moonlit night, as was undertaken here.

Technical Information – Fig. 5.11

Telescope:	10" Vixen VMC260L with 0.67x focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 10 min H-alpha 5 × 10 min OIII 3 × 10 min H-beta (All unbinned)
Field Size:	6.8' × 5.3'

Box Nebula — IC 4406

Constellation	Lupus
RA	14 h 22 min 26 s
Dec	−44° 09′ 04″

Known as the Box Nebula by visual observers, the name comes from the fact that the brighter part seen in the picture is all most observers see until they use an OIII filter to bring out the extensions. Moderate apertures will show it and it is best seen at powers above 150×

Imaging

At a mere 1.8′ × 1.8′, this planetary can be a real challenge to image. Leave it until a night of exceptional seeing and use a long focal length. At magnitude 10.2 it is bright enough to be a target for any camera and due to the strength of both H-alpha and OIII it is an excellent choice for narrowband imaging. Therefore, for those with narrowband capability it is a good target to leave for a Moonlit night, as was done with Fig. 5.12. If your mount has imperfect tracking then you will have to keep exposures short.

Technical Information – Fig. 5.12

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	5 × 10 min H-alpha 5 × 10 min OIII 3 × 10 min H-beta (All unbinned)
Field Size:	6.4′ × 5.0′

Shapley 1

Constellation	Norma
RA	15 h 31 min 42 s
Dec	-51° 31' 00"

Shapley 1 is a challenging target for moderate sized telescopes and lies in a very rich Milky Way field. This is a classic ring nebula and a similar size to the famous standard bearer of that name, but it would be better observed if it were nearer and therefore brighter, being only magnitude 12.5, and covering 72". The distance is approximately 1,000 light years.

Harlow Shapley was a leading American astronomer during the mid-twentieth century. Shapley discovered the galactic distance scale using variable stars as yard sticks. This led to a greater understanding of the scale of the universe.

Imaging

The smaller the field of view the better for this planetary due to its tiny size, therefore expect to use the longest focal length that conditions will allow for. Due to its low magnitude it may be beyond the capabilities of a DSLR and is much more suited to monochrome CCD imaging. Narrowband imaging is effective as it cuts back the light from the surrounding stars. Although this perhaps makes the planetary seem out of context – as it is in a very busy part of the Milky Way – it does have the advantage of showing the detail more clearly, as is the case in Fig. 5.13.

Technical Information – Fig. 5.13

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	9 × 10 min H-alpha
	9 × 10 min OIII
	3 × 10 min H-beta
	(All unbinned)
Field Size:	6.4' × 5.1'

RCW 86

Constellation	Centaurus
RA	14 h 40 min 29 s
Dec	-62° 38' 42"

RCW 86 is the supernova remnant (SNR) of the oldest identifiable supernova on record. It was first seen by Chinese astronomers in 185 A.D. near the star Alpha Centauri when it may have reached magnitude -4, about as bright as Venus!

We now see a set of reversed crescents, the shockwave fronts of the ancient explosion. Large apertures are needed to see it well and narrow band filters improve the view, especially OIII. The nebula lies at just over 9,000 light years away. We see about 7' x 3', but other wavelengths (and space telescopes) show it out to 45'.

Another major catalogue mentioned often in this book is the RCW or Rodgers-Campbell-Whiteoak Catalogue of H-II regions. This catalogue resulted from a study carried out by the main contributors, Alexander William Rodgers, Colin T. Campbell and John Bartlett Whiteoak, who were led by Bart Bok at Mt Stromlo Observatory in Canberra, Australia in 1960.

Imaging

This supernova remnant is rarely imaged, probably because of its magnitude - magnitude 18. It is therefore a very challenging object and is only really suitable to monochrome CCD imaging. A very dark sky and long exposures are necessary in order to tease out the filaments and so a mount with an excellent tracking capability is really required. Any focal length of telescope can be used, although a field of view larger than 1.9° x 1.5° will not produce results worthy of the necessary exposure time. Fast optics will be beneficial. An accurate GOTO mount is required in order to find this object and if the RCW catalogue isn't available then the RA and Dec coordinates provided above may be used.

Technical Information – Fig. 5.14

Telescope:	7" Intes-Micro Mak-Cass with 0.67x focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	17 x 10 min L 9 x 10 min R 9 x 10 min G 9 x 10 min B (All unbinned)
Field Size:	31' x 27'



Fig. 5.14 RCW 86.



Fig. 5.15 RCW 103.

RCW 103

Constellation	Norma
RA	16 h 17 min 06 s
Dec	-51° 07' 00"

RCW 103 is a very faint shell of a supernova remnant that is believed to be 2,000 years old. This is a very faint object even in large apertures. Filters don't help the view but using averted vision does. This remnant is situated at 10,000 light years from us and covers an area of 7' × 7'.

Imaging

At magnitude 17.5 this target is extremely time-consuming to image. It is only really suited to monochrome CCD cameras. Due to its small size, a field of view of no more than 50' × 30' is required to make imaging this SNR worth the effort. A field larger than that will struggle to resolve detail in the filaments.

Technical Information – Fig. 5.15

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	15 × 10 min L
	9 × 10 min R
	9 × 10 min G
	9 × 10 min B
	(All unbinned)
Field Size:	29' × 22'

NGC 5822

Constellation	Lupus
RA	15 h 04 min 24 s
Dec	-54° 24' 05"

NGC 5822 is a large, sprawling cluster of evenly bright stars that covers 40'. A wide field is needed to show it well. The field is evenly rich in background stars, and the lines and loops of the cluster stand out well against the field. This cluster lies at a distance of just under 3,000 light years.

Imaging

This cluster is nicely framed in a wide field of a short focal length scope that provides a field size of at least 2° × 1.5°. As the stars in the cluster are fairly bright a satisfactory image can be obtained with fairly short exposures, so it is a good object for a crescent Moonlit night or when imaging between gaps in the clouds.

Technical Information – Fig. 5.16

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	8 × 3 min R
	8 × 3 min G
	8 × 3 min B
	(All unbinned)
Field Size:	1.9° × 1.5°



Fig. 5.16 NGC 5822.



Fig. 5.17 NGC 5617.

NGC 5617

Constellation	Centaurus
RA	14 h 29 min 48 s
Dec	-60° 43' 12"

Found on the line between Alpha and Beta Centauri just over a degree from Alpha is this fine open cluster of about 150 stars covering about 10'. Small telescopes resolve it well while larger scopes show the various star colors better.

The cluster lies at a distance of 3,753 light years.

Imaging

NGC 5617 is a tiny open cluster so really needs a field size no larger than 50' × 30' to do it justice. The stars are bright so it is a great target for any camera and there is no need for luminance layering. As it is a particularly colorful collection of stars keep exposures short so that they do not saturate. An object for a night of good seeing.

Technical Information – Fig. 5.17

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 90 s R
	10 × 90 s G
	10 × 90 s B
	(All unbinned)
Field Size:	28' × 20'

NGC 5367 — CG 12

Constellation	Centaurus
RA	13 h 57 min 44 s
Dec	−39° 58′ 48″

Fig. 5.18 reveals an extensive dark nebula complex with a small, bright reflection nebula embedded in the northern end. Visually that is all you really see through any telescope. It requires a very wide field of view to sweep comfortably around the chaotic dark regions of this nebula, but the edges are so vague that this is not a fruitful exercise. Photographs bring out the true extent of this area which lies around 2,050 light years away.

Cometary Globules (CG) are unusual compared to most dark nebulae. These isolated globules exist in a hot, ionized medium that surrounds them. Most CGs can be found in the region of the Gum Nebula (see Chap. 2) and sit at between 980 and 1,500 light years from Earth. The bright heads of the CGs are a small star forming area. Massive stellar winds are creating the comet-like tails. Cometary Globules were first discovered in 1976.

Imaging

An extensive nebula this is a suitable object for a long camera lens or a very short focal length telescope. Two elements need to be considered when attempting to capture this object – the blue nebulosity and the dark dusty nebulosity. The blue nebulosity should be easily imaged by any camera. However, the dusty areas are much more challenging. A very dark sky is required in order to capture them, as they will otherwise be lost in sky glow. The use of a light pollution suppression filter is likely to restrict too much light to allow the dark regions to be evident. If the dark, dusty nebulosity is beyond the conditions then using a smaller field size of about 50′ × 30′ and merely imaging the reflection nebula is a satisfying alternative.



Fig. 5.18 NGC 5367.

Technical Information – Fig. 5.18

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	12 × 10 min L
	6 × 10 min R
	6 × 10 min G
	6 × 10 min B
	(All unbinned)
Field Size:	3° × 2°

RCW 104

Constellation	Norma
RA	16 h 24 min 12 s
Dec	−51° 35′ 00″

Studies show this nebula actually to be two objects aligned to us that are at different distances. One is a ring structure associated with a Wolf-Rayet star (the brighter portion at lower right in Fig. 5.19).

Imaging

This target is worth considering imaging with all categories of cameras. Although it has a low surface brightness, being only magnitude 18, its larger size makes it a target for a shorter focal length scope with fast optics – a field size of at least 50' × 40' is ideal. The brightest part should be easy to capture although the more extended areas will require much deeper exposing.

Technical Information – Fig. 5.19

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	35' × 35'



Fig. 5.19 RCW 104 (north is top right).



Fig. 5.20 RCW 106.

RCW 106

Constellation	Norma
RA	16 h 19 min 47 s
Dec	-51° 04' 04"

RCW 106 is a large star forming nebula associated with a massive molecular cloud in this region. This is beyond visibility for even the largest amateur telescopes. RCW 106 lies at a distance of 11,750 light years from Earth.

Imaging

This is an excellent object for all telescopes. Fig. 5.20 was taken at 2,010 mm but the area of nebulosity extends beyond this image and a shorter scope will be able to capture more. A field size up to $2.0^{\circ} \times 1.5^{\circ}$ will enable the whole molecular cloud to be captured in one image. By emission nebula standards it is not bright so many exposures will be needed for a good result and thus a DSLR might struggle. Be careful not to allow the bright star towards the right to saturate. This object is particularly suited to luminance layering.

Technical Information – Fig. 5.20

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	30' × 25'

NGC 6188-93

Constellation	Ara
RA	16 h 40 min 30 s
Dec	-48° 47' 00"

This is a very large nebula that covers $2^\circ \times 1.75^\circ$. To see the whole object properly use the telescope's lowest usable magnification followed by the higher powers to bring up the contrast around the dark nebulae. The dark wave-like nebula next to the open cluster NGC 6193 is very similar to the dark nebula that includes the Horsehead Nebula (Fig. 1.3). In the same way that Sigma Orionis lights up the background around the Horsehead, so too does NGC 6193 here.

This emission nebula sits at around 4,000 light years from us.

Imaging

This vast area of nebulosity is an astroimager's dream with countless interesting fields to choose from. To capture the full nebula requires a camera lens and a field size up to $4^\circ \times 3^\circ$. However, with a smaller field of view different parts can be imaged, or a mosaic can be constructed. The most interesting parts are the ribbons of nebulosity crisscrossing along the center of the image below. A small field size, perhaps $30' \times 20'$, will resolve great detail in these areas if imaged on a night of good seeing. With narrowband capabilities some OIII exposures could be taken and the data blended with the green/blue channel. This will help to accentuate the shells from the nebula NGC 6164-5 (top of Fig. 5.21).

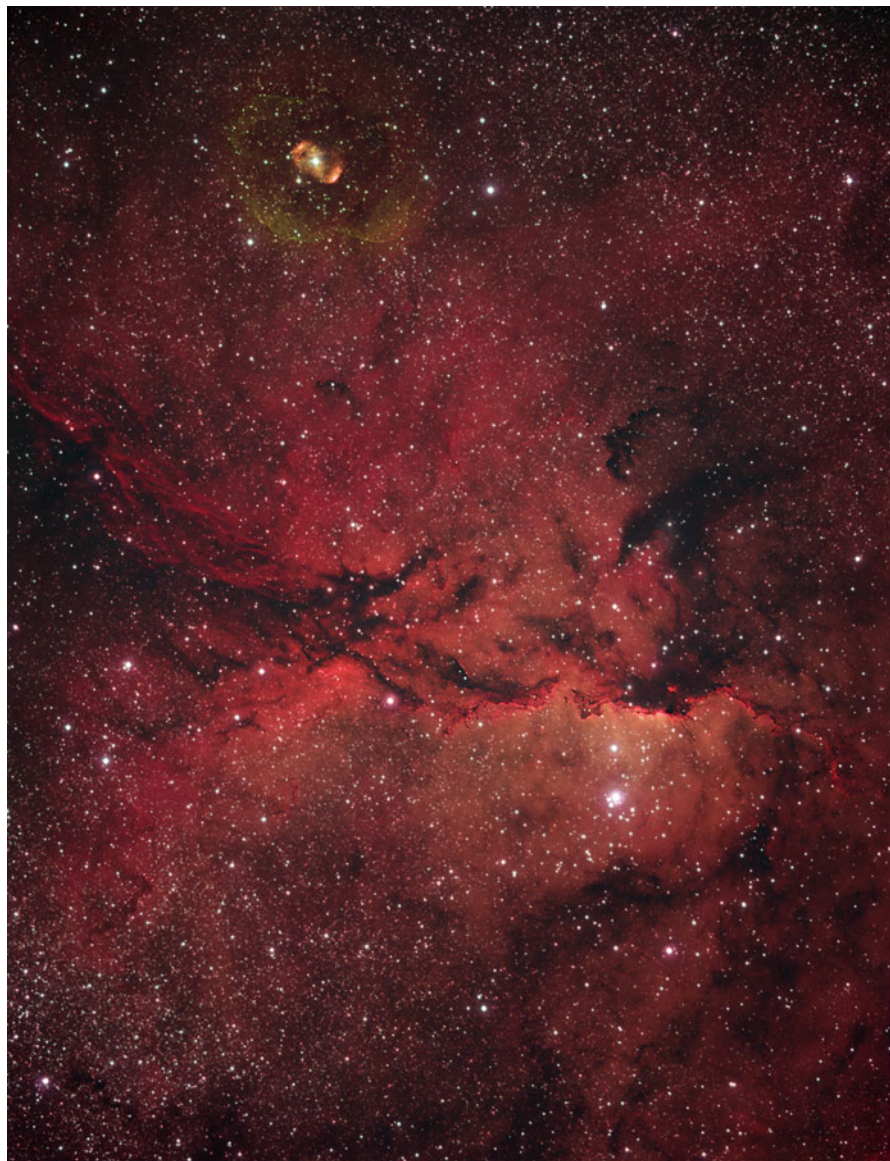


Fig. 5.21 NGC 6188-93 (north is left).

Technical Information – Fig. 5.21

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	8 × 15 min H-alpha
	6 × 15 min OIII
	4 × 15 min H-beta
	(All unbinned)
Field Size:	2.3° × 1.75°

NGC 6164-65

Constellation	Norma
RA	16 h 33 min 54 s
Dec	-48° 07' 00"

Visually we only see the two brightest portions that led early astronomers to give each section its own NGC number. Photographs soon revealed them to be connected and more, as is the case with the image provided here. The contorted inner figure-8 shape is believed to be as a result of the tidal influences of the three main stars involved with this planetary nebula. That in itself makes this a very unusual object of its type. The central part of the nebula covers $6' \times 3'$ and lies at a distance of 4,000 light years.

Imaging

This object can be seen in the top of Fig. 5.21. Due to its position in the exquisite surrounding nebula many field sizes can be chosen, suiting all scopes and cameras. A long focal length that provides a field of about $30' \times 20'$ will capture just the bi-polar nebula itself and reveal its wonderful structure. Moving to a medium focal length, and a field of at least $40' \times 30'$, will enable a frame which includes the outer OIII shells, as can be seen in Fig. 5.22. Watch out for the central star in the nebula and ensure that it doesn't saturate. If narrowband filters can be used consider taking some OIII exposures and blend these into the green/blue channels of an LRGB in order to enhance this outer shell. Alternatively, this object works well in pure narrowband as has been done here.



Fig. 5.22 NGC 6164-5 (north is top left).

Technical Information – Fig. 5.22

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 15 min H-alpha
	8 × 15 min OIII
	4 × 15 min H-beta
	(All unbinned)
Field Size:	46' × 32'

Blue Straggler — NGC 6397

Constellation	Ara
RA	17 h 40 min 42 s
Dec	−53° 40′ 00″

Just visible to the naked eye as a sixth magnitude fuzzy spot, small telescopes easily resolve the starry sphere that covers 31', which lies at a distance of 6,000 light years making NGC 6397 one of the nearest globular clusters to us.

The name Blue Straggler comes from the unusual number of blue supergiant stars that appear to have been formed from collisions between two or even three stars in the globular cluster. Another possible mechanism for the creation of the Blue Stragglers is the merging of two binary stars into a single giant star. NGC 6397 is very similar in appearance to the more famous M 4 (Fig. 6.24) close to Antares in Scorpius.

Imaging

The Blue Straggler is in a very dense star field and so looks impressive in a wide field, as presented in Fig. 5.23. Ensure that enough data is collected to do justice to the busy field. However, a smaller field of view, such as 60' × 30', will provide a lovely close-up of this beautiful cluster.

Technical Information – Fig. 5.23

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI583wsg Mono
Exposures:	5 × 5 min R 5 × 5 min G 5 × 5 min B (All unbinned)
Field Size:	2° × 1.3°



Fig. 5.23 Blue Straggler.



Fig. 5.24 NGC 4103.

NGC 4103

Constellation	Crux
RA	12 h 06 min 42 s
Dec	-61° 15' 00"

This compact open cluster sits in a rich field. Small telescopes easily resolve the cluster, while larger apertures bring up the colors better. The cluster is about 3,000 light years distant.

Imaging

A tiny cluster – a mere 6' across – this requires a small field size to resolve the stars. Any camera will do this object service and a satisfactory image can be produced with minimum exposure time, making this a suitable object for the end of an imaging session or between banks of clouds, although due to the image scale good seeing is required.

Technical Information – Fig. 5.24

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 2 min R 10 × 2 min G 10 × 2 min B (All unbinned)
Field Size:	34' × 27'

RCW 94 & 95

Constellation	Norma
RA	15 h 40 min 48 s
Dec	−54° 10′ 12″

These emission nebulae are part of a vast star forming molecular cloud that sits at a distance of 10,117 light years. RCW 94 is the large nebula and RCW 95 is the small one in the bottom left corner.

Imaging

An area of faint nebulosity this is best suited to a monochrome CCD camera. A larger field of view, up to $3^{\circ} \times 2^{\circ}$, will capture a much more extensive section of this molecular cloud although the section shown in Fig. 5.25 is the brightest part.

Technical Information – Fig. 5.25

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min L 5 × 10 min R 5 × 10 min G 5 × 10 min B (All unbinned)
Field Size:	46' × 32'



Fig. 5.25 RCW 94 and 95 (west is up).

RCW 120 — Gum 58

Constellation	Scorpius
RA	17 h 12 min 24 s
Dec	−38° 28′ 12″

RCW 120 is another HII star forming emission nebula. The star formation going on is still in its infancy and a very large young star, about ten times the size of the Sun, is due to ignite in the next few hundred thousand years and it is expected to become one of the intrinsically brightest stars in the galaxy. The nebula lies at 4,500 light years.

Imaging

At magnitude 18 this is best suited to a dedicated CCD camera. It is a fairly isolated nebula so there is nothing to be gained from using a large field of view – 50' × 30' or even smaller is ideal, as used in Fig. 5.26. Ensure that the bright star doesn't overwhelm the image. For those without the RCW catalogue, use the RA and Dec coordinates to locate it.

Technical Information – Fig. 5.26

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QHY9 Mono
Exposures:	10 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	18.3' × 13.5'



Fig. 5.26 RCW 120.



Fig. 5.27 Coffee Bean Nebula.

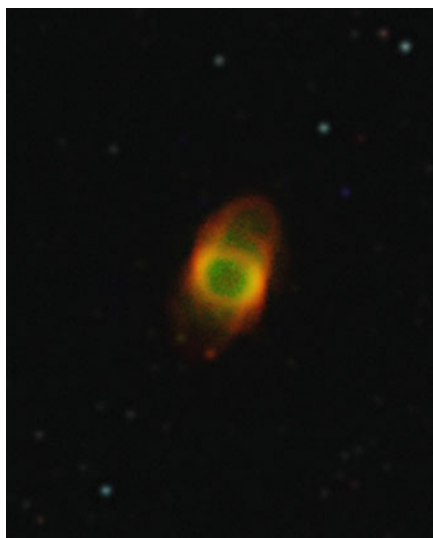


Fig. 5.28 Menzel 1.

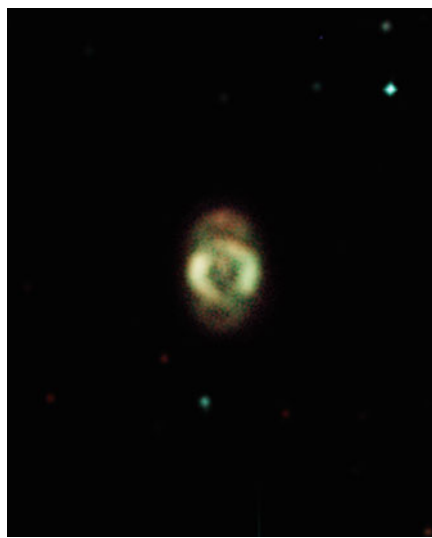


Fig. 5.29 Menzel 2.

Coffee Bean Nebula — RCW 98

Constellation	Norma
RA	15 h 55 min 24 s
Dec	−54° 39′ 00″

This is a ring-type structure around a Wolf-Rayet star. Strong radiation from nearby OB stars is causing star formation in each bright section of the nebula where proto-stars have been detected by radio telescopes. The nebula is around 9,800 light years away.

Imaging

The brightest part of this nebula is easily imaged with any camera, using a field size larger than about 20' × 15'. There is, however, some extended fainter nebulosity that might be more difficult to detect without using a monochrome CCD. This object lends itself to luminance layering or hybridising with H-alpha. Without the RCW catalogue use the above coordinates to locate it.

Technical Information – Fig. 5.27

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	12.6' × 9.1'

Menzel 1 — Sa 2-123

Constellation	Norma
RA	15 h 34 min 18 s
Dec	−59° 09′ 00″

This small 12th magnitude planetary nebula covers 26", about the size of Mars at its best in a telescope. We appear to be viewing this object on a skewed angle. With large apertures at over 200 magnifications we can see a central ring and from that we see faint extensions using an O-III filter. The nebula is roughly 3,400 light years distant.

The name for this object originates from Donald Howard Menzel, who was a research assistant of Harlow Shapley early in his career but later found fame studying many planetary nebulae, some of which bear his name.

Imaging

Menzel 1 is a good target for all types of cameras but is challenging due to its size. As always with small planetaries it should only be attempted on nights of great seeing and the longer the focal length the better (up to the limitations of the local seeing conditions and guiding accuracy). Due to the high level of emission of both H-alpha and OIII it is an excellent target for narrowband imaging, as has been done in Fig. 5.28.

Technical Information – Fig. 5.28

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	5 × 10 min H-alpha 5 × 10 min OIII 3 × 10 min H-beta (All unbinned)
Field Size:	4.1' × 3.3'

Menzel 2 — Sa 2-137

Constellation	Norma
RA	16 h 14 min 30 s
Dec	−54° 57′ 00″

Fig. 5.29 reveals a series of interlocking ringlets reminiscent of a chain. The telescope however only shows the brightest of these, which is enhanced with a narrowband filter, and appears slightly oval and broken. The nebula covers 23" and is magnitude 11.6.

Imaging

See Menzel 1 above.

Technical Information – Fig. 5.29

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	5 × 10 min H-alpha 5 × 10 min OIII 3 × 10 min H-beta (All unbinned)
Field Size:	3.1' × 2.5'

Chapter Six



The Heart of the Galaxy

Corona Australis
Ophiuchus
Sagittarius
Scorpius

Northern hemisphere astronomers often make the pilgrimage south of the equator at least once in their lives to stand in a dark sky site and witness first-hand what with all intents and purposes is the central bulge of the Milky Way galaxy passing directly overhead. The grandeur of this spectacle is not lost even on casual observers.

Far from being an homogenous band of milk across the sky, the *via lactia* from Roman times no less, the southern Milky Way is a patchwork of bright star clouds and silhouetted upon that background lies a plethora of inky black clouds that many ancient southern civilizations preferred as constellations to the star patterns we use. Once you have seen this for yourself then it is not hard to understand why!

Many of the objects in this chapter are very famous because they are relatively close to the equator and so are available to many imagers the world over. Famous objects in this chapter such as the Eagle, Triffid, Swan, Cat's Paw and Lagoon Nebulae are all within 25° of the celestial equator. Of course, the closer your imaging site is to the geographical equator the higher these objects are in the sky and the easier they are to image. But even from latitudes where they rarely get above about 20° from the horizon it is still worth attempting to image them on nights of particularly good seeing as they really are exquisite objects.

The Galactic Bulge

Constellations	Ara/Norma/Scorpius Ophiuchus/ Sagittarius/Scutum
RA	18 h 03 min 48 s
Dec	-24° 23' 00"

The area of the Milky Way that we call the ‘Galactic Bulge,’ is dominated by the star clouds of the constellations Scorpius, Ophiuchus, Sagittarius and Scutum. On southern winter evenings this part of the sky straddles the zenith. On a cool, transparent night lay people who have stepped out into the dark are staggered by the brilliance and immensity of the spectacle that greets them. Although initially beyond their comprehension many people soon realize that this is the single biggest thing that one can view without optical aid that is beyond the earth’s atmosphere!

Imaging

Due to its size the Galactic Bulge has to be imaged with a very wide angled camera lens or else a mosaic of smaller fields needs to be undertaken. Fig. 6.1 is a 3 frame mosaic using an 18 mm lens orientated perpendicular to the plane of the Milky Way.

It is essential to ensure there is a generous overlap with each of the frames. This will ensure that you are able to produce a seamless final image. It will also allow you to crop the edges of the images where distortion may have occurred.

Finally, it is crucial that perfect focusing is achieved. If the stars on one of the images are even slightly larger than the others it will be very obvious in the final mosaic.



Fig. 6.1 The Galactic Bulge.

Technical Information – Fig. 6.1

Camera Lens:	Canon 18–55 mm at 18 mm
F-stop:	f/5.5
Camera:	QHY12 One Shot Color
Exposures:	3 Frame Mosaic 6 × 10 min each frame (All unbinned)
Field Size:	51° × 38°

Heart of the Galaxy Reference Chart

Fig. 6.2 shows the positions of the objects presented in this chapter. While this won't help you to locate the objects it does put them into context and give some idea of the richness of this portion of the sky.

1. **Milky Way Kiwi** Fig. 6.3
2. **NGC 6072** Fig. 6.4
3. **NGC 6337** Fig. 6.5
4. **Bug Nebula** Fig. 6.6
5. **Prawn Nebula** Fig. 6.7
6. **Rho Ophiuchi Nebula** Fig. 6.8
7. **Cat's Paw Nebula** Fig. 6.9
8. **Lobster Nebula** Fig. 6.10
9. **Butterfly Cluster** Fig. 6.11
10. **M 7** Fig. 6.12
11. **M 21** Fig. 6.13
12. **Wild Duck Cluster** Fig. 6.14
13. **Snake Nebula** Fig. 6.15
14. **Small Sagittarius Star Cloud** Fig. 6.16
15. **Triffid Nebula** Fig. 6.17
16. **Lagoon Nebula** Fig. 6.18
17. **Swan Nebula** Fig. 6.19
18. **Eagle Nebula** Fig. 6.20
19. **Anteater Nebula** Fig. 6.21
20. **M 22** Fig. 6.22
21. **M 55** Fig. 6.23
22. **M 4** Fig. 6.24
23. **M 25** Fig. 6.25

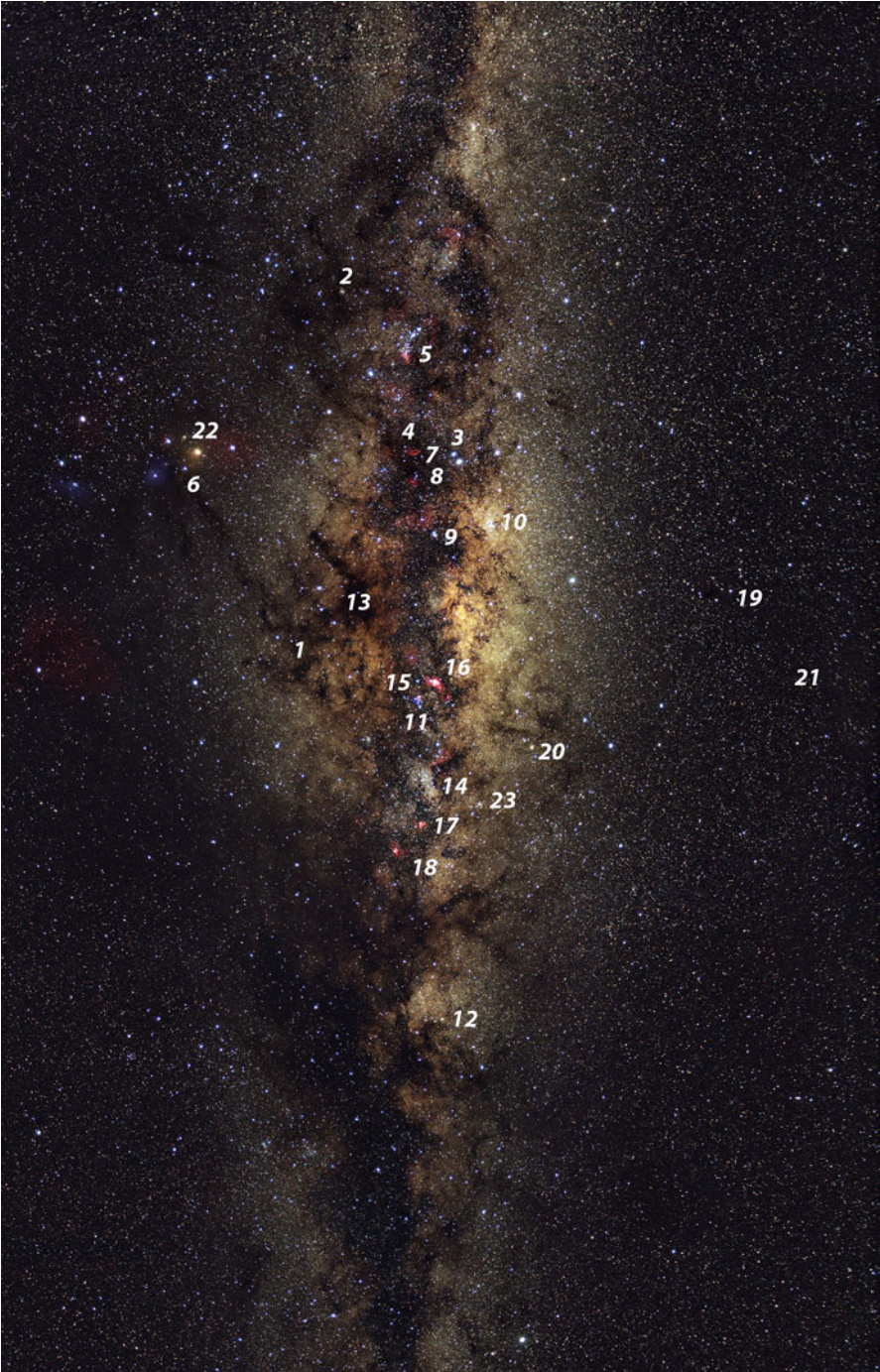


Fig. 6.2 Heart of the Galaxy Reference Chart.

Milky Way Kiwi

Constellation	Ophiuchus
RA	17 h 335 min 52 s
Dec	-23° 09' 25"

In keeping with the tradition of bird constellations in the southern sky and birds made from dark-lanes as with the Emu in the last chapter, a few decades ago a southern observer noticed a familiar shape sitting in amongst the bright star clouds near the galactic center. It was none other than the flightless bird the Kiwi! This Milky Way Kiwi has a head and beak made of the familiar dark nebula known as the Pipe Nebula. The stem of the Pipe is the long beak, while the bowl of the Pipe represents the head. The mottled, round star cloud just to the north is a perfect match for the dense but fine coat of Kiwi feathers. A pair of curving, dark-lanes makes up the legs and feet of the stubby ground-dwelling forest bird.

Imaging

This area of the Milky Way is extremely bright and so any camera, even using short exposures, will produce great images. The area around the Kiwi is rich with interesting star clusters and nebulosity, and therefore any size field will yield pleasing results. The Kiwi itself takes up an area of about $13^\circ \times 10^\circ$ and so a camera lens is required to frame it. If a wider field is possible then many famous nebulae can also be included in the image. Fig. 6.3 shows the Lagoon, Eagle, Swan and Triffid Nebulae all in the same field as the Kiwi.



Fig. 6.3 Milky Way Kiwi (north is bottom right).

Technical Information – Fig. 6.3

Camera Lens:	Canon 18–55 mm at 55 mm
F-stop:	f/5.5
Camera:	QSI 583wsg Mono
Exposures:	6 × 2 min R
	6 × 2 min G
	6 × 2 min B
	(All unbinned)
Field Size:	16° × 12°

NGC 6072

Constellation	Scorpius
RA	16 h 13 min 00 s
Dec	−36° 14′ 00″

Appearing as a classic stretched ring structure in telescopes, NGC 6072 is revealed to have a jagged inner rim in photos. In this respect it is not unlike the Flying Jaw Nebula, NGC 2899 (Fig. 3.4). NGC 6072 covers 40" making it above average in size for planetary nebulae, and shines at magnitude 11.7.

Imaging

This planetary can be a real challenge to image. Leave it until a night of exceptional seeing and use as long a focal length as possible. A field size larger than 25' × 20' will yield little detail. It is bright enough to be a target for any camera and due to the strength of both H-alpha and OIII it is an excellent choice for narrowband imaging. So for those with narrowband capability it is a good target to leave for a Moonlit night, as was the case with Fig. 6.4.

Technical Information – Fig. 6.4

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	5 × 10 min H-alpha 5 × 10 min OIII 3 × 10 min H-beta (All unbinned)
Field Size:	14' × 10'

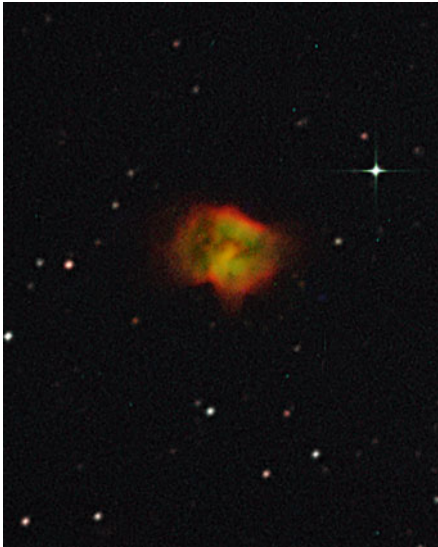


Fig. 6.4 NGC 6072.



Fig. 6.5 NGC 6337.



Fig. 6.6 Bug Nebula.

NGC 6337

Constellation	Scorpius
RA	17 h 22 min 18 s
Dec	-38° 29' 00"

This planetary nebula is very much a classic ring nebula and easily seen as such even in modest telescopes. Covering 48" and shining at magnitude 12.3, NGC 6337 lies at 4,500 light years from us.

Imaging

The smaller the field of view the better for this planetary due to its tiny size, therefore expect to use the longest focal length that conditions will allow for. It is an excellent choice for all cameras. The main ring of the planetary is surrounded by much fainter nebulosity and so deeper exposure will be needed to reveal this. Narrowband imaging is effective as it cuts back the light from the surrounding stars. Although this perhaps makes the planetary seem out of context – as it is in a very busy part of the Milky Way – it does have the advantage of showing the detail more clearly, as is the case here.

Technical Information – Fig. 6.5

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	5 × 10 min H-alpha 5 × 10 min OIII 3 × 10 min H-beta (All unbinned)
Field Size:	15' × 11'

Bug Nebula — NGC 6302

Constellation	Scorpius
RA	17 h 13 min 42 s
Dec	−37° 06′ 00″

NGC 6302 is a bright, bi-polar planetary nebula famous for its similarity to a bug splattered on a car windshield! Shining at magnitude 9.6, the Bug covers $3' \times 1.4'$ which equates to a physical size of 2 light years at a distance of 3,800 light years from Earth.

Imaging

Due to its magnitude the Bug Nebula is bright enough to be a target for any camera and due to the strength of both H-alpha and OIII it is an excellent choice for narrowband imaging. So for those with narrowband capability it is a good target to leave for a Moonlit night, as was the case with Fig. 6.6. There are small amounts of nebulosity that appear to have been ejected from the main area. These can be seen to the right in this image. These areas are quite faint and so deeper exposure may be required to capture them. As always with small planetaries, long focal length is required to do it justice. If your available field is larger than $50' \times 30'$ then it is probably not worth considering the object.

Technical Information – Fig. 6.6

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QHY9 Mono
Exposures:	8 × 10 min H-alpha 8 × 10 min OIII 4 × 10 min H-beta (All unbinned)
Field Size:	13' × 10'

Prawn Nebula — IC 4628

Constellation	Scorpius
RA	16 h 55 min 36 s
Dec	−39° 30′ 00″

IC 4628 is a large emission nebula next to the open cluster Trumpler 24. Covering 30′ × 15′ this nebula is best seen through a scope using a narrowband filter. The Prawn Nebula sits at 6,000 light years from Earth.

Imaging

The Prawn Nebula is the most interesting part of a much larger area of nebulosity which is bright and an easy target for any camera even at relatively short exposures. A field size of about 2° × 1° is necessary to frame the Prawn itself. However, if a larger field is used, of at least 3° × 2.5°, then the impressive open cluster NGC 6231 can also be included in the frame as well as Trumpler 24.

Technical Information – Fig. 6.7

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	10 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	1.7° × 1.1°



Fig. 6.7 Prawn Nebula (north is left).

Rho Ophiuchi Nebula — Barnard 47 & 51

Constellation	Ophiuchus/Scorpius
RA	16 h 32 min 17 s
Dec	−24° 16′ 14″

Possibly one of the most colorful and diverse targets to photograph in the sky, the Rho Ophiuchi Nebula is a difficult object to observe due to its great size. Reflection and dark nebulae suffer from the fact that they have very indistinct edges to them. This makes it harder for an observer to determine where the object begins and ends.

Barnard 47 and 51 are the two long, dark nebulae seen heading up and to the right in the image. These can be traced in binoculars and telescopes. The golden yellow nebulosity is being lit up by the red giant star Antares. The globular cluster M4 (see Fig. 6.24) sits just underneath Antares, while Rho Ophiuchi itself lights up the distinctly blue reflection nebula.

Imaging

This is a great target for any camera due to the variety of objects in the field. The faintest part of the image is the red nebulosity to the left of this image and deep exposing is required to capture it. However, individual exposures need to be kept relatively short due to the presence of Antares. A lens of 55 mm or less is needed to frame this object as a field of about $10^\circ \times 7^\circ$ is required to capture all the different beautiful elements of this area of the sky. As can be seen in the reference chart (Fig. 6.2), the dark-lanes are actually more extensive than is shown in Fig. 6.8, and lead all the way up to the Milky Way Kiwi; therefore a lens with a wider field of view will capture their true size and much more besides.



Fig. 6.8 Rho Ophiuchi Nebula (north is right).

Technical Information – Fig. 6.8

Camera Lens:	Canon 18–55 mm at 55 mm
F-stop:	f5.5
Camera:	QSI 583wsg Mono
Exposures:	10 × 5 min L
	5 × 5 min R
	5 × 5 min G
	5 × 5 min B
	(All unbinned)
Field Size:	10.6° × 7.5°

Cat's Paw Nebula — NGC 6334

Constellation	Scorpius
RA	17 h 20 min 24 s
Dec	−18° 51' 54"

Not an overly bright emission nebula in telescopes, this is however an interesting field. There are four fairly round nebulous patches that make up the toe pads of the Paw and another elongated patch that marks the heel. An OIII filter will reveal the stream of faint nebulosity heading away to the north-west. Also located on the west side of the Cat's Paw is the dark nebula Barnard 257. NGC 6334 is situated at a distance of 5,550 light years.

Imaging

This is an excellent object for all cameras and for those with a short tube refractor it is a great object to put it through its paces. If possible try to include Barnard 257 in the image as it provides good contrast. For those whose scope/camera combination provides a field size of around 30' × 20' it is worth considering imaging just one of the three Paws. Each of them consists of an interesting intricate lattice of nebulosity and any of them would make a great image in itself.

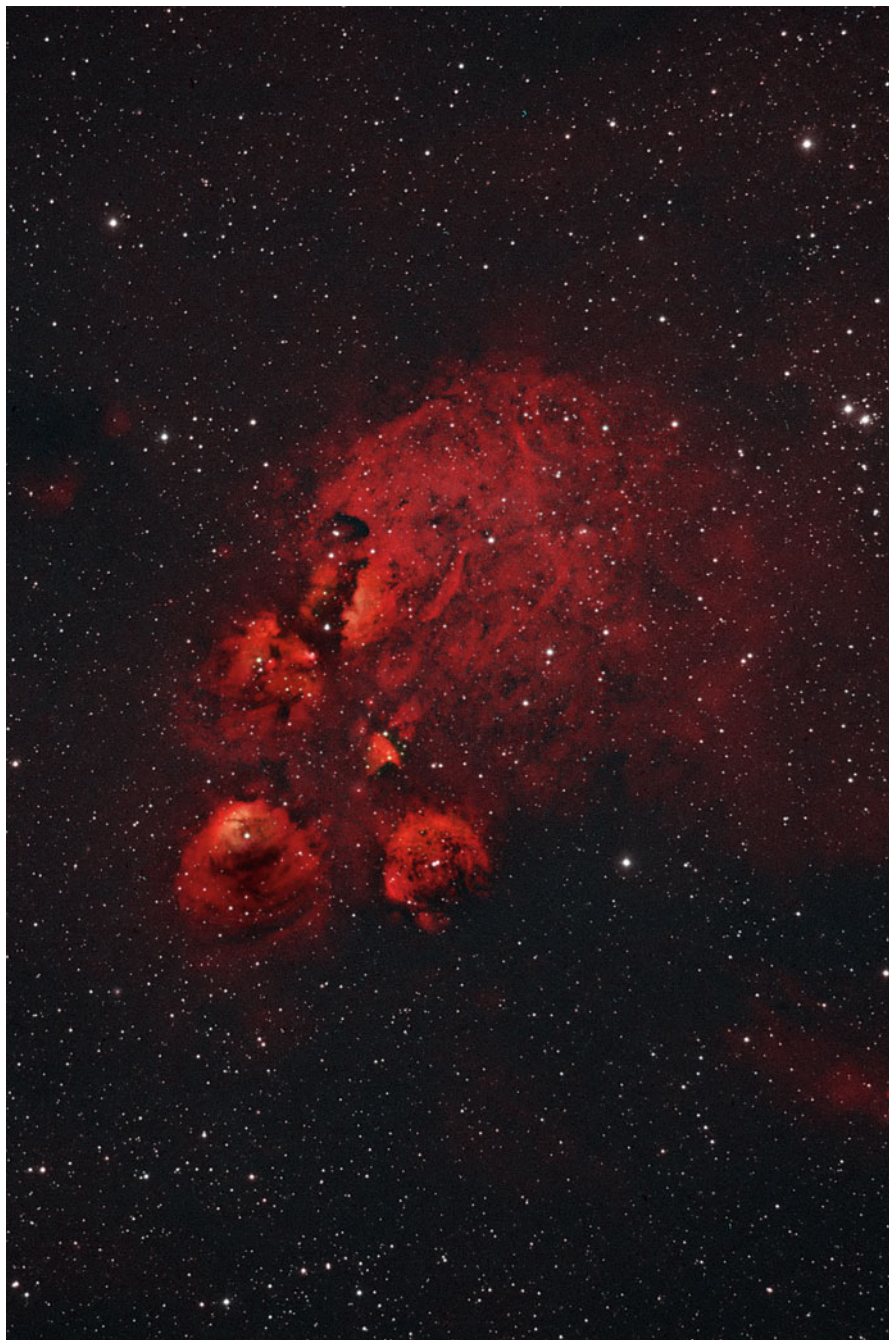


Fig. 6.9 Cat's Paw Nebula.

Technical Information – Fig. 6.9

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	6 × 15 min H-alpha
	6 × 15 min OIII
	4 × 15 min H-beta
	(All unbinned)
Field Size:	1.7° × 1.1°

Lobster Nebula — (War & Peace Nebula) — NGC 6357

Constellation	Scorpius
RA	17 h 22 min 18 s
Dec	−38° 29′ 00″

This is a large, faint and very complex emission nebula. Images with south at the top show an obvious lobster-like creature complete with pincer-shaped claws and buggy eyes! Others however see the brightest section, which is the mouth of the Lobster, as a white dove, while in the eastern section (to the right in the image) they see a skull, hence the reference to war and peace.

Above the white dove is the small open cluster Pismis 24. The star Pismis 24-1 is believed to be a pair of stars where each component is over 100 solar masses in size. The white dove is the only part of the nebula complex to be seen in a telescope. The whole complex sits at 8,000 light years from the Sun.

Imaging

The Lobster is a relatively large nebula requiring a field of view of at least $2^\circ \times 1^\circ$ to frame it completely. A great object for the short focal length refractor with any camera. As can be seen in the heart of the galaxy reference chart (Fig. 6.2) the Lobster Nebula is only a few degrees away from the Cat's Paw Nebula. Therefore a good image could be obtained by using a long focal length camera lens and capturing both objects in the same field of view. At the opposite extreme there are many excellent fields that can be chosen using a much smaller field of view. The lower image of Fig. 6.10 is taken of just the brightest part of the nebula using a scope of over 2,000 mm focal length.

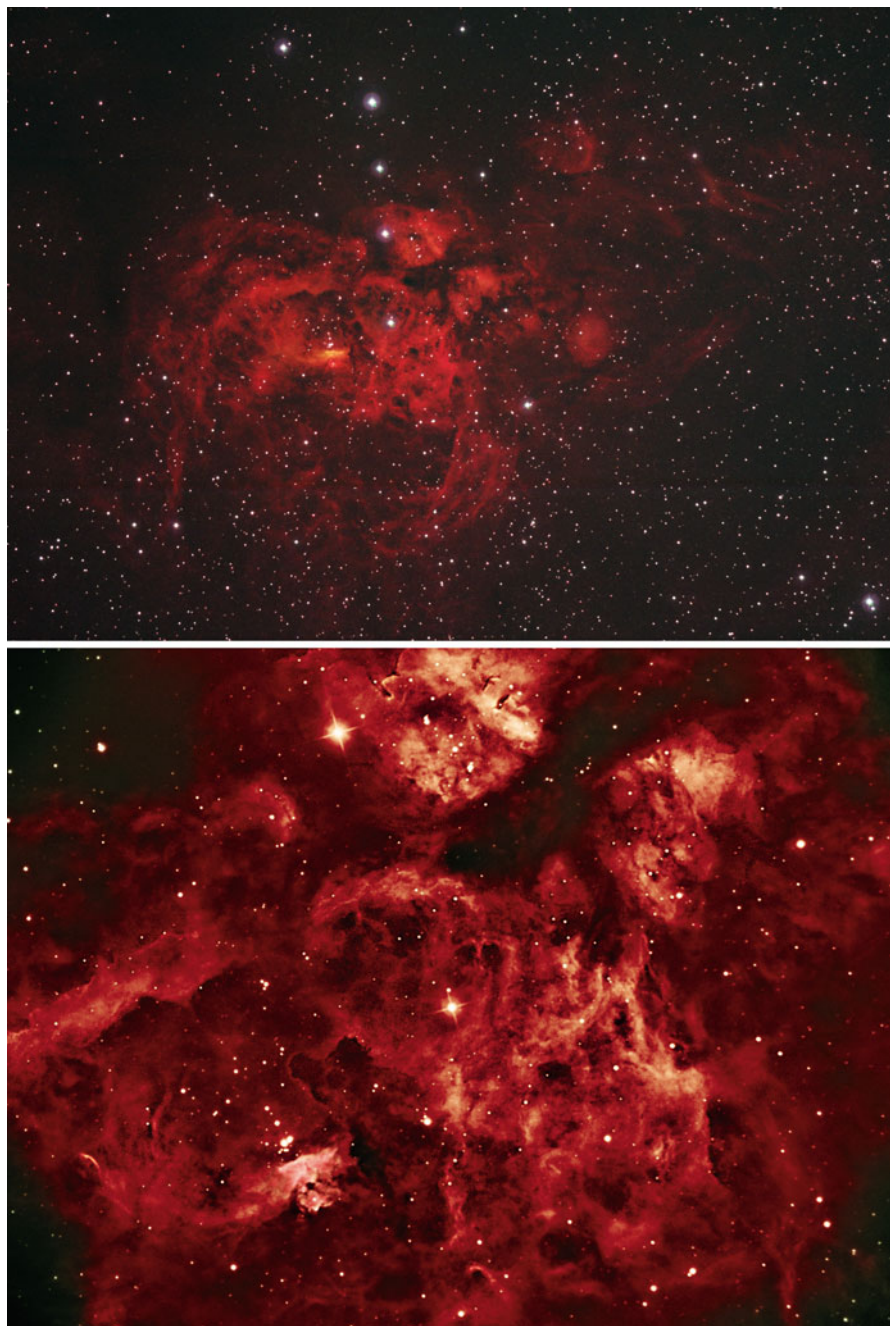


Fig. 6.10 Lobster Nebula (south is up).

Technical Information – Fig. 6.10 top image

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	6 × 15 min H-alpha 6 × 15 min OIII 4 × 15 min H-beta (All unbinned)
Field Size:	2° × 1.3°

Technical Information – Fig 6.10 bottom image

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QHY9 Mono
Exposures:	6 × 10 min H-alpha 6 × 10 min OIII 4 × 10 min H-beta (All unbinned)
Field Size:	31' × 24'

Butterfly Cluster — M 6 — NGC 6404

Constellation	Scorpius
RA	17 h 40 min 06 s
Dec	−32° 13′ 00″

On close inspection through any small telescope the pattern that makes up the shape of a Butterfly is very distinct. The majority of the stars in the cluster appear to run from south-west to north-east in two almost parallel lines, the southern line ending in a red giant. In the center however is a rectangular wedge of stars at right angles coming in from the north-west making the body of the Butterfly while the two rows mark the wings.

There are around 80 stars covering 33'. The cluster is an easy target for binoculars. M 6 lies at 5,222 light years.

Imaging

The stars that make up the Butterfly Cluster are fairly bright so exposures must be kept short in order to maintain their color and to prevent saturation. A field of about 50' × 40' is all that is required to frame the cluster but as it is embedded in rich star fields with nebulosity it is worth using a larger field. Collecting extra data is necessary to pick up the red nebulosity.

Technical Information – Fig. 6.11

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	6 × 3 min R 6 × 3 min G 6 × 3 min B (All unbinned)
Field Size:	2.3° × 1.7°



Fig. 6.11 Butterfly Cluster (south is up).



Fig. 6.12 M 7.

M 7 — NGC 6475

Constellation	Scorpius
RA	17 h 53 min 54 s
Dec	−34° 49′ 00″

A brilliant naked eye open cluster that sits off the end of the stinger in Scorpius, M 7 is easily resolved in small binoculars and needs a wide field to be viewed properly in a telescope as it covers 80'. The cluster contains around 80 brilliant, white stars with sprays that radiate from a central core. M 7 is estimated to be between 800 and 1,000 light years from Earth.

Imaging

As the cluster covers a relatively large area a field of view of at least 2° × 1° is necessary to do it justice. If using a monochrome CCD camera RGB exposures are all that is necessary to capture all the detail. M 7 is only 6° away from M 6 so an image containing both clusters is possible.

Technical Information – Fig. 6.12

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	6 × 3 min R 6 × 3 min G 6 × 3 min B (All unbinned)
Field Size:	2.2° × 1.7°

M 21 — NGC 6531

Constellation	Sagittarius
RA	18 h 04 min 24 s
Dec	−22° 30′ 00″

Often overlooked due to its brilliant nebulous neighbors, M 20 and M 8, this fine cluster contains around 70 stars in an area of 13'. Fig. 6.13 shows the exquisite loop of stars just north of the *lucida* at the center.

M 21 sits at 4,250 light years from the Sun.

Imaging

Although a field of view no larger than 50' × 30' is required to frame this object effectively it is also a nice addition to an image of M 20, which lies less than 1° away. Keep exposures short in order to avoid saturating the stars.

Technical Information – Fig. 6.13

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	6 × 3 min R 6 × 3 min G 6 × 3 min B (All unbinned)
Field Size:	30' × 22'



Fig. 6.13 M 21.



Fig. 6.14 Wild Duck Cluster (M 11).

Wild Duck Cluster — M 11 — NGC 6705

Constellation	Scorpius
RA	18 h 51 min 06 s
Dec	−06° 16′ 00″

M 11 is a compact, but very rich galactic cluster that contains 2,900 stars in an area of 13'. This open cluster is not too dissimilar to some of the looser globular clusters we can see. Higher powers in modest telescopes reveal the flying V shape that leads to its descriptive name of the Wild Duck Cluster. M 11 sits at 6,200 light years from the Sun.

Imaging

The Wild Duck Cluster is a great target for all cameras. It is a fairly small open cluster so a field of view no larger than 50' × 40' is required to make the most of the object. It contains stars of many different colors so ensure that they do not saturate.

Technical Information – Fig. 6.14

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	12 × 6 s R 12 × 60 s G 12 × 60 s B (All unbinned)
Field Size:	29' × 22'

Snake Nebula — Barnard 72

Constellation	Ophiuchus
RA	17 h 23 min 30 s
Dec	−23° 38′ 00″

Barnard 72 requires a night of great transparency to be easily seen. Small telescopes will reveal the Snake-like features set against the rich Milky Way field. The inky black spots to the west are a real standout in the telescope as well. B 72 is about 18′ across and lies no more than 1,600 light years away from us.

Imaging

The Snake Nebula is an easy target for any camera. While a field of view as small as 25′ × 20′ will frame the Snake, the real beauty of the object derives from its position in the wider rich star field. So the object actually benefits from a larger field of view. If using a monochrome CCD camera, no luminance data is required for this object.

It is possible that the Barnard catalog will not be in the GOTO handset or planetary program. Therefore the provided coordinates might be the best way to locate the Snake.

Technical Information – Fig. 6.15

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	6 × 5 min R 6 × 5 min G 6 × 5 min B (All unbinned)
Field Size:	2.5° × 2.0 °



Fig. 6.15 Snake Nebula B 72.



Fig. 6.16 Small Sagittarius Star Cloud (M 24).

Small Sagittarius Star Cloud — M 24

Constellation	Sagittarius
RA	18 h 16 min 30 s
Dec	−18° 50′ 00″

Visible to the unaided eye as a distinct star cloud, M 24 is a fine object in binoculars and small telescopes with a wide field of view. M 24 covers an area of about 120' × 40'. This star cloud, although in Sagittarius, actually belongs to the more distant spiral arm in Norma about 10,000 light years away. In spite of its greater distance compared to the brighter star clouds of Sagittarius, M 24 is far more rewarding in a telescope with its greater abundance of brilliant stars set over a faint bed of back-ground stars.

Fig. 6.16 shows the small cluster NGC 6603 embedded in the north-east end of the star cloud. In the bottom left corner is the emission nebula IC 1283 – 84.

Imaging

Close to the celestial equator this object is available to many northern hemisphere imagers. Any camera/scope can do this object justice so long as it can deliver a field of view of at least 2.5° × 2°. A larger field is actually preferable as it allows room for more dark area around the cloud thus adding contrast to the image. As very short exposures are all that is required it might even be possible to image this unguided.

Technical Information – Fig. 6.16

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	5 × 3 min R
	5 × 3 min G
	5 × 3 min B
	(All unbinned)
Field Size:	2.7° × 2.0°

Trifid Nebula — M 20 — NGC 6514

Constellation	Sagittarius
RA	18 h 02 min 18 s
Dec	−23° 02′ 00″

One of the most famous nebulae in the sky, M 20 is the best example of color contrast available to telescopic observers as far as nebulosity is concerned. With a modest sized telescope, 8" aperture or more, this object will test your eye's color acuity. The steely blue of the reflection nebula sits in stark contrast to the brighter red of the southern edge of the emission nebula. The famous tri-forked dark-lanes that give this nebula its name can be brought out more with a narrowband filter. Super hot young stars at the center are affecting the young, embryonic stars trying to form on the fringes of the nebula much like similar features called the Pillars of Creation in the Eagle Nebula (M 16).

Visually we see the nebula cover $20' \times 20'$, but the camera extends that by another 50%. M 20 sits at a distance of 5,200 light years from Earth.

Imaging

The Trifid Nebula is one of the most frequently imaged object south of the celestial equator, partly because it has a declination of −23 Dec and is thus available to many in the northern hemisphere. It makes a great target for all cameras due to its mixture of red emission and blue reflection nebula. Due to its distinctive appearance it looks good in any field of view large enough to frame it. The emission nebula is brighter than much of the blue reflection nebula so in order to capture all the blue nebulosity on offer it is worth spending the time to collect many exposures.



Fig. 6.17 Trifid Nebula.

Technical Information – Fig. 6.17

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	15 × 5 min L
	10 × 5 min R
	10 × 5 min G
	10 × 5 min B
	(All unbinned)
Field Size:	40' × 30'

Lagoon Nebula — M 8 — NGC 6523

Constellation	Sagittarius
RA	18 h 03 min 48 s
Dec	−24° 23′ 00″

The Lagoon Nebula is so large, $57' \times 41'$, that it needs the widest possible field on any telescope just to show some sky around it for contrast! Visible to the naked eye as a discrete nebulous spot set against a dark area near the true center of the Milky Way, a hand held OIII filter placed carefully in front of the observer's eye reveals M 8 as the brightest light source in that part of the sky. Using the same filter through a modest telescope we see a wealth of structure throughout the nebula, especially the numerous Bok Globules that are the birth place of future stars trying to coalesce from the cold, black sooty material. The Bok Globules are best seen in the close-up image (bottom image in Fig. 6.18). M 8 lies at the same distance from us as M 20.

Imaging

Due to its brightness the Lagoon is an easy target for any camera and a good start for those beginning astroimaging. Even very short exposures will pick up great detail. It is also a great target for any optical set-up as there are countless ways to frame it. The top image in Fig. 6.18 shows the full extent of the nebula and is taken with a short tube refractor. An even wider field would enable the inclusion of the nearby nebulae NGC 6559 and IC 1274. If a camera lens or very short scope is used, the Lagoon Nebula can be framed alongside the Trifid Nebula. At the other end of the scale there are many interesting features at the heart of the Lagoon that a long focal length scope can be used to great effect, as in the bottom image of Fig. 6.18. It is also an excellent contender for narrowband imaging.



Fig. 6.18 Lagoon Nebula.

Technical Information – Fig. 6.18 top image

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	10 × 10 min L 5 × 10 min R 5 × 10 min G 5 × 10 min B (All unbinned)
Field Size:	2.3° × 1.7°

Technical Information – Fig. 6.18 bottom image

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	6 × 10 min H-alpha 6 × 10 min OIII 4 × 10 min H-beta (All unbinned)
Field Size:	28' × 20'

Swan Nebula — Omega Nebula — M 17 — NGC 6618

Constellation	Sagittarius
RA	18 h 20 min 48 s
Dec	-16° 11' 00"

The image of a swan is mostly seen through a telescope with south up. The reference to the Omega Nebula originally came from photographs where the field is as per Fig. 6.19. From this some people see a capital Ω .

Even in a small telescope this is a stunning sight. The bright portions have great structure. In larger apertures with an OIII filter the fainter swirls and wreaths are revealed.

M 17 is some 5,000 to 6,000 light years from the Sun.

Imaging

All cameras and scopes can get something out of this object. Fig. 6.19 does not show the full extent of the nebulosity in this area. To show this requires a field size of at least $2^\circ \times 1.5^\circ$. However, long focal lengths have the advantage of being able to tease out all the filaments that make this object so fascinating. It is an excellent object for narrowband imaging on a Moonlit night, as has been done here.

Technical Information – Fig. 6.19

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	6 × 15 min H-alpha 6 × 15 min OIII 4 × 15 min H-beta (All unbinned)
Field Size:	42' × 30'



Fig. 6.19 M 17 (north is right).

Eagle Nebula — M 16 — NGC 6611 & IC 4703

Constellation	Serpens Cauda
RA	18 h 18 min 48 s
Dec	−13° 47′ 00″

M 16 is the open cluster while IC 4703 is the famous emission nebula. Together they seem to be linked to M 17 across the border in Sagittarius.

The Pillars of Creation, made famous by the Hubble Space Telescope, (in the center of Fig. 6.20), are best seen with an OIII filter in larger telescopes. The brilliant white stars of the cluster at the heart of the nebula are blasting out a cavity in the nebula. In the process they are destroying the proto-stars in the vicinity. The denser parts of the surrounding nebulosity are protecting the material in the leeward side of the stellar winds, but not forever.

The image reveals the spread out wings of the Eagle, and the faint head and beak as well. Some claim to be able to see a face when the image is orientated as per Fig. 6.20.

M 16 is 6,500 light years from us.

Imaging

Due to its fame, and its close proximity to the celestial equator, the Eagle Nebula is a very satisfying target for those new to astroimaging the world over. It is large and bright so any camera with any scope or lens can do it justice. If the whole Eagle is desired then a field of at least $2^\circ \times 1.5^\circ$ is required. However, if the Pillars of Creation are the target, then a field as small as $25' \times 20'$ will do the job. It is also a great object for narrowband imaging as is the case in Fig. 6.20.



Fig. 6.20 Eagle Nebula (north is left).

Technical Information – Fig. 6.20

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	6 × 15 min H-alpha
	6 × 15 min OIII
	4 × 15 min H-beta
	(All unbinned)
Field Size:	1.76° × 1.2°

The Anteater Nebula — NGC 6723 – 26/27 – 29 – IC 4812 — Bernes 157

Constellation	Corona Australis/Sagittarius
RA	12 h 01 min 54 s
Dec	–18° 51' 54"

The rather bizarre looking complex of dust and gas combines the steely blue reflection nebulae of IC 4812 and NGC 6726/27 which form the bulging eyes with the densest part of Bernes 157 forming the body of the Anteater. From the body faint legs are spread out either side. The Anteater appears to be eyeing up nearby NGC 6723, a globular in neighboring Sagittarius.

As with all reflection/dark dust nebulae combinations this is not an easy object to come to grips with in a telescope. It needs a very wide field and a very dark, transparent night to see this well. The irregular variable star R Coronae Australis is immersed in NGC 6729, the smallest of the three reflection nebulae.

This complex is 420 light years away, while the Anteater may not be as close to its prey as it would like, NGC 6723 is a further 28,000 light years away again!

Imaging

This object is a very satisfying object to image due to its complex nature. It is however quite challenging to capture all its parts. The blue reflection nebulae and the globular NGC 6723 are easy for any camera as they are fairly bright. However, the dark, dusty nebulae are much fainter and require a fairly dark sky. Much extra exposure will be needed to really bring this nebulosity to the fore. A field of view of at least $2.5^\circ \times 2^\circ$ is required to capture all the dusty areas. However, a smaller field of view can be used to capture just the area around the blue reflection nebulae to great effect.



Fig. 6.21 Anteater Nebula (north is right).

Technical Information – Fig. 6.21

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	2.7° × 2.1°

M 22 — NGC 6656

Constellation	Sagittarius
RA	18 h 36 min 24 s
Dec	−23° 54′ 00″

This globular is arguably the third most impressive after 47 Tucanae and Omega Centauri. The cluster’s proximity at 10,000 light years makes it one of the closest to us of its type. Easily resolved into a ball of dazzling stars in a small telescope, M 22 was the first globular to be recognized as such in the seventeenth century.

Imaging

A great target for any camera and if using a monochrome CCD camera it is unnecessary to collect luminance data. Due to its size and brilliance M 22 will still look impressive in a field of view as large as 2° × 1.5°. It is the closest of the great southern globulars to the celestial equator so should be available to many imagers even in the north.

If the core saturates then take a set of shorter exposures and layer them when processing the image.

Technical Information – Fig. 6.22

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 3 min R 8 × 3 min G 8 × 3 min B (All unbinned)
Field Size:	36′ × 28′



Fig. 6.22 M 22.



Fig. 6.23 M 55.

M 55 — NGC 6809

Constellation	Sagittarius
RA	19 h 40 min 00 s
Dec	−30° 58′ 00″

M 55 is easily seen in binoculars and finder scopes as a fuzzy patch in a barren area off to the side of the Milky Way. This is a Class XI globular cluster meaning that it is fairly loose and easily resolved. M 55 sits at a distance of 17,300 light years from Earth.

Imaging

A great target for any camera and if using a monochrome CCD camera it is unnecessary to collect luminance data. Due to its size and brilliance M 55 will still look impressive in a field of view as large as $2^{\circ} \times 1.5^{\circ}$.

If the core saturates then take a set of shorter exposures and layer them when processing the image.

Technical Information – Fig. 6.23

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 3 min R 8 × 3 min G 8 × 3 min B (All unbinned)
Field Size:	38' × 31'

M 4 — NGC 6121

Constellation	Scorpius
RA	16 h 23 min 36 s
Dec	−26° 32′ 00″

One of the easiest globular clusters to find in the entire sky, M 4 sits close to the brilliant red super-giant star Antares. Close enough to make the finding easy, but not close enough to be lost in the glare of Antares.

M 4 is a Class IX globular and appears very similar to the Blue Straggler, NGC 6397 in Ara (Fig. 5.23), and they both lie at the same distance of 7,200 light years from Earth. This makes them the closest globulars to us. Easily resolved in small telescopes M 4 can also be found in the wide picture of the Rho Ophiuchi Nebula (Fig. 6.8).

Imaging

To image M 4 on its own requires a field of view of at least 40′ × 30′. However, a camera/scope combination that provides a larger field will enable some of the nebula found in the Rho Ophiuchi Nebula complex to enter the field of view. It is then a case of framing M 4 in such a way as to make the most of the stunning colors that surround it.

Technical Information – Fig. 6.24

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 3 min R
	8 × 3 min G
	8 × 3 min B
	(All unbinned)
Field Size:	36′ × 28′



Fig. 6.24 M 4.



Fig. 6.25 M 25.

M 25 — IC 4725

Constellation	Sagittarius
RA	18 h 31 min 36 s
Dec	−19° 15′ 00″

M 25 seems to be made up of a pair of concave and convex lines of stars with the apex of their two curves almost meeting in the middle. The northern chain has some bright yellow stars on the eastern end.

M 25 is 2,000 light years away and covers around 32'.

Imaging

A great target for any camera in that it only requires short exposures to capture the cluster and the surrounding rich star field. Luminance layering is unnecessary so RGB subs are all that is necessary if a monochrome CCD is used. Although the cluster only covers about 32' a generous field of at least 1° × 1° really helps to frame it. On a side note Pluto lies somewhere in Fig. 6.25!.

Technical Information – Fig. 6.25

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	8 × 3 min R
	8 × 3 min G
	8 × 3 min B
	(All unbinned)
Field Size:	2.4° × 1.8°

Chapter Seven



The Deep South

Apus
Chamaeleon
Dorado
Octans
Pavo
Reticulum
Tucana
Volans

This chapter covers the area mostly within 30° of the south celestial pole (SCP) excluding the Magellanic Clouds (see Chap. 8). Much like its counterpart zone in the northern sky the deep south contains several surprises that are both a challenge and delight to astroimagers.

Clusters, galaxies and dark dusty nebulae are the name of the game in this area of the sky. As it is far from the plain of the Milky Way there are no bright emission nebulae to image so it is one of the more challenging parts of the night sky for the astroimager. Apart from the globular clusters the other objects really require a dark sky to image them successfully. Light pollution suppression filters will cut down the light too much for many of these objects.

NGC 7098

Constellation	Octans
RA	21 h 44 min 18 s
Dec	-75° 07'

This is probably the best galaxy in the constellation of Octans. It is a barred-ring spiral galaxy but visually only the bar region is easy to see. But at high powers using a large aperture telescope the faint ring structure is revealed. This galaxy shines at an overall magnitude of 11.3.

Imaging

At 7' × 3', NGC 7098 is a relatively small galaxy and therefore needs a long focal length in order to capture any detail. Any camera should be able to capture at least some of the galaxy but the arms are much fainter than the core so extensive exposure maybe necessary. However, avoid saturating the core or else take a series of shorter exposures as well that can then be layered in order to restore core detail.

Technical Information – Fig. 7.1

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	14 × 5 min L 6 × 5 min R 6 × 5 min G 6 × 5 min B (All unbinned)
Field Size:	26' × 19'



Fig. 7.1 NGC 7098.



Fig. 7.2 NGC 1672.

NGC 1672

Constellation	Dorado
RA	04 h 45 min 42 s
Dec	−59° 15′

Through a telescope NGC 1672 appears to have only one arm going from the eastern end of the bar and curling north then west. The photograph shows an almost ghost-like arm turning south from the western end of the bar before heading east. This is also a Seyfert galaxy with strong starburst regions surrounding the core along the bar.

NGC 1672 is magnitude 9.7 and covers $6.6' \times 5.5'$, which equates to 75,000 light years across at a distance from us of 60 million light years.

Imaging

The Hubble Space Telescope (HST) has imaged this galaxy and revealed the full extent of HII regions present. While the galaxy is a good target for any camera a DSLR might struggle to pick them up. But if a monochrome CCD camera is used then taking addition H-alpha subs may help to reveal some of the HII.

Technical Information – Fig. 7.2

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	7 × 10 min L
	4 × 10 min R
	4 × 10 min G
	4 × 10 min B
	(All unbinned)
Field Size:	21' × 14'

NGC 6744

Constellation	Pavo
RA	19 h 09 min 48 s
Dec	−65° 51′

This is a beautiful multi-armed barred spiral. At 30,000,000 light years from us it is relatively close so it appears fairly large (20.1' × 12.9') in small telescopes. NGC 6744's brightness (magnitude 8.5) combined with the size makes it a top-draw candidate for viewing or imaging.

Imaging

Due to its size NGC 6744 is a suitable target for a short or medium focal length. A camera/scope combination that provides a field of at least 50' × 40' is ideal. The field used in Fig. 7.3 is really a bit small. It has a much fainter outer arm which will require long exposure time to register. There is also a faint, and much smaller, partner galaxy – NGC 6744A. At magnitude 15.1 it might be a challenge for a DSLR to pick it up.

Technical Information – Fig. 7.3

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 5 min L
	5 × 5 min R
	5 × 5 min G
	5 × 5 min B
	(All unbinned)
Field Size:	28' × 25'



Fig. 7.3 NGC 6744 (north is right).



Fig. 7.4 NGC 6101.

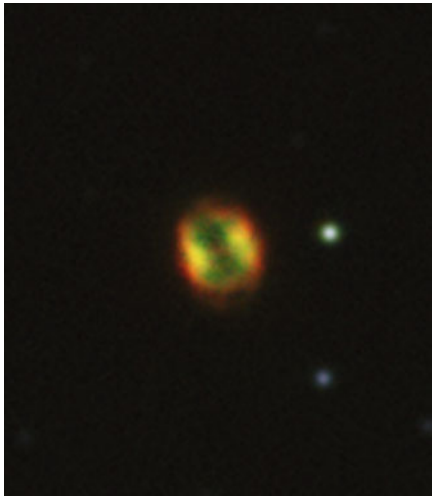


Fig. 7.5 NGC 3195.

NGC 6101

Constellation	Apus
RA	16 h 25 min 48 s
Dec	-72° 12'

NGC 6101 is a Class X globular cluster, which means that it is a fairly loose example. NGC 6101 shines at magnitude 9.2 and covers 5'. This cluster lies at 50,000 light years from the Sun. Modest telescopes of 8" aperture will resolve this lovely cluster to the core.

Imaging

This small, loose globular makes a pleasant change from the giant globulars found in this part of the sky. At magnitude 9.2 it is an easy target for any camera but a medium to long focal length is required that provides a field of view no larger than about 40' × 30'. Any larger and the globular will seem insignificant. Good seeing is required to ensure pinpoint stars.

Technical Information – Fig. 7.4

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 2 min R 7 × 2 min G 7 × 2 min B (All unbinned)
Field Size:	14' × 12'

NGC 3195

Constellation	Chamaeleon
RA	10 h 09 min 24 s
Dec	−80° 52′

NGC 3195 is the last entry in Sir Patrick Moore’s Caldwell Catalogue due to its proximity to the SCP. NGC 3195 is a favorite amongst southern planetary nebula observers. The magnitude 11.6 light is spread over 42". Small telescopes show it well, but higher powers with larger apertures reveal the distinctive bi-polar nature of the outer shell. The nebula sits at 5,500 light years from us. Even though this object is expanding at a rate of 40 km/s and approaching us at 17 km/s, don’t hold your breath to see any change in your lifetime!

Imaging

A camera/scope combination that provides a field no larger than 30' × 20' is required to capture any detail in this planetary. It stands in stark contrast to the other objects in this area of the sky – mainly galaxies, clusters and dark nebulosity. While any camera can be used it is one of the few objects in the deep south that calls out for narrowband imaging. If the camera has this capability it is worth leaving this object for a Moonlit night of good seeing.

Technical Information – Fig. 7.5

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	6 × 10 min H-alpha 6 × 10 min OIII 4 × 10 min H-beta (All unbinned)
Field Size:	4.0' × 3.3'

Great Peacock Globular — NGC 6752

Constellation	Pavo
RA	19 h 10 min 54 s
Dec	−59° 59′

This object is so named because of its position in the constellation of Pavo, the Peacock. It is arguably number four on the globular cluster list ahead of the more renowned Great Hercules Globular, M 13! Small telescopes resolve the dazzling core easily and show the many spidery arms that trail out from the center. The brilliant blue giant foreground star on the south-western edge is the signature of this cluster. This is a stunning sight at high powers in a large aperture telescope.

Covering an area similar to the Moon this fifth magnitude cluster appears as one of the tail feathers in the Peacock to the naked eye. NGC 6752 is actually the third brightest globular in the sky after Omega Centauri and 47 Tucanae. NGC 6752 sits at 13,000 light years from Earth.

Imaging

Due to its magnitude, this globular cluster is an excellent target for all cameras. If using a monochrome CCD it is unnecessary to take luminance data as straight RGB will suffice. Ensure that the bright star does not saturate in order to maintain its color data. A field of at least 40' × 30' is required to frame the entire cluster but it still looks impressive in a much larger field and even a short tube refractor will easily resolve the core.



Fig. 7.6 Great Peacock Globular (north is right).

Technical Information – Fig. 7.6

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 5 min R 8 × 5 min G 8 × 5 min B (All unbinned)
Field Size:	41' × 29'

Pavo Galaxy Cluster — NGC 6872-6876

Constellation	Pavo
RA	20 h 16 min 54 s
Dec	−70° 46′

There are dozens of galaxy clusters in the southern sky that could have been included in this book, but this cluster is a bit above average thanks to one of its main members. NGC 6872 (bottom right in Fig. 7.7) is a giant barred spiral, in fact one of the largest known at 380,000 light years long, which is nearly four times the diameter of the Milky Way. Even at the vast distance of 220 million light years away NGC 6872 still covers 6′ in the telescope. Large apertures reveal the long spindly arms trailing away from an almost circular center. NGC 6876 (center of Fig. 7.7) is the typically dominant giant elliptical galaxy found at the heart of most galaxy clusters.

Imaging

This is one of the easiest galaxy clusters to image and is suitable for all cameras. A field size of about 30′ × 20′ is required to frame the whole cluster but it will still look fine in a larger field. The cluster contains many interesting galaxies that would make fine images themselves. To do justice to NGC 6872 a field no larger than 20′ × 15′ would be required. This same field size could also be used to image NGC 6876 and its companions in fine detail.



Fig. 7.7 Pavo Galaxy Cluster (north is right).

Technical Information – Fig. 7.7

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	9 × 10 min L
	5 × 5 min R
	5 × 5 min G
	5 × 5 min B
	(All unbinned)
Field Size:	25' × 16'

South Celestial Serpent — MW9

Constellation	Apus
RA	17 h 21 min 52 s (The Head)
Dec	−77° 11' 35"
RA	17 h 24 min 50s (The Body)
Dec	−79° 00' 10"
RA	17 h 00 min 00s (The Tail)
Dec	−81° 02' 40"

This is the last entry in the Mandel-Wilson Catalogue of Unexplored Nebulae. This is a very large object covering over $6^\circ \times 1.5^\circ$. Listed as an integrated flux nebula, this type of nebula is largely unheralded due to its size and faintness. Unlike many reflection nebulae that are lit by just a few stars, IFNs are lit by large numbers of nearby stars in the Milky Way.

The Mandel-Wilson Catalogue of Unexplored Nebulae was started by Steve Mandel of Soquel, California, and his main sponsor Michael Wilson in 2004. The Mandel-Wilson Catalogue covers mostly the area around the north celestial pole, with its one entry in the south being MW 9.

Listed above are the centers for the three main parts of the South Celestial Serpent, which runs almost north–south. Fig. 7.8 is however only the back part of the head. This area, which includes the galaxies IC 4633 and IC 4635, was first revealed to the public by David Malin back in the late 1970s. Large aperture telescopes with a wide field can show much of this region from a rural location.

Imaging

The South Celestial Serpent is one of the faintest objects in this book and is only really suited to a monochrome CCD camera in very dark skies. Its vast size calls for the widest possible field of view. This image was taken with a 446 mm refractor and captures only a tiny part of it. A 250 mm camera lens would produce good results. The alternative is to produce a mosaic. If this is attempted ensure that focusing is spot on with all images and that the seeing conditions do not change drastically. If they worsen (or get better) then leave the second frame for another night. An object suitable for a long focal length scope is the galaxy IC 4633 (bottom right of this image). With long exposure this galaxy will be seen to be surrounded by all the dusty nebula of the Serpent.

It is unlikely that the Mandel-Wilson Catalogue of Unexplored Nebulae will be in the planetarium software, or handset, used with your scope so you will have to use the coordinates provided to locate the different parts of the Serpent. It will be more of a challenge to locate on an inaccurate mount. The faint nebosity will not show up on short exposures so it will take perseverance to work out exactly what is in the frame. The best thing to do is to aim for the field centers listed above and adjust the field position as desired. Alternatively aim for IC 4633 as it is one of the brightest objects in the area and most recognisable.



Fig. 7.8 South Celestial Serpent (head only).

Technical Information – Fig. 7.8

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI 583wsg Mono
Exposures:	20 × 10 min L
	10 × 10 min R
	10 × 10 min G
	10 × 10 min B
	(All unbinned)
Field Size:	2.3° × 1.6°

47 Tucanae — NGC 104

Constellation	Tucana
RA	00 h 24 min 06 s
Dec	−72° 05′

South of the celestial equator a battle for supremacy rages in deep space. This is no ordinary battle, although us mere mortals participate. In one camp we have those who believe that this cluster, 47 Tucanae, is the greatest globular cluster in the heavens. In the other camp is an equally ardent group of people who assert, often vehemently, that their champion Omega Centauri (Fig. 5.9) is king of the globulars! Those who try to have a foot in both camps are renounced and challenged to take a side in a fight that could endure for eternity.

The reason for this war is simple – contrast. Two very dissimilar looking globulars that have the ability to stun both novices and veteran observers alike when seen through a good telescope on a fine night. There is also a similarity between the myth surrounding how Orion and Scorpius are chasing each other around the sky. It seems that when one of the two clusters is high in the sky then the other is low.

47 Tuc, as it is often referred to, is a dazzling ball of bright white stars that become suddenly more condensed towards the middle. Easily resolved in small telescopes, through large aperture scopes you feel like a traveller in a spacecraft looking out of the window when viewing 47 Tuc at high powers. The thought that crosses most observers' minds at this point is, "Would this be what it is like to live on a planet around a star when looking up at your night sky?!"

Visible to the unaided eye as a fourth magnitude star sitting just west of the Small Magellanic Cloud (Fig. 8.1), NGC 104 covers just over 30' which corresponds to a diameter of 120 light years at the distance of 16,700 light years from Earth.

Imaging

One of the most frequently imaged globulars in the southern sky it is so bright it can even be captured by a point-and-shoot camera placed against the eyepiece. Fig. 7.9 was taken with a medium focal length scope in order to concentrate on the core. But a short focal length, providing a field of view of up to $2.5^\circ \times 1.5^\circ$ will still show the globular in all its glory with space around it to breathe. As with all globulars, exposure lengths should be as long as possible before saturation occurs. A second set of exposures could be taken in order to layer into the core if necessary. With a monochrome CCD, luminance layering is unnecessary so only RGB need be acquired.



Fig. 7.9 47 Tucanae (north is right).

Technical Information – Fig. 7.9

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 5 min R
	8 × 5 min G
	8 × 5 min B
	(All unbinned)
Field Size:	30' × 24'

75 Tucanae — NGC 362

Constellation	Tucana
RA	01 h 03 min 12 s
Dec	−70° 51′

Often overlooked due to the presence of its illustrious neighbor 47 Tucanae (Fig. 7.9), an opportunity to view this fine cluster should not be missed. At magnitude 6.8 and covering 14' NGC 362 is easily resolved in modest telescopes and handles high powers well.

Globular clusters are considered the oldest objects in the universe but it was found that 75 Tucanae is some three billion years younger than most similar looking globulars. NGC 362 lies at 30,000 light years from the Sun.

Imaging

A great object for a medium or long focal length scope that provides a field of view no larger than 50' × 30'. It is also bright enough for any camera. With a monochrome CCD RGB exposures are all that is required. It is a great cluster to image in the same session as 47 Tucanae (Fig. 7.9) in order to compare these two magnificent objects.



Fig. 7.10 75 Tucanae (north is right).

Technical Information – Fig. 7.10

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 5 min R
	8 × 5 min G
	8 × 5 min B
	(All unbinned)
Field Size:	23' × 18'

Topsy Turvy Galaxy — NGC 1313

Constellation	Reticulum
RA	03 h 18 min 12 s
Dec	−66° 30′

NGC 1313 is a very late type (young) barred spiral full of starburst regions. It's not too dissimilar to the Large Magellanic Cloud, except bigger and more developed. Visually NGC 1313 is only the strong bar and arms that emanate from either end of the bar, as well as a few of the brighter, disconnected patches shown in Fig. 7.11. A narrowband filter used with large apertures will reveal the H-II regions dotted along the arms, but the outer halo is only visible to the camera. The chaotic nature of this galaxy is as a result of an interaction with a neighboring galaxy.

NGC 1313 sits at a distance of 15 million light years from us.

Imaging

The central structure of this galaxy is bright and is accessible to all cameras. However, the dusty outer areas are more challenging to capture and require a dark sky and deep exposure. This image was taken with a medium focal length and hasn't captured the full extent of the dust. Therefore a shorter telescope/camera, providing a field larger than $40' \times 30'$ might actually be preferable. As there is a high abundance of HII regions in the galaxy those with narrowband capability should capture some H-alpha subs to blend in.



Fig. 7.11 Topsy Turvy Galaxy (north is left).

Technical Information – Fig. 7.11

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	15 × 10 min L
	6 × 10 min R
	6 × 10 min G
	6 × 10 min B
	3 × 15 min H-alpha (blended with the red)
	(All unbinned)
Field Size:	28' × 18'

Spanish Dancer — NGC 1566

Constellation	Dorado
RA	04 h 20 min 0 s
Dec	−54° 56′

NGC 1566 is classed as a Seyfert galaxy with an active nucleus that may contain a black hole. Covering $8.3' \times 6.6'$ and shining at magnitude 9.7, the Spanish Dancer is one of the leading galaxies in the Dorado-Reticulum Galaxy Cluster, which lies some 40,000,000 light years from the Sun.

A veritable twin of M 99 in Coma Berenices yet more symmetrical, the spiral pattern of NGC 1566 can be discerned in modest telescopes with powers of 150× or more. It is always a pleasure to get first time viewers of this tight spiral to describe what they see without prompting or prior knowledge. Nine times out of ten they pick up on the spiral arms coiling around the small core.

Imaging

A fairly bright galaxy this is an excellent target for all cameras on, ideally, a medium to long focal length scope that provides a field of view larger than about $30' \times 20'$. Keep exposing until the ends of the outer arms can be seen to touch the galaxy again. While long exposures are best for this ensure that the bright star in the field does not saturate excessively.



Fig. 7.12 Spanish Dancer (north is right).

Technical Information – Fig. 7.12

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 10 min L
	4 × 10 min R
	4 × 10 min G
	4 × 10 min B
	(All unbinned)
Field Size:	25' × 18'

Cobra and the Mouse — Meat Hook Galaxy — NGC 2442 & ESO 59-11

Constellation	Volans
RA	07 h 36 min 18 s
Dec	−69° 32′

Known to southern visual observers as the Cobra and the Mouse, NGC 2442 is also known as the Meat Hook Galaxy.

There are many themes containing a predator/prey situation mapped out across the sky and this is just another one playing out in a quiet corner of the deep south.

NGC 2442 is another apparently one-armed barred spiral galaxy. The reason for this is obviously due to the interaction with the nearby Mouse, ESO 59-11. When viewed with south at the top NGC 2442 appears to be a Cobra snake rearing up to strike at the poor little Mouse.

NGC 2442 is magnitude 10.4 and covers an area of $5.5' \times 4.9'$. The galaxy lies at a distance of 50 million light years away.

Imaging

These galaxies are a good target for any camera. There are many ways to frame them and so any scope can be used successfully, although if the field size is too large the Mouse might appear as just another star and so the pairing will lose some of its appeal. To just frame the Cobra and the Mouse a field no smaller than $17' \times 11'$ is required. With a wider field, at least $25' \times 30'$, a beautiful nearby elliptical galaxy (NGC 2434) could also be in the frame.



Fig. 7.13 Cobra and the Mouse (north is right).

Technical Information – Fig. 7.13

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 10 min L
	4 × 10 min R
	4 × 10 min G
	4 × 10 min B
	(All unbinned)
Field Size:	22' × 16'

Chamaeleon I — IC 2631 – Ced 110-111

Constellation	Chamaeleon
RA	11 h 09 min 48 s
Dec	-76° 37'

Although off the plane of the Milky Way by about seventeen degrees the constellation of Chamaeleon contains three molecular clouds of dust and gas with some that harbor low density star forming regions.

Chamaeleon (Cha) I contains the bright reflection nebulae IC 2631 and Cederblad (Ced) 110 and 111. These three compact blue nebulae contrast greatly with the varying degrees of darkness that pervades an area of nearly three square degrees. The Cederblad Catalogue is a list of mostly reflection nebulae compiled in 1946 by astronomer Sven Cederblad.

The whole molecular cloud appears to have been stirred up literally as there are many signs of concentric structure running east–west along the north–south axis of the nebula as can be seen in Fig. 7.14. This molecular cloud is fairly close to us at 500 light years and contains nearly 300 stars and approximately 80 x-ray sources.

Imaging

This object is an excellent target for a short focal length scope or even a camera lens that provides a field of at least $2.3^\circ \times 1.5^\circ$. However, a larger field might actually be preferable. Although the dusty nebulosity is faint it is still within reach of a DSLR. There are many facets to the object which should be captured. Firstly there is the dusty nebulosity, then there are the blue reflection nebulae (Ced 111 and IC 2631) and finally the yellow reflection nebula (Ced 110). This field can be a challenge to find with an inaccurate GOTO mount but locating the reflection nebula IC 2631 is probably the easiest route.



Fig. 7.14 Chameleon 1.

Technical Information – Fig. 7.14

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI583wsg Mono
Exposures:	12 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	2.3° × 1.6°

Chamaeleon II — Haast Eagle and Possum Nebulae

Constellation	Chamaeleon
RA	12 h 53 min 29 s
Dec	−76° 48′ 30″

In eastern Chamaeleon, south of the constellation Musca, we find Cha II. The nebula complex is riddled with Bok Globules like dark nebulae that seem to have starless cores at this time, but these could eventually ignite at a later stage. These non-cataloged dark nebulae are extremely difficult to observe even with the largest amateur apertures.

Photographically the dark objects contrast nicely with the steely grey dust clouds in this area. From these scattered blobs emerges another tale of predators and prey. (To see this successfully Fig. 7.15 needs to be rotated and viewed with north up.) At the northern-most end of this nebula group lurks the shadowy silhouette of a bird of prey. We have bestowed the descriptive name of the Haast Eagle on this bird. The Haast Eagle, now extinct, was the largest eagle that ever lived. Its wingspan was similar to modern golden eagles, but it was body size that made this bird so great.

Why did we choose the Haast Eagle? Not just because of its great size but also because of its prey, the largest bird that ever lived, the Moa! It just so happens that a few degrees south-west, surrounding the star Beta Chamaeleontis, we have a nebula that strongly resembles the ancient Moa (Fig. 7.17). These two nebulae sit in an area of about ten square degrees.

South-east of the Haast Eagle we find a small bunch of rounded dark spots, some oval and others pointed at one end. Not one of the most popular marsupials in southern hemisphere forests, we have nonetheless immortalized the Possum, seen here climbing down a tree, in the night sky.

Imaging

Due to their low magnitude these dark dusty nebulae require very dark skies to register any data on a CCD sensor. It is likely that a monochrome CCD is all that can be used. This image was taken at 446 mm but the whole dust cloud covers a much wider area. Therefore, using a camera lens on the CCD would make a very good wide field shot – anything up to a $10^\circ \times 10^\circ$ field would be useful. Alternatively a great mosaic could be made which would incorporate Figs. 7.15, 7.16 and 7.17. The trick here is to keep exposing – the more subs taken the more of the dust will show up. As with all these dusty areas in Chamaeleon the field may be difficult to find with an inaccurate GOTO mount. The coordinates should go some way to help. Ensure that excellent flats are taken to help completely remove gradients, which will then allow the very faint dust to be teased out from the background.



Fig. 7.15 Haast Eagle and Possum Nebulae (north is left).

Technical Information – Fig. 7.15

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI583wsg Mono
Exposures:	18 × 10 min L
	8 × 10 min R
	8 × 10 min G
	8 × 10 min B
	(All unbinned)
Field Size:	2.1° × 1.5°

Chamaeleon III — Talon and Thumbprint Nebulae

Constellation	Chamaeleon
RA	12 h 39 min 39 s
Dec	−79° 20′ 15″

In the northern region of Cha III we can find the bright/dark nebula the Thumbprint. The Thumbprint Nebula was first coined by David Malin back in the late 1970s. Visible in large telescopes it still takes a very transparent sky to show this small object at all. The Thumbprint covers $5.5' \times 3.3'$.

Looking at the wider view in Fig. 7.16, and considering the nearby Haast Eagle, we have dubbed this stream of streaky dust, the Talon. The shaft of the Talon stretches up from the south and appears to be reaching to pluck the Thumbprint out of the sky!

The condensations of Cha III have the lowest density of any in the region and are not expected to produce stars. The area is covered with long filaments and the major condensations often consist of clumps of material loosely bound and held mainly by electromagnetism along the filament lines. These nebulae lie approximately 1,600 light years from the Sun.

Imaging

The Thumbprint Nebula is likely to be the most obvious part of this field when trying to locate it successfully because it will appear as a region of no stars. For more information see the Haast Eagle and Possum Nebula above.



Fig. 7.16 Talon and Thumbprint Nebulae.

Technical Information – Fig. 7.16

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI583wsg Mono
Exposures:	15 × 10 min L
	7 × 10 min R
	7 × 10 min G
	7 × 10 min B
	(All unbinned)
Field Size:	1.7° × 1.4°

Chamaeleon III — Moa Nebula

Constellation	Chamaeleon
RA	12 h 18 min 21 s
Dec	-79° 18' 44"

The Moa is the brightest and easiest of the Chamaeleon II and III nebulae to find. The chest is marked by Beta Chamaeleontis while the head is marked by the magnitude 8.0 star HD 106248. Fig. 7.17 shows the reflection nebula around HD 106248 is shining yellow because of the star. The Moa's cranium is a well defined edge like a shockwave front that tapers off to form the beak.

The Moa's back curves off in another apparent shock front to the east of Beta Cha. All of this is just discernible in large telescopes, without a filter. IC 3104, a small elliptical galaxy just south of Beta Cha, makes the perfect Moa's egg. Similar in appearance to the other great southern birds the Emu, Rhea and Ostrich, the Moa lived in magnificent isolation to become the largest bird that ever lived.

Imaging

On a well performing mount the above coordinates will successfully locate the field. Centering the star HD 106248 (center of Fig. 7.17) is all that is required to frame the Moa. Rotating the camera so that east or west is at the top may be beneficial as it will allow for more room around the Moa. Long exposures and very dark skies are required to even register any data at all. Unfortunately this makes the central star a problem as it easily saturates. It might simply be a case of this being a trade-off – the star saturates but the faint dusty nebulosity is picked up (as in Fig. 7.17).

There is little color in the nebulosity so spend much longer gathering luminance subs and just get color detail for star color. Accurate flats maybe essential to remove bad gradients.



Fig. 7.17 Moa Nebula.

Technical Information – Fig. 7.17

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI583wsg Mono
Exposures:	12 × 10 min L
	6 × 10 min R
	6 × 10 min G
	6 × 10 min B
	(All unbinned)
Field Size:	1.7° × 1.4°

Chamaeleon III — Rippling Flames Nebula

Constellation	Chamaeleon
RA	12 h 32 min 24 s
Dec	−80° 13' 42"

The last region of the Chamaeleon III complex contains a series of serpentine shapes that appear like rippling flames along the edge of a fire. These shapes are very reminiscent of the branches of a Kaizuka Tree (Kaizukaibuki – *Juniperus chinensis*). They are purely photographic as this nebulosity is too faint for even the largest of amateur telescopes. The Rippling Flames lie at the feet of the Moa in a south-eastern direction.

Imaging

The dust in this area seems a little thicker than in the other areas of Chamaeleon and because of this it is probably one of the easiest areas of this complex to image. That said, it is still extremely faint and so requires dark skies. A monochrome CCD might be the only sort of camera that can obtain the data.



Fig. 7.18 Rippling Flames Nebula (north is left).

Technical Information – Fig. 7.18

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QSI583wsg Mono
Exposures:	12 × 10 min L
	6 × 10 min R
	6 × 10 min G
	6 × 10 min B
	(All unbinned)
Field Size:	2.2° × 1.5°

Chapter Eight



The Clouds of Magellan

Dorado
Mensa
Tucana

Anyone that has seen the Magellanic Clouds from a dark site may be forgiven for thinking they are simply separate pieces of the Milky Way. This is, however, far from the case. They are in fact irregular dwarf galaxies that are orbiting the Milky Way. Due to their relatively close proximity to us (in galactic terms) they are packed with astronomical objects easily visible in small telescopes and available for amateur astroimaging, many of which take on a character quite different from objects available for imaging in the Milky Way itself.

Back in the late 1950s astronomer Karl Henize produced a catalogue from an extensive survey of the Magellanic Clouds. The catalogue was broken up into various types and objects numbered with the letter N when pertaining to nebulae. It is important to remember that the numbering sequence repeats for both clouds, e.g. N 11 in the Large Magellanic Cloud is not N 11 in the Small Magellanic Cloud.

As the Magellanic Clouds are outside the plane of the Milky Way the light from them travels through less interstellar dust. Interstellar dust is the major cause of stellar light absorption (extinction) and particularly so at OIII wavelengths. The result is that astroimages of objects in the Clouds often have a much more varied mixture of colors in them (in general less red) than those of similar objects in the Milky Way, as can be seen from the images in this chapter. All in all they provide a unique imaging opportunity.

Small Magellanic Cloud — NGC 292

Constellation	Tucana
RA	0 h 52 min 45 s
Dec	−72° 49′ 43″

NGC 292, or the Small Magellanic Cloud (SMC) is the smaller of the two ‘Nubeculas’ first sighted by Europeans during Ferdinand Magellan’s circumnavigation of the globe at the start of the sixteenth century, and later named in his honor.

The SMC is an object that suffers from having a bigger, more illustrious neighbor – the Large Magellanic Cloud (LMC). Often overlooked because of this, the SMC is well worth the effort to visit. The gourd-like shape of our little satellite galaxy is easily distinguished in binoculars. By following a trail from the brilliant blue giant stars of the bowl where the Magnificent Seven reside, and flowing out through the oxygen rich NGC 346 to the nearer nebula groups containing NGC 456 and NGC 602, you can gain an appreciation of what a truly distended galaxy this is. The SMC is tidally distorted by both the LMC and our own Milky Way. In so doing we are causing an eruption of star forming regions in both Magellanic Clouds. The SMC sits at 210,000 light years from Earth.

Imaging

Due to its large size the SMC requires a camera lens to capture it in its entirety – between 50 and 80 mm is an ideal size. It is therefore a particularly good object for a piggybacked DSLR. While it will increase the required exposure time, if a low quality lens is used (as was with Fig. 8.1) it is worth stopping down the lens to reduce coma. With a monochrome CCD camera take some H-alpha and OIII exposures to help bring out the nebulosity. If 47 Tucanae (bottom center) is saturating it is also worthwhile taking some short exposures to help restore its core. If using a wider angle lens both the Small and the Large Magellanic Clouds can be accommodated in the same field and make a wonderful pair.

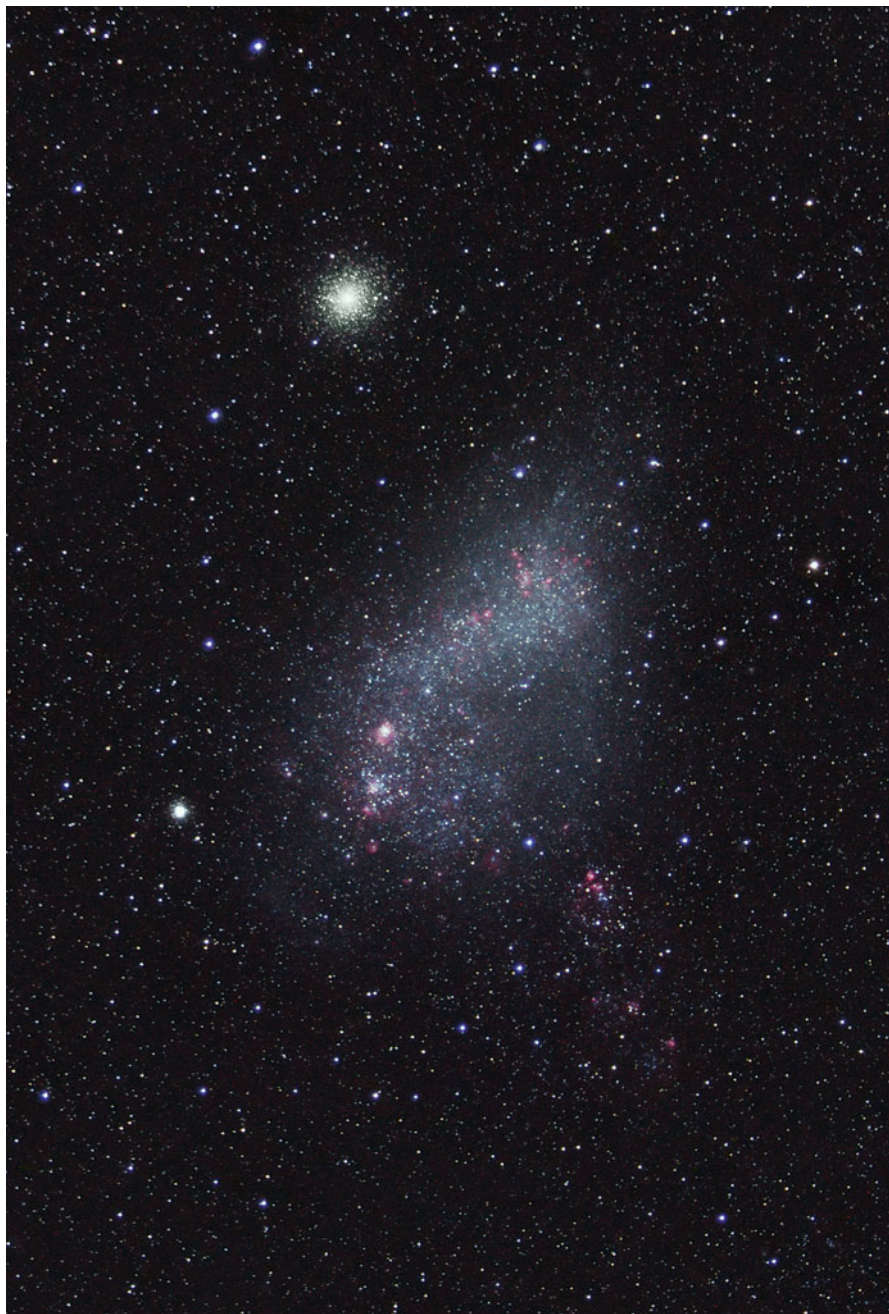


Fig. 8.1 Small Magellanic Cloud (north is left).

Technical Information – Figs. 8.1 and 8.2

Camera Lens:	Canon 18–55 mm at 55 mm
F-stop:	f/5.5
Camera:	QSI583wsg
Exposure:	8 × 5 min L
	6 × 5 min R
	6 × 5 min G
	6 × 5 min B
	3 × 10 min H-alpha (blended with the red)
	(All unbinned)
Field Size:	8.5° × 6.9°

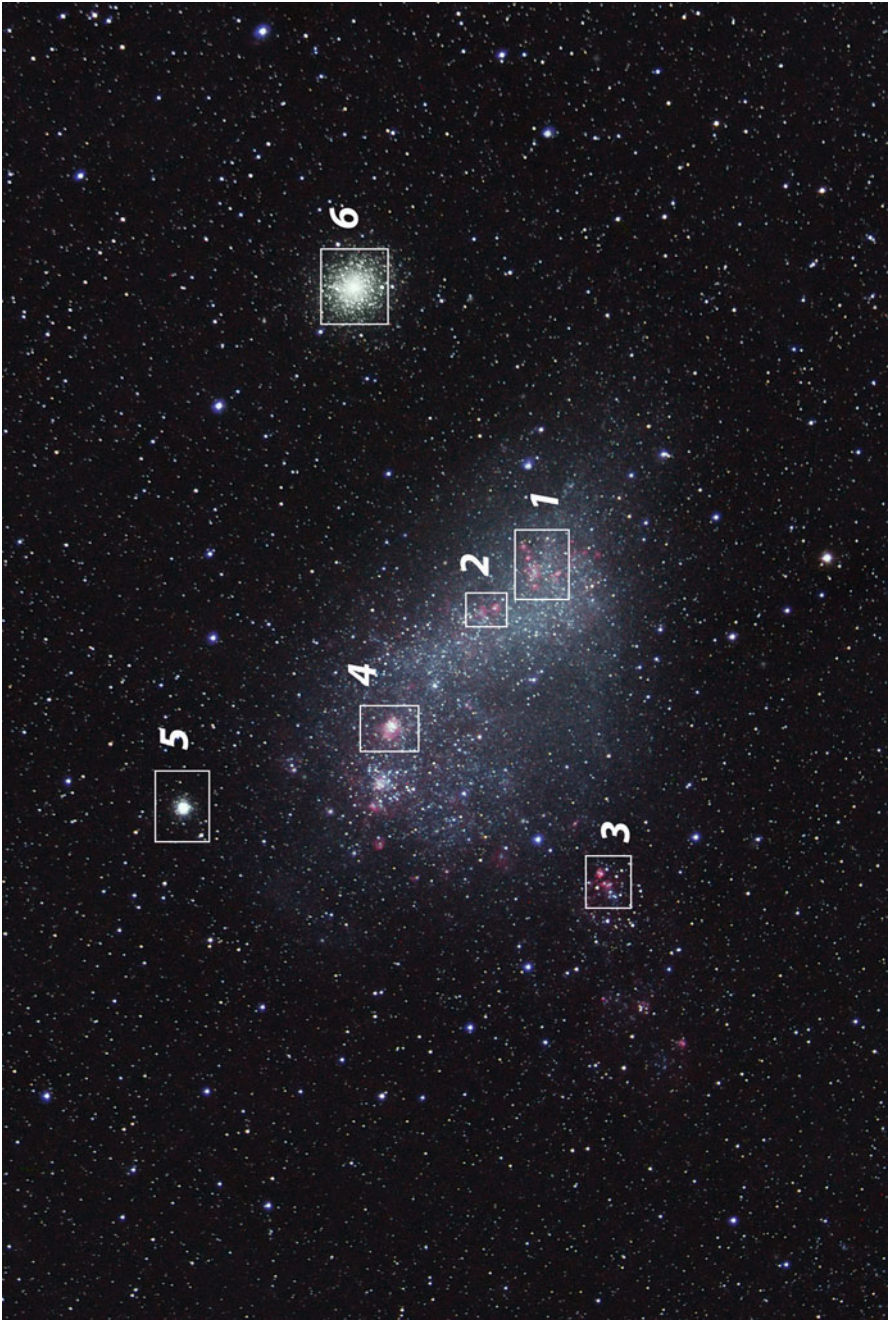


Fig. 8.2 Small Magellanic Cloud Reference Chart.

Small Magellanic Cloud Reference Chart

Fig. 8.2 shows the positions of the objects in the SMC that are presented in this chapter. While this won't necessarily help you to locate the objects it does put them into context and gives some idea of the amount of interesting areas that are to be imaged in the SMC. Also included are the nearby magical globular clusters of 47 and 75 Tucanae from Chap. 7.

1. **The Magnificent Seven** Fig. 8.3
2. **N36 and N37** Fig. 8.5
3. **NGC 456-60-65** Fig. 8.6
4. **NGC 346** Fig. 8.7
5. **75 Tucanae** Fig. 7.10
6. **47 Tucanae** Fig. 7.9

Magnificent Seven – NGC 249–261–267, Dem 132, N 25–28–30

Constellation	Tucana
RA	0 h 47 min 00 s
Dec	−73° 12′ 30″

Being in the most distant part of the SMC we find things a little condensed compared to the nearer side of this galaxy. In this field there are seven, mostly round nebulae composed strongly of oxygen that happen to form the number 7 or the letter L depending upon when you view them.

Modest telescopes show the Seven faintly, but with larger apertures and using an OIII filter make the Magnificent Seven a highlight on a tour of the SMC.

Although this has been presented as one target, the Magnificent Seven actually comprises many objects, each with their own unique catalogue number often taken from completely different catalogues even though they are within a few arcminutes of each other. This is the case with most of the targets presented in this chapter. Fig. 8.4 is an example of a reference chart that shows the number of actual catalogued objects that exist within a $25' \times 20'$ field.

Imaging

A medium to long focal length scope is required to fit the whole Seven in the same field of view – a field of at least $25' \times 20'$. If a scope/camera combination gives a larger field – over 1° – then the Seven can also be framed with both N 36 and N 37 (Fig. 8.5). LRGB works well with this object, as do narrowband filters. For those with narrowband capability it is worth collecting both H-alpha and OIII subs to produce a hybrid image. But the image does not work well processed as HaRGB as the red color is likely to overpower the abundance of color arising from the OIII in the object.

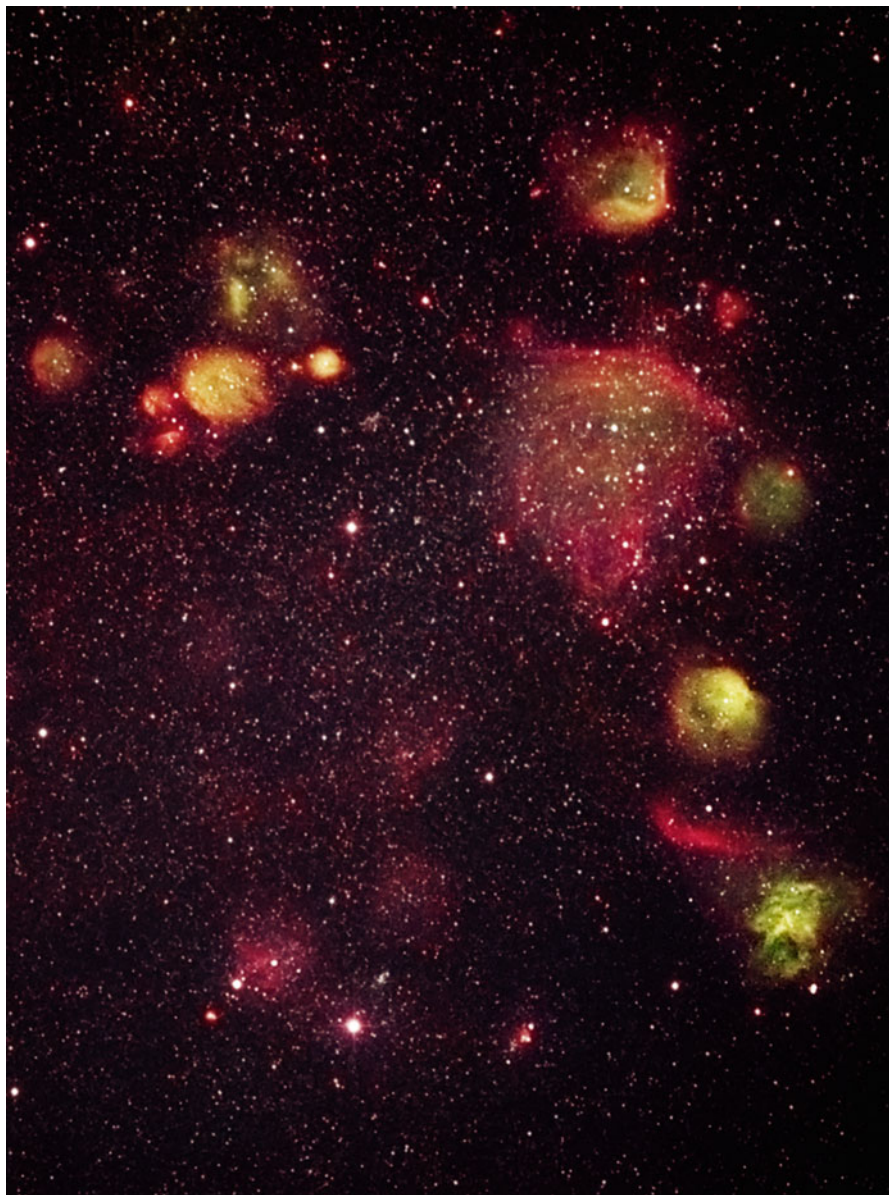


Fig. 8.3 Magnificent Seven (north is right).

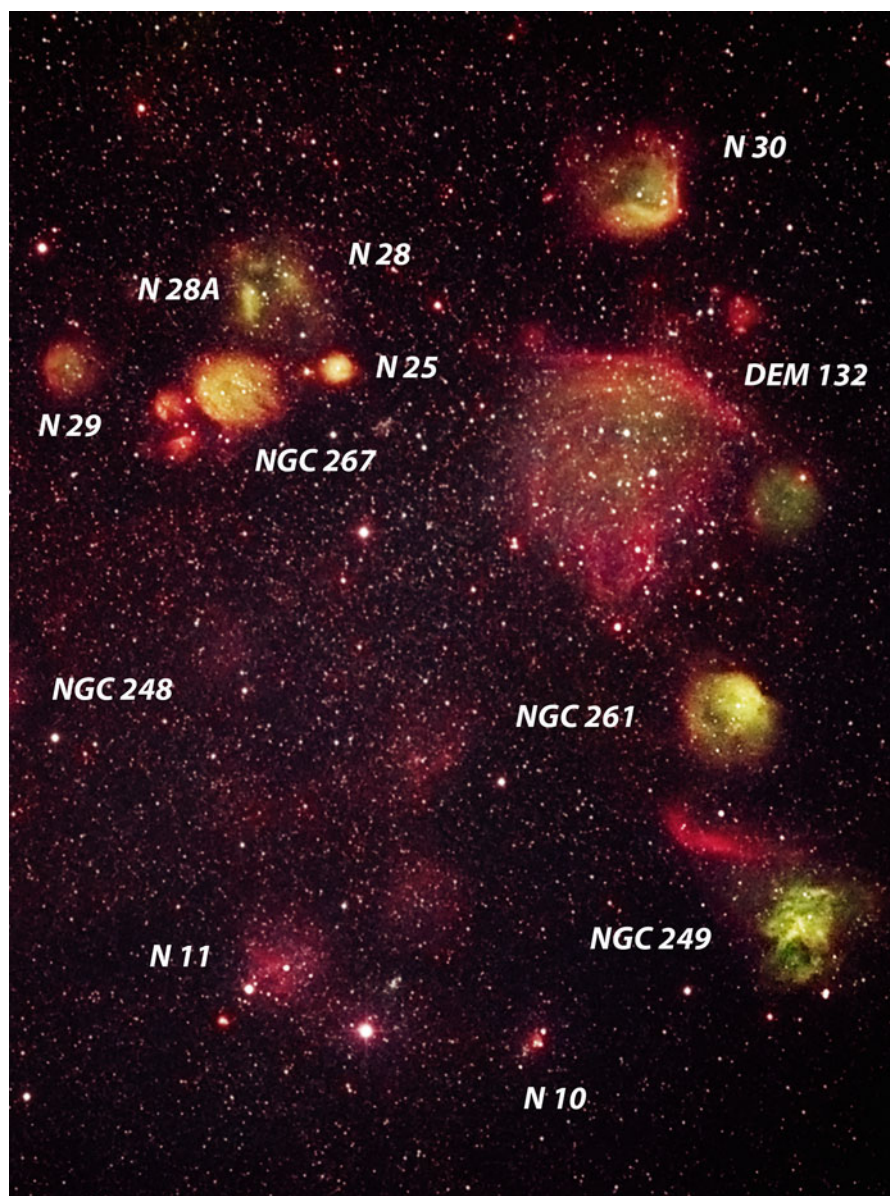


Fig. 8.4 Magnificent Seven (annotated).

Technical Information – Figs. 8.3 and 8.4

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 15 min H-alpha
	6 × 15 min OIII
	4 × 14 min H-beta
	(All unbinned)
Field Size:	25' × 20'

N 36-37

Constellation	Tucana
RA	0 h 52 min 00 s
Dec	-72° 45' 00"

This pair of emission nebulae is the first to be encountered on our way out from the heart of the SMC. The main pair of nebulae is fairly bright and responds well to the OIII filter in large telescopes, but the rest of the nebulosity shown in Fig. 8.5 is extremely faint.

Imaging

As this nebulous region is very faint it is not well suited for DSLR. Even OSC cameras may find it difficult to collect sufficient data to do it justice. It responds well to LRGB imaging although deep exposure is necessary in order to reveal the fainter nebulosity. A field of about 60' × 40' is required to frame the object. A scope/camera combination that provides a field size of over 2° × 1.5° will enable these nebulae to be coupled with the Magnificent Seven (Fig. 8.3).

Technical Information – Fig. 8.5

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	14 × 10 min L 8 × 10 min R 8 × 10 min G 8 × 10 min B (All unbinned)
Field Size:	36' × 30'



Fig. 8.5 N 36-37 & DEM 87.

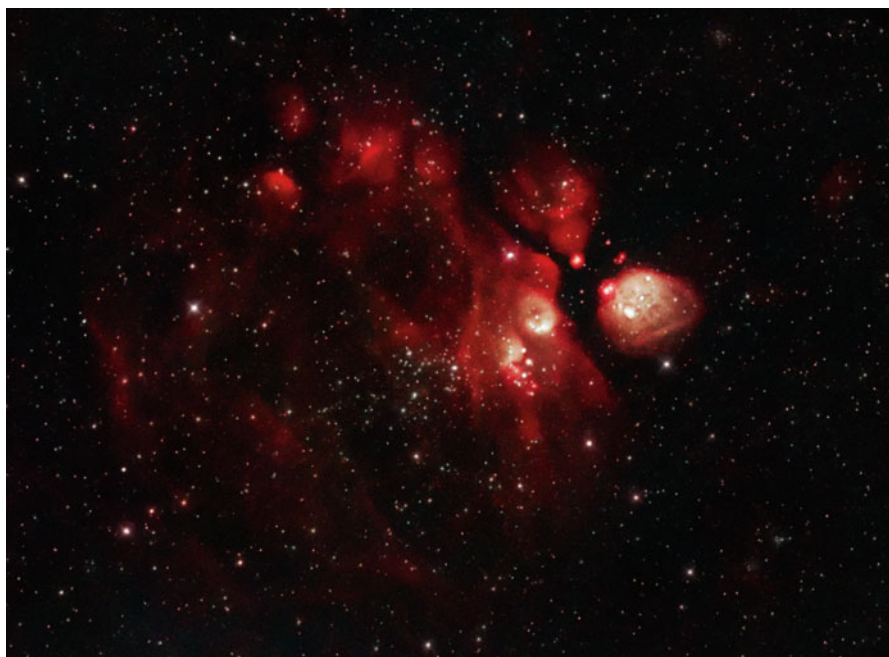


Fig. 8.6 NGC 456-60-65.

NGC 456 – 60 – 65

Constellation	Tucana
RA	1 h 15 min 25 s
Dec	-73° 17' 51"

Like a menagerie of weird creatures the array of emission nebulae around NGC 456 is worth examining in detail through a large telescope using an OIII filter. The assortment of irregular shapes appear to be cut through with dark lanes, while the individual nebulae have a large brightness range amongst them.

Imaging

The brightest parts of this strange looking collection of nebulae will register on any camera but the extended area is very faint and requires deep imaging to draw out the nebulosity. A field of 40' × 30' is required to frame these objects. However, a larger field of view – at least 1.5° × 1° – will enable them to be coupled with two other very interesting areas of nebulosity – N 89 and NGC 602.

Technical Information – Fig. 8.6

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg
Exposures:	15 × 10 min L
	8 × 10 min R
	8 × 10 min G
	8 × 10 min B
	(All unbinned)
Field Size:	35' × 28'

NGC 346

Constellation	Tucana
RA	0 h 59 min 18 s
Dec	-72° 09' 48"

NGC 346 is the *lucida* of deep-sky objects in the SMC. Extremely rich in oxygen, the nebula surrounding the central star cluster has a series of wreath-like structures that seem like the arms of a barred spiral galaxy, except that there is one too many at the north-east end.

NGC 346 is nearly as big as the Eta Carinae Nebula at 200 light years across. The brilliant young blue super-giant stars in the core are eroding away the nebulosity in the nebula with their powerful energy output. With large apertures and an OIII filter the nebulosity can be traced out to 8' long and flares across the center to 7.5'. The whole nebula shines at magnitude 10.3.

Imaging

This is probably the most rewarding nebula in the SMC to image. It is the largest single nebula in the SMC but still requires a long focal length to do it justice – a field size no larger than 50' × 30' is needed to reveal the delicate structure. For those with a scope/camera combination that provides a field greater than 1.5° × 1° NGC 346 can be framed with the nearby nebula complex NGC 371 and NGC 395.

NGC 346 is one of the brightest parts of the SMC so is well suited to all types of cameras. It is a great target for LRGB but due to the abundance of OIII it is also an excellent target for narrowband imaging or a hybrid of the two. There is far less H-alpha in this object than OIII so an HaRGB hybrid is not desirable, neither is simply blending H-alpha into the red channel. In both cases the red will overpower the beautiful colors resulting from the OIII. Fig. 8.7 is purely narrowband. If narrowband data is to be blended with LRGB then ensure that OIII is added to the green/blue channel.



Fig. 8.7 NGC 346.

Technical Information – Fig. 8.7

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg
Exposures:	8 × 15 min H-alpha
	8 × 15 min OIII
	4 × 15 min H-beta
	All unbinned)
Field Size:	15' × 11.4'

Large Magellanic Cloud

Constellation	Dorado/Mensa
RA	5 h 18 min 27 s
Dec	−69° 13′ 00″

A virtual treasure trove on your back doorstep! There are few areas of the sky more jam-packed with deep-sky wonders than the Large Magellanic Cloud. The LMC shines at magnitude +1.0 and is even visible in a clear sky on the night of a full Moon.

Binoculars show the structure and layout of this satellite galaxy well. The dominant feature, known as the Bar, runs diagonally from north-west to south-east. From this highway we venture off to scores of bright and faint nebulous patches.

Small telescopes start to show the patches as either clusters or nebulae, and often both. Large apertures armed with narrow-band filters, especially OIII, literally have a field day visiting all of the oxygen rich locales. The awesome nebula complex around NGC 2070 (the Tarantula Nebula, Fig. 8.18) is easily seen in binoculars and just visible to the naked eye at a distance of 165,000 light years from Earth.

Imaging

This huge object is one of the highlights for any astroimager lucky enough to be far enough south to capture it. As with the SMC it requires a camera lens of about 50 mm or wider in order to frame it all. It is bright enough for any camera and the brighter parts of nebulosity, such as the Tarantula Nebula area (left in Fig. 8.8) will appear in exposures of only a few seconds. However, as the LMC has an exceptionally high dynamic range the more subs that are acquired the more of the fainter, less well-known areas of nebulosity will appear. Even at the scale presented in Fig. 8.8 many of the subsequent objects in this chapter can be recognised. While the LMC responds exceptionally well to LRGB, to really do it justice it is well worth obtaining some narrowband exposures if possible.



Fig. 8.8 Large Magellanic Cloud.

Technical Information – Fig. 8.8

Camera Lens:	Canon 18–55 mm at 55 mm
F-stop:	f/5.5
Camera:	QSI 683wsg Mono
Exposures:	10 × 10 min L
	6 × 5 min R
	6 × 5 min G
	6 × 5 min B
	5 × 15 min H-alpha (blended with the red)
	5 × 15 min OIII (blended with the green)
	(All unbinned)
Field Size:	8.9° × 7.1°

LMC Reference Chart

Fig. 8.9 shows the positions of the objects in the LMC that are presented in this chapter. While this won't necessarily help you to locate the objects it does put them into context and gives some idea of the amount of interesting areas that are to be imaged in the LMC.

1. **Bean Nebula** Fig. 8.10
2. **N 44** Fig. 8.11
3. **N 51** Fig. 8.12
4. **NGC 1910** Fig. 8.13
5. **Chalice Nebula** Fig. 8.14
6. **Dragon's Head Nebula** Fig. 8.15
7. **N 70** Fig. 8.16
8. **Tulip Nebula** Fig. 8.17
9. **Tarantula Nebula (wide field)** Fig. 8.18
10. **Tarantula Nebula (narrow field)** Fig. 8.19

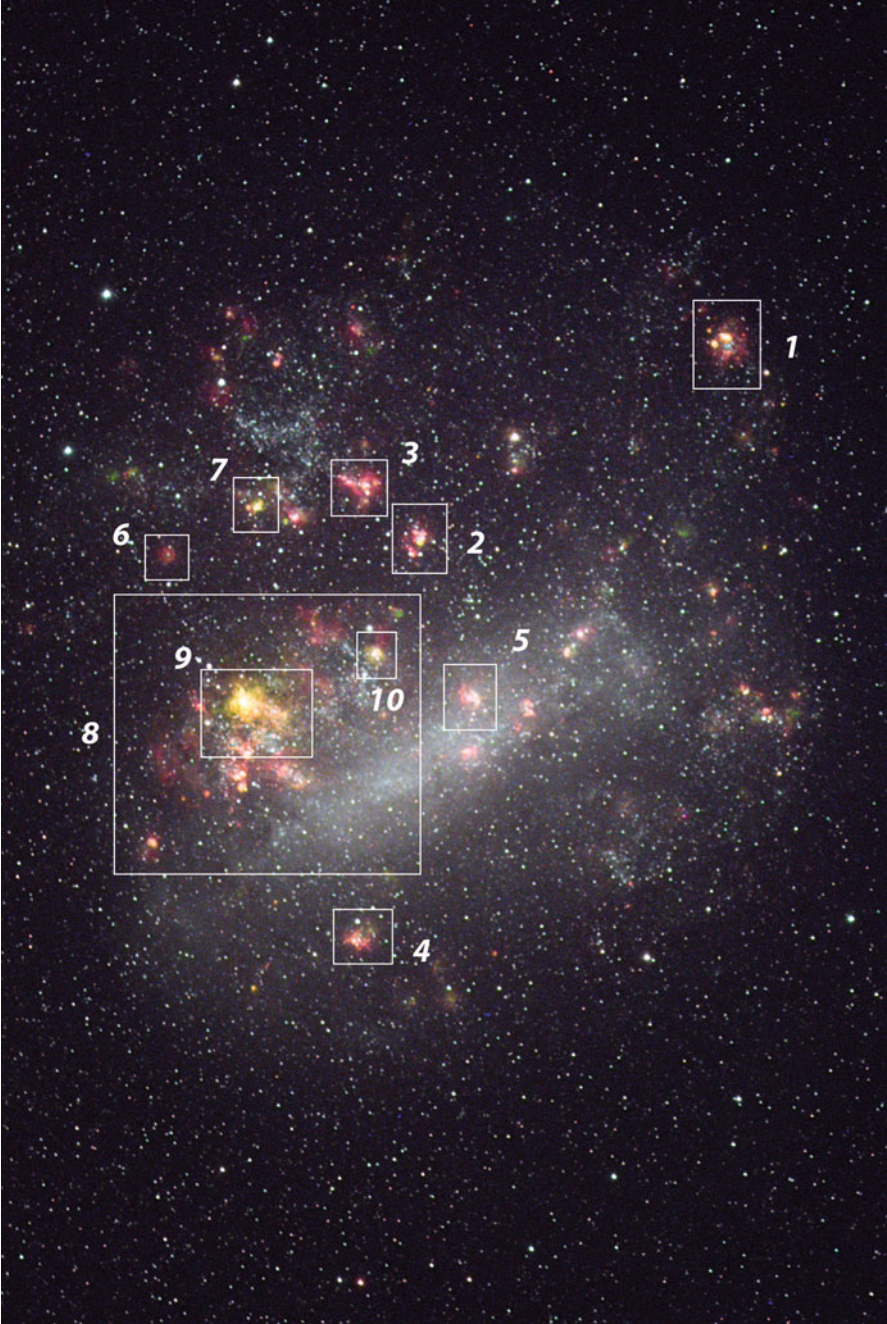


Fig. 8.9 LMC Reference Chart.

Bean Nebulae — N 11 — NGC 1760 – 61 – 63 – 69 – 73

Constellation	Dorado
RA	4 h 57 min 00 s
Dec	–66° 25' 25"

The N 11 nebula complex is fairly typical of many of these types of associations in the Large Cloud, containing a mixture of gaseous nebulae and open clusters. The young super hot stars of the cluster NGC 1761 at the center of the Bean Nebulae are blasting out a superbubble from the interior. Sometimes these shells are the result of ancient supernova explosions as well.

The large bean-shaped nebulae, NGC 1763 – 69 – 73, give this group its name and surround the brilliant cluster NGC 1761. NGC 1763, the largest ‘bean’, shows great detail and when examined at medium and high powers, a figure S can readily be discerned.

Imaging

As can be seen from the LMC image (Fig. 8.8), the Bean Nebula (top right in that image) is one of the brightest nebulae outside of the Tarantula area and is therefore an excellent target for all cameras. It works well as an LRGB image or a hybrid (as in Fig. 8.10). However, due to the abundance of OIII an HaRGB hybrid is not desirable, neither is simply blending H-alpha into the red channel. In both cases the red will overpower the beautiful colors resulting from the OIII. If narrowband data is to be blended with LRGB then ensure that OIII is added to the green/blue channel.

If the planetarium software does not hold the Henize catalogue then aim for NGC 1763. To capture just the Bean Nebula, a field of about 50' × 40' is required. However, a slightly larger field may also capture the lovely globular cluster NGC 1783 in the frame.



Fig. 8.10 Bean Nebulae (north is left).

Technical Information – Fig. 8.10

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg
Exposures:	5 × 10 min L
	5 × 5 min R
	5 × 5 min G
	5 × 5 min B
	5 × 10 min H-alpha (blended with the red)
	5 × 10 min OIII (blended with the green)
	(All unbinned)
Field Size:	40' × 27'

N 44 — NGC 1929-34-35-36-37,
IC 2128, K 822

Constellation	Dorado
RA	5 h 22 min 25 s
Dec	−67° 57′ 32″

The N 44 complex has a distinctive delta outline that is unmistakable in a telescope. The Hubble Space Telescope has closed in on the tiny nebula NGC 1929 at the north-west apex of the delta to reveal a flower on a stem nebula where young stars are blowing out a cavity in the nebulosity similar to the process occurring with M 42. Kont 822 is the large open cluster at the heart of the complex creating the nearly oval shaped superbubble.

Imaging

The central part of this complex is fairly bright and easy to image with any camera. However, there are a few fainter areas of nebulosity that it is worth exposing a little longer in order to obtain. It suits a field size of 40' × 30' but with a smaller field size the ring of nebulosity surrounding the central cluster, Kont 822, is worth imaging alone. NGC 1934 is the object that is worth entering into the GOTO catalogue in order to frame the nebulosity. With a larger field of view – 1.3° × 1° – N51 (Fig. 8.12) can also be framed in the same image.

Technical Information – Fig. 8.11

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 683wsg Mono
Exposures:	10 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	39' × 30'

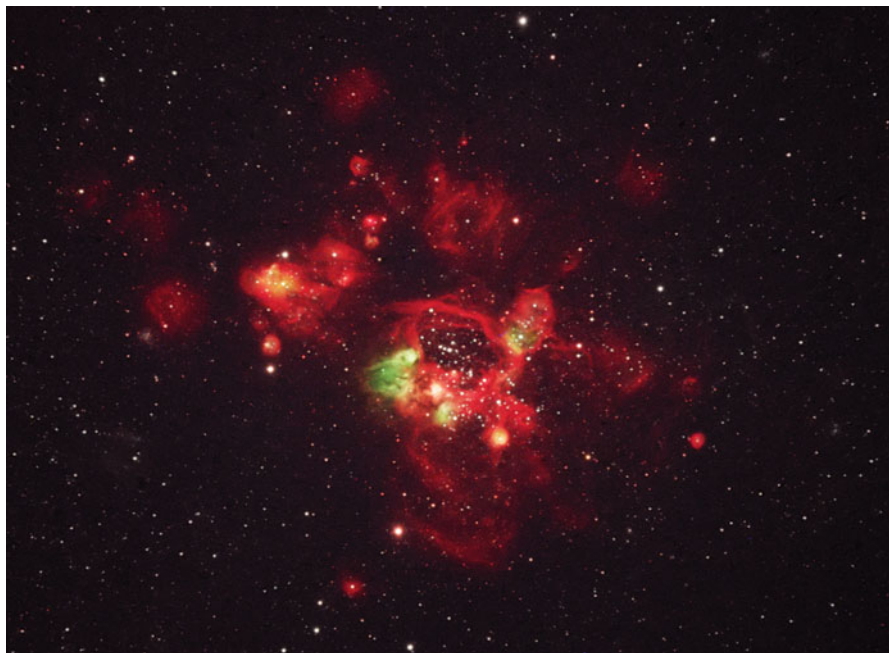


Fig. 8.11 N 44 (north is right).

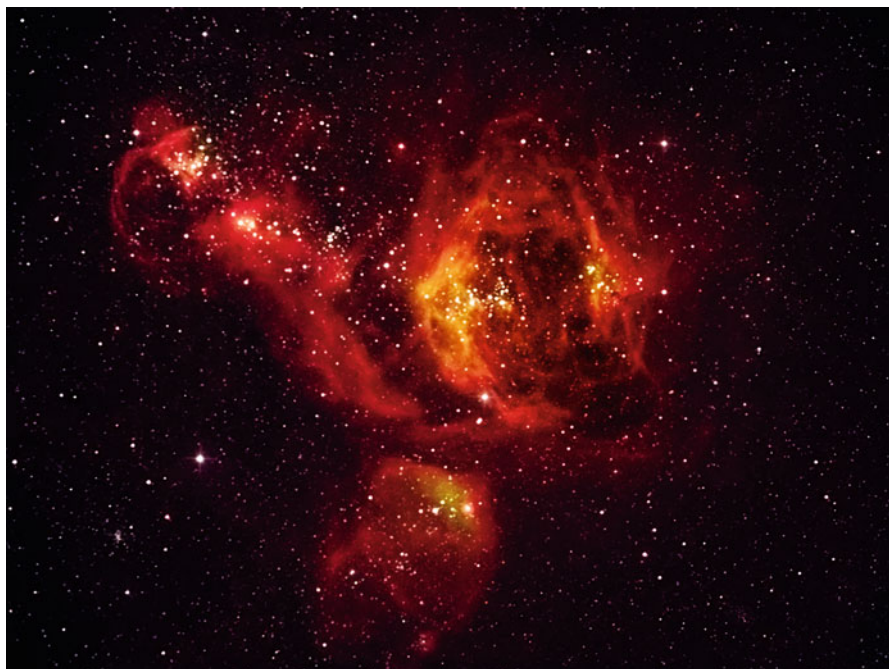


Fig. 8.12 N 51.

N 51 — NGC 1955-68-74, N 51b-51e

Constellation	Dorado
RA	5 h 26 min 30 s
Dec	-67° 31' 30"

This flower-like nebula complex is amazingly similar to the Tulip Nebula, NGC 1966 (Fig. 8.17). In this instance NGCs 1968 and 1974 make up a stem to the bloom of NGC 1955 when west is at the top as per Fig. 8.12. Once again we have a similar scenario to M 42 where the central cluster of NGC 1955 is creating a crater in the surrounding nebula. Bright enough to be viewed without a filter the OIII does however lift the contrast with larger apertures.

Imaging

N51 is a relatively bright object in the LMC so is worth considering for all cameras. It is an excellent object for a camera/scope combination that provides a field of view of about 35' × 25'. If the GOTO does not have the Henize catalogue then centering on NGC 1955 will frame the object perfectly. As it is only 40' north east of N 44, then with a larger field of view – 1.3° × 1° – N 44 (Fig. 8.11) can also be framed in the same image. If possible, capturing some extra H-alpha is worthwhile in order to enrich the red.

Technical Information – Fig. 8.12

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QHY9 Mono
Exposures:	10 × 10 min L 5 × 10 min R 5 × 10 min G 5 × 10 min B (All unbinned)
Field Size:	33' × 23'

NGC 1910

Constellation	Dorado
RA	5 h 18 min 30 s
Dec	−69° 14′ 12″

The nebulosity surrounding the open cluster NGC 1910 forms a very noticeable S shape that larger telescopes show nicely with the aid of narrow band filters. In all, five clusters can be seen in Fig. 8.13 making this an attractive field in any telescope.

The open cluster NGC 1910 contains the LBV (Luminous Blue Variable) star S Doradûs, possibly the most luminous star known to us which shines with an absolute magnitude of −10!

Imaging

NGC 1910 is one of the harder objects in the LMC to image because it sits on the central bar of the galaxy. This means that it is in a particularly star-rich field and the density of stars can overpower the surrounding nebulosity. While good results can be produced using a color camera or LRGB it is an excellent object for narrowband imaging as the narrowband filters help to limit the brightness of the stars while still allowing the nebulosity to shine through.

Technical Information – Fig. 8.13

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	9 × 15 min H-alpha 8 × 15 min OIII 5 × 15 min H-beta (All unbinned)
Field Size:	25' × 20'



Fig. 8.13 NGC 1910 (north is left).

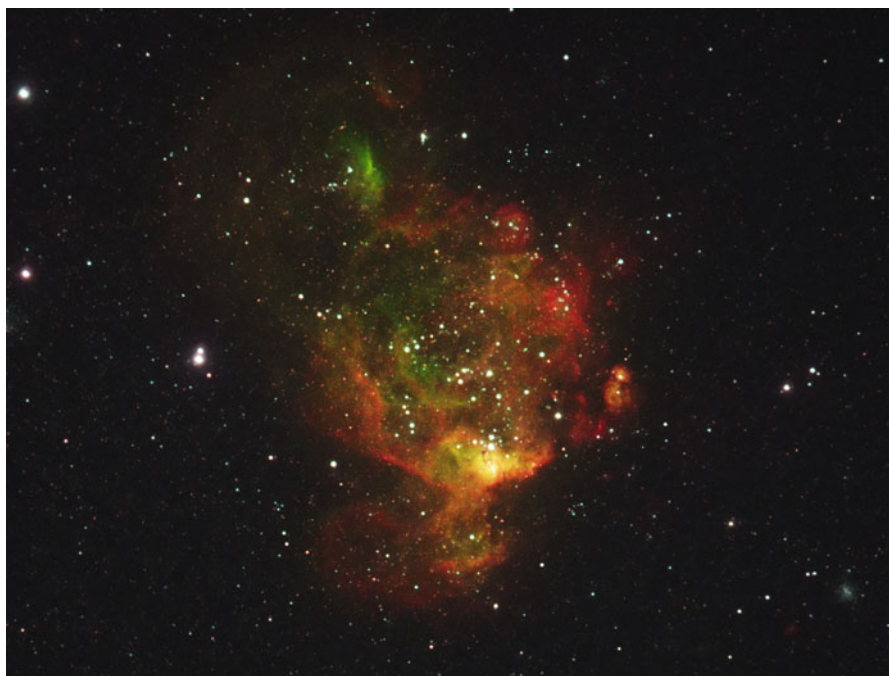


Fig. 8.14 Chalice Nebula (north is left).

Chalice Nebula — NGC 2018 — N 206

Constellation	Mensa
RA	5 h 31 min 14 s
Dec	-71° 03' 00"

With west at the top the shape of a chalice overflowing with stars is most evident. This is a delightful nebula/cluster combination that can handle high powers well. The center responds well to the OIII filter but the whole nebulosity is bright enough not to require that assistance.

Imaging

The Chalice Nebula is an excellent target for all cameras as it is one of the brightest nebulae in the LMC. LRGB will capture the rich variations in color but the addition of narrowband data will accentuate it. As it is a discrete area of nebulosity within the LMC it is best framed using a long focal length scope and camera that provide a field of view of no more than 50' × 30' in order to show the detail. An HaRGB hybrid is not desirable for this object as it is likely to result in rather bland, pure red nebulosity. In order to preserve the mixture of color stick to LRGB or blend both H-alpha data into the red channel and OIII data into the blue/green channel. Fig. 8.14 is purely narrowband and this helps to show off the colors well.

Technical Information – Fig. 8.14

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 15 min H-alpha 8 × 15 min OIII 4 × 15 min H-beta (All unbinned)
Field Size:	26' × 21'

Dragon's Head Nebula — NGC 2029-32-35-40, N 59c

Constellation	Dorado
RA	5 h 35 min 35 s
Dec	−67° 32' 40"

This is the second brightest nebula in the Large Cloud. The Dragon's Head Nebula is loaded with oxygen and is a delight at high powers with an OIII filter. This highly asymmetric nebula is a standout in a region full of nebulous clouds. The flaring nebulosity emerging from the cheeks is best seen at magnifications over 150x but this object can handle twice that if conditions allow.

Imaging

The Dragon's Head Nebula is a great target for a long focal length scope/camera that provides a field of view of about $25' \times 20'$. Although a target suitable for any camera, it is very rich in OIII so is an excellent choice for narrowband imaging. Avoid an HaRGB hybrid as this will overpower the beautiful colors resulting from the OIII.

There are many other interesting objects in near proximity to the Dragon's Head. A field of view of about $40' \times 30'$ will also frame N 57 and the nebulosity surrounding the star cluster NGC 2014 as well as NGC 2020. If a shorter focal length scope is used, that provides a field of view over $2^\circ \times 1^\circ$, then the Dragon's Head, N 44 (Fig. 8.11) and N 51 (Fig. 8.12) can all be placed in the same wide field.



Fig. 8.15 Dragon's Head Nebula (north is left).

Technical Information – Fig. 8.15

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	7 × 20 min H-alpha
	7 × 20 min OIII
	4 × 20 min H-beta
	(All unbinned)
Field Size:	23' × 17'

N 70

Constellation	Dorado
RA	5 h 43 min 25 s
Dec	−67° 50′ 00″

N 70 is perhaps the best known of the numerous supernova remnants (SNRs) in the Large Cloud. It has a low surface brightness so it is a difficult object even with a large telescope and a narrowband filter. Despite this it is still worth the effort to find. The faint ring is brighter on the western edge and becomes almost fractured on the opposite side.

Imaging

N 70 is a small, discreet target so it is necessary to image with a long focal length and small field size if the full extent of the filaments are to be revealed. An image taken through a short focal length scope is likely to be disappointing. If your GOTO scope or planetarium does not contain the Henize catalogue it may be necessary to use the RA and Dec coordinates in order to find the object. Although a DSLR can be used, many subs will be necessary as it is rather faint. It is a perfect object for luminance layering and while a hybrid with H-alpha data can be attempted it will show little improvement.

Technical Information – Fig. 8.16

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min L 5 × 10 min R 5 × 10 min G 5 × 10 min B (All unbinned)
Field Size:	20' × 14'



Fig. 8.16 N 70.



Fig. 8.17 NGC 1962-65-66-70 (north is right).

Tulip Nebula — NGC 1962-65-66-70

Constellation	Dorado
RA	5 h 26 min 50 s
Dec	−68° 49′ 02″

This nebula complex is almost lost in the plethora of bright star clouds and its proximity to the Bar and the nearby Tarantula Nebula. There are four NGC objects listed that are each a tiny open cluster embedded in the northern part of the circular wreath of nebulosity surrounding a smattering of bright stars in the center. The nebulosity requires large apertures and narrow band filters to be seen at its best.

In the center of the cluster NGC 1966 there is a shell structure that has been blown away from a massive Wolf-Rayet star. This can be seen as two green circular arcs in Fig. 8.17.

Imaging

The area shown in the wide field shot of the Tarantula (Fig. 8.18) is a treasure trove for the astrophotographer. Using a long focal length scope opens up a multitude of interesting fields to be imaged. One of the most interesting is the Tulip Nebula. It is amongst the brightest parts of the extended Tarantula area and requires a field size of 25' × 20' to frame it perfectly. As can be seen on the wide field image, it emits strongly in OIII and therefore cries out for extra OIII exposures to be taken and hybridized with an LRGB. An HaRGB hybrid is not recommended as it will likely disguise the shell structure at the heart of the cluster.

Technical Information – Fig. 8.17

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	7 × 10 min L 5 × 5 min R 5 × 5 min G 5 × 5 min B 7 × 15 min H-alpha (blended with the red) 7 × 15 min OIII (blended with the green) (All unbinned)
Field Size:	21' × 16'

Tarantula Nebula — NGC 2070

Constellation

Dorado

RA

5 h 37 min 17 s

Dec

−69° 13′ 25″

No one who has observed this amazing object fails to be impressed! Amongst the top five objects in the entire sky the Tarantula Nebula is one object that compares favourably with photographs. Sir John Herschel dubbed it the Great Looped Nebula during his time at the Cape of Good Hope in South Africa during the 1830s. Even the smallest telescopes show the spidery nature of the nebulosity.

Although narrow band filters are not required to show the nebulosity, an OIII filter with a large telescope gives a view that is beyond immediate comprehension. The exquisite detail that is rife throughout the field of view at 150× is hardly bettered in any similar object in the sky!

The brilliant tight cluster R136 at the heart of the giant spider, containing the super giant star 30 Doradûs, needs a very high power to resolve it well.

The nebula is so vast that if it were placed at the distance of M 42 in Orion it would fill the whole of the constellation of Orion and be as bright as the full Moon! Perhaps it is fortunate for those of us who wish to enjoy the rest of the deep-sky that it is not that close?

Fig. 8.18 shows the Tarantula residing in an area of great activity. Surrounding NGC 2070 are numerous SNRs, superbubbles, nebula complexes, clusters and star clouds. It is perhaps this immense richness that puts some people off tackling this area visually. Photographically all the hard work is justly rewarded.

Imaging

The Tarantula Nebula has to be in the top five most imaged objects in the southern sky and it is easy to see why. Its brightness makes it suitable for any camera. Even unguided imaging can produce good results here because exposures of only a few seconds will register data. Likewise, it is suited to any telescope/camera combination as there are so many different fields that can be chosen to image. Fig. 8.18 shows the full extent of nebulosity covered by the wider Tarantula area and is taken with a short focal length refractor with a field of view of $2.6^\circ \times 2.0^\circ$. Fig. 8.19 shows a close up view using a 2,010 mm telescope, which provided a field size of $41' \times 33'$. Any field size in between these will do it justice. DSLR, OSC, LRGB, narrowband and hybrids are all excellent ways of capturing it. Be careful not to saturate the center of the Tarantula. Taking a series of shorter exposures is worthwhile in order to restore the core if necessary.

The level of OIII is extremely high in the Tarantula therefore a hybrid of HaRGB is likely to result in an image that is far too red and therefore lacks the magical color that is available in the object. A much better idea is to produce a hybrid that uses both H-alpha and OIII data.

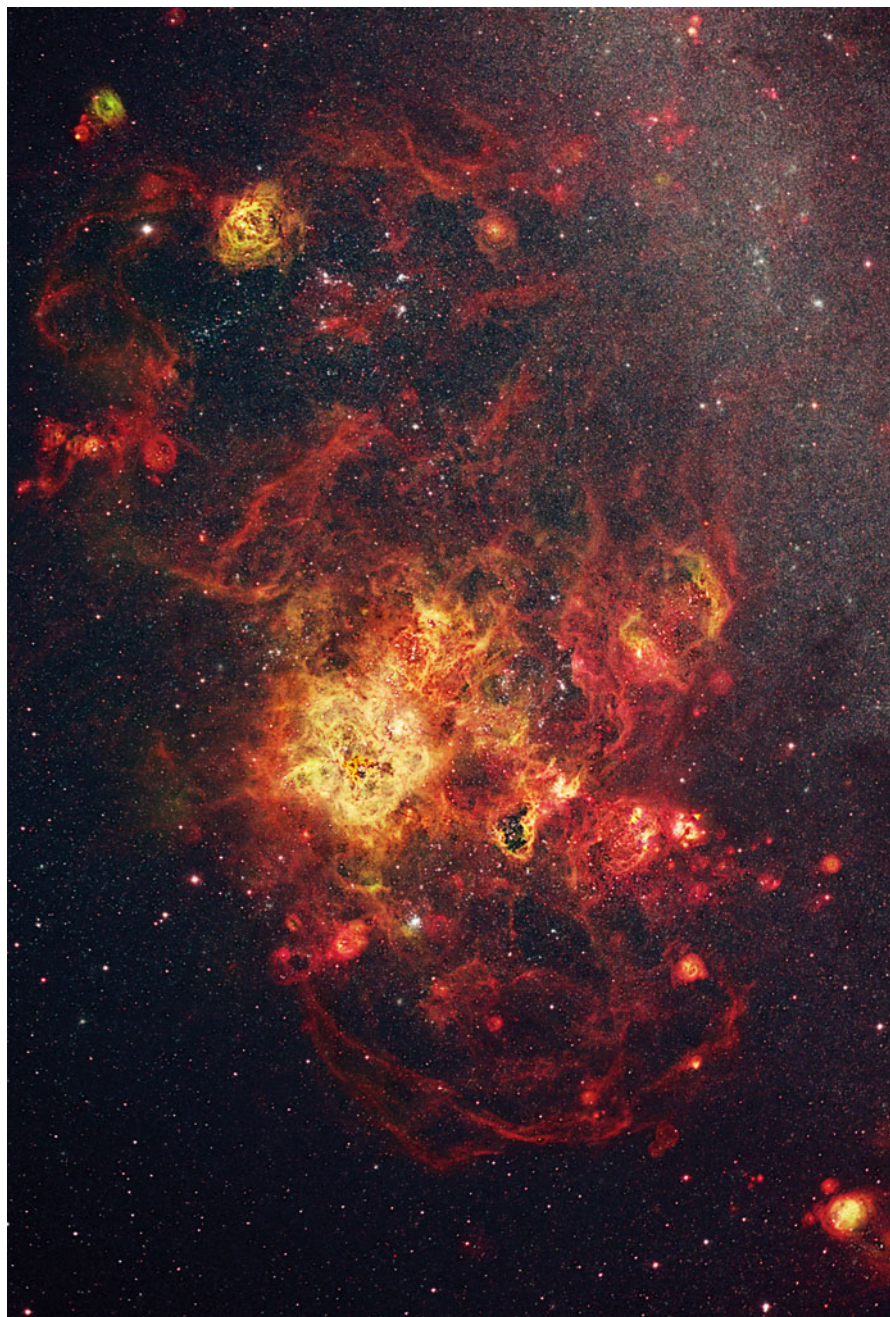


Fig. 8.18 Tarantula Nebula (north is left).

Technical Information – Fig. 8.18

Telescope:	TS Refractor with 0.8× flattener/reducer
Focal Length:	380 mm
F-ratio:	f/4.8
Camera:	QSI 683wsg Mono
Exposures:	5 × 3 min R
	5 × 3 min G
	5 × 3 min B
	12 × 15 min H-alpha (blended with the red)
	10 × 15 min OIII (blended with the green)
	(All unbinned)
Field Size:	2.6° × 1.8°

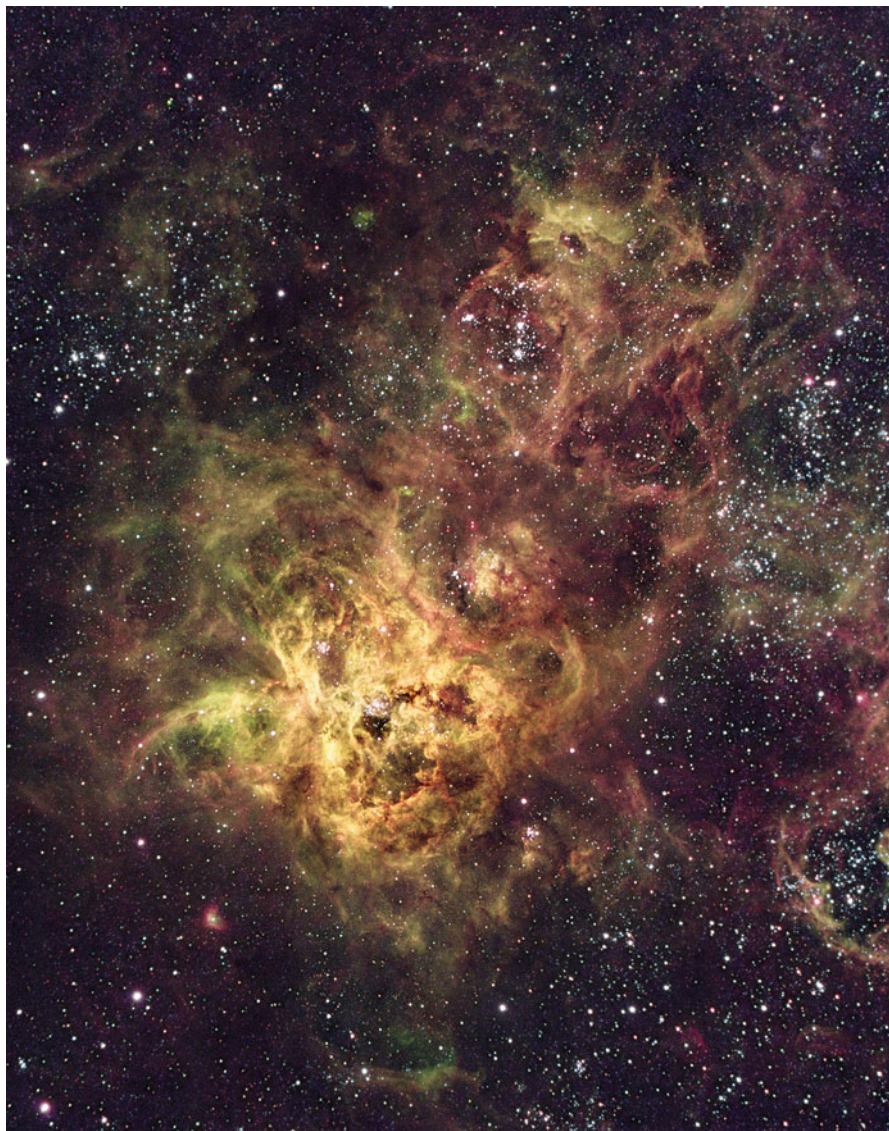


Fig. 8.19 Tarantula Nebula (north is left).

Technical Information – Fig. 8.19

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 15 min H-alpha
	8 × 15 min OIII
	4 × 15 min H-beta
	(All unbinned)
Field Size:	41' × 33'

Chapter Nine



Galaxies in the Furnace

Aquarius

Cetus

Eridanus

Fornax

Grus

Sculptor

During southern spring evenings when the great band of the Milky Way lies around the horizon and the south galactic pole pushes up toward the zenith, this is the time to venture well beyond the bounds of our own galaxy to other 'Island Universes.' We journey through the southern galaxies which spread out across the void like sparks flying from the great celestial furnace!

Many of the galaxies and planetaries in this chapter are within 25° of the celestial equator so are within reach of many astroimagers living north of the geographical equator. Accurate flats are important for the objects presented here especially if you live in urban areas.

NGC 55

Constellation	Sculptor
RA	0 h 14 min 54 s
Dec	-39° 11' 00"

NGC 55 is a fine edge-on spiral galaxy that lies between the Sculptor Group and our own Local Group of galaxies at a distance of 7 million light years. At magnitude 8.1 this galaxy is visible in 10 × 50 binoculars and small telescopes show it well.

In large apertures at 150× the galaxy stretches across the whole field of view and the impression is not too dissimilar to viewing the winter Milky Way with the naked eye. The galaxy breaks up into numerous star clouds cut by irregular dark-lanes. The OIII filter reveals several emission nebulae as well.

Imaging

At 31' × 6' NGC 55 is an excellent target for a medium focal length scope but is also large enough to reveal detail with a much larger field of view, anything up to 2.5° × 1.5°. At photographic magnitude 8.4 it is suitable for all varieties of cameras. However, in order to capture the fainter HII regions a monochrome camera is more desirable. Extra H-alpha exposures will enhance these regions when blended during processing.



Fig. 9.1 NGC 55 (north is left).

Technical Information – Fig. 9.1

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 5 min L
	5 × 5 min R
	5 × 5 min G
	5 × 5 min B
	3 × 15 min H-alpha (blended with the red)
	(All unbinned)
Field Size:	32' × 24'

Claw Galaxy — NGC 247

Constellation	Cetus
RA	00 h 47 min 06 s
Dec	−20° 46′

NGC 247 is another member of the Sculptor Group of galaxies lying some 11.1 million light years from the Sun. Gravitationally bound to the other spirals in neighboring Sculptor, NGC 247 is a late spiral galaxy lacking a strong core but showing plenty of signs of starburst activity.

This is a low surface brightness object that covers $19' \times 5.5'$ and shines at magnitude 9.2. Medium apertures show the shape well and hint at the darkening in the north end that gives this galaxy its claw-like appearance.

Imaging

The Claw Galaxy is a great target for DSLR and OSC cameras even under medium light polluted skies although in order to pick up the fainter, outer arm some extra exposure time will be required. A scope of at least medium length is needed to bring out detail – a field larger than $30' \times 25'$ is necessary. However, a much larger field, up to $2.5^\circ \times 1.5^\circ$, will still produce an excellent image. There are many HII regions in the galaxy so if you have a monochrome CCD camera you could take some H-alpha subs for later blending.



Fig. 9.2 Claw Galaxy (NGC 247).

Technical Information – Fig. 9.2

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	30' × 19'

Silver Coin Galaxy — Sculptor Galaxy — NGC 253

Constellation:	Sculptor
RA	0 h 47 min 36 s
Dec	−25° 17' 00"

Discovered by Caroline Herschel in 1783, NGC 253 is the fifth brightest galaxy in the sky at magnitude 7.6. This is an easy target for binoculars with the long axis covering 30' (the diameter of the Moon). Small telescopes show a fine ellipse with a strong bright center. Medium telescopes and larger start to show the spiral nature of this galaxy even though it is nearly edge-on to us. Large apertures bring up the wealth of dark-lanes that highlight the zigzag structure well. NGC 253 is reputed to be one of the dustiest galaxies known.

NGC 253 is a member of the Sculptor Group of galaxies, a similar sized group to our own Local Group, and sits at 11.4 million light years from Earth.

Imaging

Due to its brightness it is an excellent target for all types of cameras. A DSLR will easily resolve all the dark-lanes and a modified camera will help to pick up the red HII regions. It is bright enough to be a target for those living in medium light polluted skies. A field of at least 50' × 40' is necessary in order to adequately frame the galaxy. However, an excellent image can be produced with a much larger field, anything up to 2.5° × 1.5°. If such a field is used then the galaxy will be accompanied by the nearby globular cluster NGC 288, (1.8° to the south-east), which makes a wonderful pairing.



Fig. 9.3 Silver Coin Galaxy (north is right).

Technical Information – Fig. 9.3

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QHY9 Mono
Exposures:	15 × 5 min L
	5 × 5 min R
	5 × 5 min G
	5 × 5 min B
	(All unbinned)
Field Size:	55' × 35'

NGC 300

Constellation	Sculptor
RA	0 h 54 min 54 s
Dec	-37° 41' 00"

NGC 300 was previously thought to be a member of the Sculptor Group of galaxies but has since been found to reside in an area between that group and the Local Group at a distance of 5.9 million light years. Although at first glance this galaxy looks to be face-on, NGC 300 is in fact tilted to us by 42°. This leads to its oval dimensions of 20' × 13'.

With a visual magnitude of 8.1 NGC 300 is just visible in binoculars as a faint patch. Larger apertures with a narrowband filter reveal several HII regions sprinkled along the obvious spiral arms.

Imaging

While the center of NGC 300 is bright, the extended arms are actually extremely dim. To get the most out of the object it is therefore best suited to imaging from a dark site. The more exposures taken the greater the extent of these arms will be revealed. In order to capture the whole galaxy a field of at least 30' × 25' is required. However, a larger field is preferable, anything up to 60' × 30'. Achieving deep color in the faint arms can be a challenge so extensive RGB exposures will be necessary. There are many HII regions in this galaxy and so taking extra H-alpha exposures is desirable.

Good quality flat frames maybe essential for this image as the outer arms are very delicate and can easily get lost in gradients.

Technical Information – Fig. 9.4

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 15 min L 5 × 10 min R 5 × 10 min G 5 × 10 min B 4 × 10 min H-alpha (blended with the red) (All unbinned)
Field Size:	26' × 20'



Fig. 9.4 NGC 300 (north is right).



Fig. 9.5 NGC 613.

NGC 613

Constellation	Sculptor
RA	1 h 34 min 18 s
Dec	−29° 25′ 00″

At a distance of 65 million light years NGC 613 is definitely not a member of the Sculptor Group of galaxies! In spite of that great distance this galaxy is well worth hunting down. At magnitude 10.0 this is a relatively bright, compact object. Large telescopes with moderate to high powers show the arms emanating from the bar very well.

Imaging

At 5' × 4' NGC 613 is a small target and so requires extensive focal length. A scope/camera combination that provides a field no larger than 30' × 20' is required to make it worthwhile imaging. Its outer arms double right back on themselves and to capture this requires long exposure. It is best suited to a monochrome CCD camera in order to pick up the color, but a DSLR will also produce a satisfactory result.

Technical Information – Fig. 9.5

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	9 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	23' × 17'

Robin’s Egg Nebula — NGC 1360

Constellation	Fornax
RA	3 h 33 min 18 s
Dec	−25° 51′ 00″

In a region strong in galaxies you may be forgiven for mistaking NGC 1360 for a galaxy if it weren’t for the fact that it emits strongly in oxygen. This strong oxygen signature confirmed NGC 1360 as a planetary nebula. NGC 1360’s large size of 6.5’ means that even small scopes will show it easily. The visual magnitude is 9.4, and NGC 1360 lies some 1,700 light years from the Sun.

Imaging

Due to its amorphous nature, the Robin’s Egg is easily imaged without needing luminance, using only RGB data. An OSC and DSLR will also do the object justice. Any telescope will show up the blue egg shape but it is best imaged with a field no larger than 30’ × 20’. When imaging make sure enough data has been collected to capture the red ejected material at the top end of the Egg (Fig. 9.6). If a scope/camera combination that provides a larger field of view is used, larger than about 1.5° × 1°, it may be possible to achieve a good pairing of NGC 1360 and the face-on spiral galaxy NGC 1398.

Technical Information – Fig. 9.6

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 10 min R 10 × 10 min G 10 × 10 min B (All unbinned)
Field Size:	20’ × 15’



Fig. 9.6 Robin's Egg Nebula.

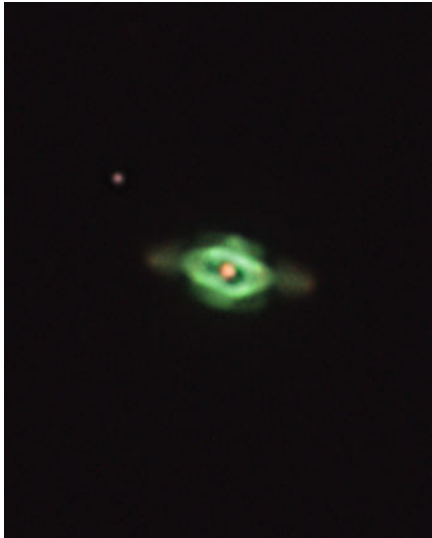


Fig. 9.7 NGC 7009.

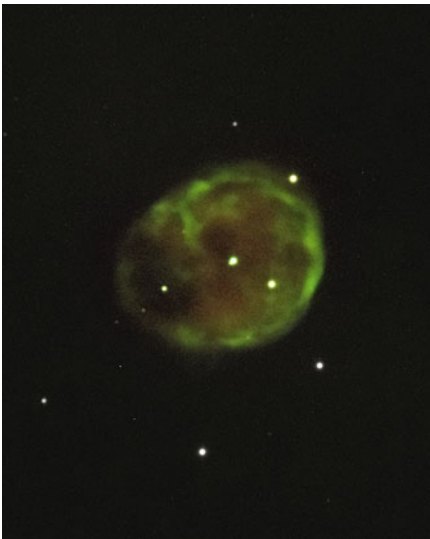


Fig. 9.8 Skull Nebula.



Fig. 9.9 IC 5148-50.

Saturn Nebula — NGC 7009

Constellation:	Aquarius
RA	21 h 04 min 12 s
Dec	−11° 22′ 00″

Appearing the same size as the planet Mars at its best, NGC 7009 needs good seeing and high powers to show the Saturn-like shape well. The tiny ansae, or appendages that form the rings, are the real challenge for observers.

If you have access to a large Dobsonian with a freshly ‘silvered’ mirror then this object is an ideal candidate to show how such mirrors out-perform aluminized mirrors when it comes to showing true color. With a large aperture silvered mirror at high powers the brilliant turquoise of the Saturn Nebula is hardly comparable anywhere else in the night sky!

Imaging

Being the smallest object in the book, barely 30" × 26", the Saturn Nebula is a challenge to image. Not only must a long focal length be used it should be undertaken on a night of exceptional seeing if any central structure is to be resolved. The object is, however, fairly bright – magnitude 8 – so it is a good target for any camera. Exposures must be kept short to prevent the central star from saturating. Luminance is unnecessary as adequate data can be acquired by RGB alone. It is also a good target for those Moonlit nights if narrowband imaging is an option (as in Fig. 9.7).

Technical Information – Fig. 9.7

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	10 × 2 min R 10 × 2 min G 10 × 2 min B (All unbinned)
Field Size:	8' × 5'

Skull Nebula — NGC 246

Constellation:	Cetus
RA	0 h 47 min 00 s
Dec	−11° 53′ 00″

The Skull Nebula is one of the largest planetaries in the sky covering 4', the vast majority of planetaries being 1' or smaller. At magnitude 10.9 the light is spread over that area making it a low surface brightness object best seen in moderate to large telescopes with an OIII filter. NGC 246 lies between 1,600 and 2,500 light years from us.

Imaging

The Skull Nebula is easily accessible to all camera types, although un-modified DSLR might struggle to pick up the red, central region. Although it is big for a planetary nebula it still requires a relatively small field of view to do it justice – no larger than 50' × 30'. As is the case with many planetary nebulae it emits strongly in OIII and H-alpha so for those with monochrome CCD cameras it is well worth imaging in narrowband (as is the case with Fig. 9.8).

Technical Information – Fig. 9.8

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	8 × 10 min H-alpha 7 × 10 min OIII 4 × 10 min Hb (All unbinned)
Field Size:	18' × 13'

IC 5148-50

Constellation	Grus
RA	21 h 59 min 36 s
Dec	-39° 23' 00"

IC 5148-50 is another fairly large planetary nebula. Originally given two Index Catalogue numbers in the late nineteenth century, photographs show its true nature. This is a beautiful ring nebula with a thick torus that responds well to the OIII filter yet is still visible without one in modest apertures.

Imaging

In order to reveal any detail in the torus a long focal length is required. A field no larger than 26' × 20' is ideal. From a dark site it is quite a challenge for a DSLR and in light pollution using a filter will make it very difficult to capture the detail. For those with a monochrome CCD it is a great object to image in narrowband, as was done in Fig. 9.9. It is important to be aware of the red nebulosity found in the torus itself.

Technical Information – Fig. 9.9

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	8 × 10 min H-alpha 7 × 10 min OIII 4 × 10 min Hb (All unbinned)
Field Size:	15' × 10.8'

Helix Nebula — NGC 7293

Constellation	Aquarius
RA	22 h 29 min 36 s
Dec	−20° 48′ 00″

The Helix Nebula is the largest, brightest and nearest planetary nebula in the sky. Easily seen as a glowing patch half the width of the Moon in binoculars, NGC 7293 needs a wide field of view in any telescope to be seen well. In large telescopes with an OIII filter even the full Moon can't overpower it! Visually the Helix is about 13' across but in Fig. 9.10 we see an outer torus that extends out to 22' × 12'. NGC 7293 sits at a mere 700 light years from Earth.

Imaging

Given its large size for a planetary this is an excellent target for a scope of any focal length. A field of view of at least 40' × 30' is required to capture the entire object. While the intricate structure of the central part requires magnification a pleasing result can still be obtained that only shows the basic ring and outer shells. So a much larger field, anything up to 2.5' × 1.5', will produce a satisfying image. At magnitude 7.3 it is an excellent target for all cameras even under light polluted skies (although a light pollution suppression filter is advantageous). However, the two outer shells of the Helix are quite challenging and require significant extra exposure time. A monochrome CCD camera will find it easier to capture them and blending H-alpha data into the red channel can help.



Fig. 9.10 Helix Nebula (north is right).

Technical Information – Fig. 9.10

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	18 × 10 min L
	7 × 10 min R
	7 × 10 min G
	7 × 10 min B
	(All unbinned)
Field Size:	42' × 28'

NGC 7424

Constellation	Grus
RA	22 h 57 min 18 s
Dec	−41° 04′ 00″

NGC 7424 is a multi-armed, transitional, face-on barred spiral galaxy. Through a telescope we see a large evenly luminous patch with a bar and faint central core. It is referred to as a grand design galaxy, due to its well formed spiral arms. NGC 7424 lies some 37.5 million light years from the Sun and may not belong to any particular galaxy cluster. NGC 7424 is magnitude 10.2 and covers $7.6' \times 6.2'$.

Imaging

This face-on spiral has a fairly low surface brightness so is best suited for mono-chrome CCD cameras. Due to the abundance of HII regions in the galaxy a set of H-alpha exposures is worth collecting and blending, as in Fig. 9.11. It is recommended that a long focal length scope be used in order to achieve the necessary resolution to capture the finer detail in the arms – a field no larger than $40' \times 30'$. However, a larger field size of about $1.5^\circ \times 50'$ will capture both NGC 7424 and the spiral galaxy NGC 7462. While the individual galaxies will appear small their different shapes make for a good pairing.

Technical Information – Fig. 9.11

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	9 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	3 × 10 min H-alpha (blended with the red)
	(All unbinned)
Field Size:	27' × 21'



Fig. 9.11 NGC 7424.



Fig. 9.12 Grus Trio.

Grus Trio — NGC 7582-90-99

Constellation	Grus
RA	23 h 18 min 50 s
Dec	−42° 19′ 30″

Less famous than the illustrious Leo Trio of M 65-66 and NGC 3628, the Grus Trio is however more telescope friendly covering an area of 15′ × 6′, meaning that the Trio can all be seen in moderate to high powers.

NGC 7582 is the largest and brightest member at magnitude 10.1, with the other two being 11th magnitude. The Trio sit at around 60 million light years from the Sun.

Imaging

This Trio of spiral galaxies fits nicely in the field of view of a scope/camera combination that provides a field no less than 30′ × 20′. However, if you only have a short scope you can actually image the Grus Quartet, which includes these three plus another face-on barred spiral NGC 7552, lying about 27′ to the south-west. They are all bright enough to be good targets for all types of camera.

Technical Information – Fig. 9.12

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 583wsg Mono
Exposures:	10 × 5 min L 5 × 5 min R 5 × 5 min G 5 × 5 min B (All unbinned)
Field Size:	29′ × 22′

NGC 1097

Constellation	Fornax
RA	2 h 46 min 18 s
Dec	−30° 16′ 00″

NGC 1097 is a Seyfert galaxy with a currently weak active core. The bar appears eye-shaped being broader around the bright spiral core. Extremely thin arms emerge from the end of the bar. The arm that comes from the southern end of the bar is being tidally distorted by the small companion NGC 1097A. It takes a very transparent night for modest telescopes to show the thin arms. Shining at magnitude 9.2 NGC 1097 covers $10.5' \times 6.3'$.

Studies of the four optical jets, two of which are seen in Fig. 9.13 at the top right, have revealed that they are in fact composed of stars from a cannibalized dwarf galaxy. NGC 1097 sits at 45 million light years from Earth.

Imaging

NGC 1097 is an object for a medium to long focal length scope that provides a field of at least $30' \times 20'$. Any camera will produce satisfactory results. However, what make this galaxy special are the four faint jets that shoot out from its core. They are extremely faint and require extensive exposure. Fig. 9.13 consists of 600 min of luminance exposure and even then only two of the jets have been captured. A very dark sky is essential to accomplish this.



Fig. 9.13 NGC 1097 (north is right).

Technical Information – Fig. 9.13

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 683wsg Mono
Exposures:	40 × 10 min L
	10 × 10 min R
	10 × 10 min G
	10 × 10 min B
	(All unbinned)
Field Size:	30' × 20'

Fornax Galaxy Cluster — AGC S 373 — (Sand Dune Deep Field)

Constellation	Fornax
RA	3 h 36 min 28 s (for NGC 1380)
Dec	−34° 58′ 35″

About one dozen fairly bright galaxies make up the Fornax Galaxy Cluster (Abell Galaxy Cluster S 373) although 58 are listed altogether. Dominated by several large elliptical type galaxies this group sits at approximately 62 million light years. NGCs 1399 and 1404 lie near the center while on the edge is the brilliant barred spiral NGC 1365 (see Fig. 9.15).

Even small apertures will show the brightest 12 members in a field of around 1° across. Only parts of the Virgo Super-cluster rival the Fornax Galaxy Cluster in number density per square degree for amateur telescopes.

Imaging

The entire Fornax Cluster covers a vast area of the sky so a short focal length scope that produces a super-wide field of view is essential. Any camera will pick up the main, brighter galaxies with short exposures. However, in order to do the field justice and record the most galaxies possible it should be imaged deep and from a dark site.

Viewed on a small page there seems little of interest in Fig. 9.14. However, when seen on a large computer monitor (and with the aid of a planetarium program) it is fascinating to see the variety and number of galaxies recorded in the image – literally hundreds – even though this is only 50 min worth of exposure taken using a 90 mm scope.



Fig. 9.14 Fornax Galaxy Cluster (north is right).

Technical Information – Fig. 9.14

Telescope:	William Optics 90 mm Refractor with 0.8× flattener/reducer
Focal Length:	446 mm
F-ratio:	f/4.96
Camera:	QHY9 Mono
Exposures:	6 × 10 min L (All unbinned)
Field Size:	2.3° × 1.7°

Great Barred Spiral — NGC 1365

Constellation	Fornax
RA	3 h 33 min 36 s
Dec	−36° 08′ 00″

Possibly the best example of a barred spiral galaxy in the entire sky, NGC 1365 is a favorite amongst galaxy hunters who can set their telescopes on to it. At a declination of -36° NGC 1365 sits up high enough for many mid-northern latitude observers with a clear, dark southern horizon. The zigzag pattern is clear in modest scopes, while larger apertures easily reveal the reversed S shape.

NGC 1365 lies on the near side of the Fornax Galaxy Cluster at 56 million light years from the Sun. The Great Barred Spiral covers $8.9' \times 6.5'$, and shines at magnitude 9.3.

Imaging

A great target for medium and long focal length telescopes it is bright enough for any camera to capture. Ensure that enough data has been obtained for the outer spiral arms to be seen to come all the way back to touch the galaxy again.

As can be seen in Fig. 9.14, NGC 1365 is in the bottom left corner of the field. Using a scope/camera combination providing a field of view of at least $2.3^\circ \times 2^\circ$, and moving NGC 1365 to the top right of that field, will enable an image to be captured that will couple NGC 1365 with the interacting galaxies NGC 1316 and NGC 1317, as well as countless others in the Fornax Cluster. Mosaicing these two images together really does show the extent of this galaxy cluster.



Fig. 9.15 NGC 1365.

Technical Information – Fig. 9.15

Telescope:	7" Intes-Micro Mak-Cass with 0.67× focal reducer
Focal Length:	1,206 mm
F-ratio:	f/6.7
Camera:	QSI 683wsg Mono
Exposures:	10 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	20' × 16'

NGC 1531-32

Constellation	Eridanus
RA	4 h 12 min 00 s
Dec	−32° 51′ 00″

NGC 1532 is an edge-on barred spiral interacting with its small elliptical companion galaxy NGC 1531 similar to NGC 4631 in Canes Venatici. NGC 1532 is some 55 million light years away from us. There may be other dwarf galaxies around NGC 1532 that are also causing the strange tidal distortions seen, apart from the obvious NGC 1531.

NGC 1532 is $13' \times 1.3'$ and is magnitude 9.9 visually. Modest telescopes show the tapered ellipse part of the galaxy well, including the thin dark-lane. NGC 1531 is magnitude 12.1 and covers $1.3' \times 0.8'$.

Imaging

These interacting galaxies make a beautiful pair, requiring a field size of at least $35' \times 25'$. A larger field size – up to $1.5^\circ \times 1^\circ$ – will still produce an interesting image. NGC 1532 is best suited to monochrome CCD cameras with filters to produce the full color depth and in order to capture the fainter arm that leads towards the companion galaxy NGC 1531.



Fig. 9.16 NGC 1531-2 (north is left).

Technical Information – Fig. 9.16

Telescope:	10" Vixen VMC260L with 0.67× focal reducer
Focal Length:	2,010 mm
F-ratio:	f/7.7
Camera:	QSI 583wsg Mono
Exposures:	12 × 10 min L
	5 × 10 min R
	5 × 10 min G
	5 × 10 min B
	(All unbinned)
Field Size:	35' × 26'

Part II



An Introduction to Digital Astroimaging

Chapter Ten



Equipment Inventory for Astroimaging

Astroimaging takes many different forms, necessitating the use of various types of equipment for each one. Much satisfaction can be achieved by imaging star trails, for which the only requirement is a camera capable of long exposures. If you intend to take wide field images of the night sky then it will be necessary for you to have some way of tracking the movement of the sky and for this a cheap mount capable of tracking is also required. If your aim is to image the planets and the moon then a basic webcam or video camera will suffice without the need for a high quality mount.

Long exposure astroimaging at prime focus requires additional specialized equipment and therefore often a higher budget. Most of the images in this book have been captured in this way and so there follows in this chapter an outline of the necessary equipment.

Optics

There are so many different telescopes that are excellent for astroimaging that it's difficult to say which is the best. In any case several factors must be considered before making any purchase.

The angular diameter of a target is the apparent size of an object as seen from our position on Earth and is therefore independent of its true size, as objects are all at different distances from Earth. Throughout the book objects with a large angular diameter are referred to as large objects or targets and those with a small angular diameter as small objects or targets. The angular diameter of the objects in this book range from 30×26 arcseconds (Saturn nebula Fig. 9.7) to $70^\circ \times 40^\circ$ (the Emu – Fig. 6.1). In order to successfully capture each object the field of view provided by the telescope/camera must match the object being imaged.

For any particular camera it is the focal length of the telescope that determines the field of view. Telescopes with a focal length less than 1,000 mm may be considered short, a focal length between 1,000 and 2,000 mm medium, and any telescope over 2,000 mm long. In order to capture all the targets in this book successfully it is therefore necessary to have a telescope in each of these ranges (or to use focal reducers – see below).

Although it does not directly affect image scale, the focal ratio of the telescope (the relationship between aperture and focal length) is an important factor to consider. The lower the 'f' number, the 'faster' the telescope and the shorter the exposure times needed to record data. Fast telescopes may be considered to be f/5 and under, medium speed f/5–f/8, and slow speed above f/8. As with focal length, the slower the scope the more demand is placed upon your mount because more accurate guiding is required for longer exposures.

It is also important to consider how portable the telescope is. If imaging is always undertaken at home then a large telescope is not a problem. However, if imaging is only ever done away from home, such as at a dark site or at star parties, then a small telescope may be considered ideal.

If you are new to astroimaging it is a good idea to start with a short focal length telescope and aim for some of the larger targets first. There are a number of reasons for this. First, a small, light telescope puts less strain on a mount. When you are starting out in astroimaging you will probably have a relatively small mount (such as the Skywatcher EQ6 Pro) and a large telescope on such a mount can make it unstable. Second, it is easier to guide a short focal length scope because they have a wide field of view and tend to be relatively fast so record data quicker.

Short tube refractors make excellent entry into the world of astroimaging. They are easy to use because the lenses are fixed and so do not require collimation. They are of two types – achromat and apochromat. Due to the way light is refracted, different wavelengths come to focus at different points. With a basic achromat refractor this can lead to color halos (chromatic aberration) if using a DSLR or a one shot color CCD camera. The problem can be avoided if a monochrome CCD camera with filters is used because the telescope can be refocused between filters, but this is time consuming.

The next best option is to purchase a semi-apochromat, often called a doublet. These have better quality glass that reduces chromatic aberration. However, semi-apochromats do not have good correction outside the visible region, particularly at IR wavelengths where CCD sensors are very sensitive. For best performance a true apochromat, often referred to as a triplet because it has three optical elements, should be preferred. These refractors are designed to ensure that all wavelengths of light, well into the IR, are brought together at a single point and therefore produce the sharpest image with no chromatic aberration. Until recently triplet refractors were very expensive. However, there are now many fairly cheap high quality short tube triplet refractors on the market that make an excellent introduction to astroimaging.

Imaging the smaller targets in this book requires longer focal lengths. Long focal length refractors tend to be very expensive. A more realistic choice is to enter the world of reflective optics. Popular designs include the Classic Newtonian, Schmidt-Cassegrain, Maksutov-Cassegrain and Ritchey-Chrétien. Each of these designs use mirrors that make the light path folded, allowing longer focal lengths to be achieved without requiring awkwardly long tubes. This therefore makes them relatively portable. With folded optics it is important to realise that where the secondary mirror obscures part of the main mirror, the ratio of the size of secondary to main mirror will determine the maximum contrast available in your images.

Field Flatteners and Focal Reducers

Apart from some high-end specially designed models, most telescopes do not have flat focal planes. This means that if the center of the field of view is at focus, the edges won't be. While field curvature is not really a big deal for visual astronomy,

it can have a major effect on astroimages. The sensor of a CCD is flat and thus the result of field curvature is an image in which the stars in the center are perfect points while those around the edges are elongated, pointing towards the center of the image. If the object of interest only occupies the center of the field then this can be rectified by cropping the out-of-focus part of the image. However, this is not very satisfactory as it limits the field of view you can image.

In order to resolve this problem it is necessary to add a field flattener. This is an extra lens that counteracts the field curvature and thus provides a flat field. The amount of field curvature varies according to a number of factors including focal length, focal ratio and the specific optical design of the telescope. It is therefore necessary to purchase a field flattener that is effective for each particular telescope. Fig. 10.1 is an image that was taken without the use of a field flattener. As can be seen, the stars in the outer parts of the image all point towards the center of the field. In this particular image the cluster only covers the center of the field enabling the bad stars to be cropped away. But if the object had filled the frame this wouldn't have been possible without cropping the object itself.

Another important accessory is the focal reducer, which is a lens that shortens the focal length of the telescope and therefore decreases the focal ratio. A shorter focal length increases the field of view, thus enabling larger targets to be imaged with the same telescope, while a decreased focal ratio means faster imaging time. A focal reducer can therefore be a way of effectively getting two telescopes out of one. Focal reducers have a compression factor that specifies what effect they will have on the focal length and focal ratio. So, for example, a focal reducer with a compression factor of $0.67\times$ will reduce the focal length and focal ratio of the telescope to 67% of their original value. It is also often possible to get a combined field flattener/focal reducer.

The distance between the CCD sensor and the flattener/reducer is critical to obtaining the flattest field and the designed reduction ratio. This means that spacers might need to be purchased in order for this optimum to be achieved.

Telescopes Used in the Book

Four different telescopes were used to capture the targets presented in this book – two with short focal lengths, one with a medium and one with a long focal length. Focal reducers were also used thus increasing the potential for each telescope.

Firstly, the William Optics Megrez 90 mm doublet refractor was used. This has a native focal length of 558 mm (f/6.2). However, in order to produce a flat field a $0.8\times$ focal reducer/flattener was used, which brought the focal length down to 446 mm (f/4.96). This gave an excellent field of view of $2.3^\circ \times 1.73^\circ$.



Fig. 10.1 Omega Centauri taken with a William Optics 90 mm refractor and Canon 400D DSLR, without using a field flattener.



Fig. 10.2 TS Super Apo Triplet 80 mm refractor (f/l 480 mm; f/6).

The other short focal length telescope used was the Teleskop Service TS Super Apo triplet. It has 80 mm aperture with a native focal length of 480 mm (f/6). However, by using a Televue 0.8× focal reducer/flattener the focal length was brought down to 380 mm at f/4.8, and hence a field of view of $2.7^\circ \times 2.04^\circ$, making it an excellent, cheap, and fast wide field imaging platform.

The mid focal length scope used in the book was a 7" Maksutov-Cassegrain – the Russian made Intes-Micro Alter M703. It has a native focal length of 1,800 mm (f/10). However, it was never used at this focal length. Rather, an AP 0.67× focal reducer was used, which brought the scope down to 1,206 mm (f/6.7) providing a field of view of $51.2' \times 38.5'$. This scope is excellent as it produces pin-point stars right to the edge. It also keeps focus well even though it has a moving primary mirror. It makes a good alternative to a mid-focal length refractor with a far higher retail price.

The long focal length scope used in the book is the 10" Vixen VMC260L, which is a modified Cassegrain. This has a native focal length of 3,000 mm, (f/11.5). Coupled to the cameras used in this book and using the AP 0.67× focal reducer the focal length was reduced to 2,010 mm, (f/7.7) with a field of view of $30.7' \times 20.13'$. Most of the images captured with this scope were taken using the reducer as the seeing was rarely good enough to make the best of the 3,000 mm. However, at 2,010 mm (f/7.7) it proved to be really effective.

Finally, for the very large targets, an 18–55 mm Canon camera lens was used. This was attached directly to the front of the CCD camera using a specially made adapter that ensured optimal distance between the lens and the CCD sensor, thus ensuring perfect focusing.

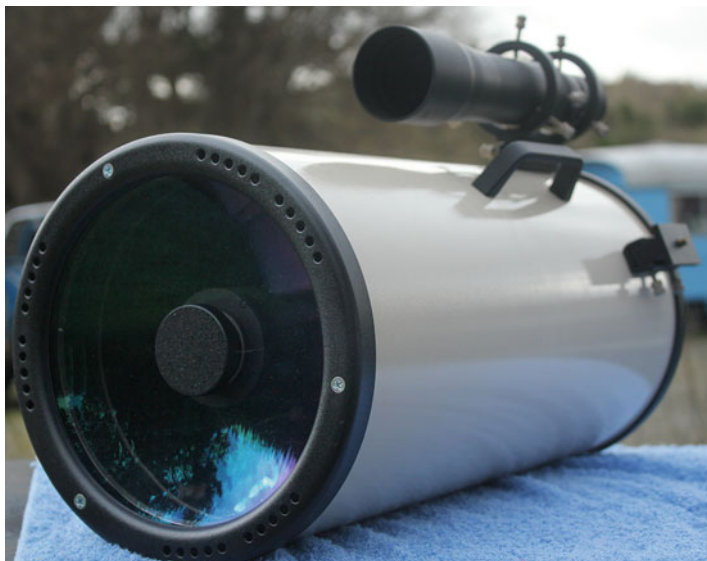


Fig. 10.3 Intes-Micro M703 7" Mak-Cass (f/l 1,800 mm; $f/10$).



Fig. 10.4 Vixen VMC260L 10" Modified Cassegrain (f/l 3,000 mm; $f/11.5$).

The Mount

Of all the equipment essential to astroimaging probably the most important is a good, solid mount. An average quality telescope on a good mount can produce acceptable images, whereas a top-end telescope on a poor mount is likely to result in poor images.

Mounts come in many forms. The most ideal for astrophotography are fork mounts on a wedge, and German-Equatorial mounts, both of which have one axis aligned parallel to the Earth's rotational axis.

They come in various sizes. Small mounts include the popular Skywatcher EQ6 Pro and the iOptron iEQ45; medium mounts include the Losmandy Titan, Paramount MX and the Takahashi EM-400 Temma-II; and large mounts include the Astro-Physics AP1200 and the Paramount ME. As always, the sky's the limit when it comes to the cost of mounts. Small mounts tend to be (but are not always) cheaper than larger ones.

Mounts vary in a number of ways. Firstly, each type has a different weight capacity, in other words, how much equipment it can carry and still perform well. The smaller mounts can carry up to about 25 kg, the medium about 60 kg and the large ones in excess of 80 kg. If they are loaded far beyond their capacity then resultant problems include poor guiding and motor burn-out amongst others.

There are a number of other crucial differences between types of mount aside from carrying capacity. As the mount is the piece of equipment that tracks the stars, thus compensating for the Earth's rotation, the tracking ability of the mount is of utmost importance. Most people these days use autoguiders to compensate for flaws in the tracking ability of mounts, but not all mounts react equally well to autoguiding as they have different levels and forms of periodic error.

Periodic error is caused by imperfections in the mount's worm gear. The error is periodic because it repeats itself for every complete turn of the worm gear and the cheaper the mount the larger this error tends to be. For example, the Skywatcher EQ6 Pro can have a periodic error of up to 40 arcseconds while the Astro-Physics 1,200 boasts a periodic error of less than 5 arcseconds. Autoguiding is of course used to 'guide out' this periodic error. However, the magnitude of the periodic error isn't the only crucial factor affecting the performance of the mount. The way in which this periodic error changes throughout the duration of a worm gear cycle is also important. The smoother the change the easier it is to guide out. If there are sudden jumps in the periodic error no autoguider will be able to react quickly enough to correct it. So a mount with a large but smooth periodic error can outperform a mount with a small but jerky periodic error.

Many mounts have the ability of improving their periodic error via software, a process known as periodic error correction. Software, such as the commercially

available PemPro from CCDWare or the free PECPrep, analyse the periodic error of the mount and program the mount's firmware accordingly, thereby reducing periodic error. While periodic error correction is certainly useful if you are imaging without an autoguider, opinion is divided over whether it is beneficial to use it in conjunction with an autoguider. No periodic error correction was used capturing the images for this book.

These days most astroimagers use GOTO mounts, which enable them to locate astronomical targets easily. Mounts vary widely in their GOTO accuracy, with the more expensive mounts tending to have greater GOTO accuracy thereby making it easier to find astronomical targets. This accuracy becomes more crucial the smaller the astronomical target and the longer the focal length of the telescope used. As the field of view decreases with focal length the more accurate the GOTO has to be in order to bring the desired object onto the sensor of the CCD.

Mounts Used in the Book

Two brands of mounts were used to take the images for this book – the Skywatcher EQ6 Pro and the Losmandy Titan. Both were excellent in their own way.

Two different EQ6 Pro mounts were used and it was found that there was a wide variation in their periodic error. The first one had a very high frequency periodic error which could not be guided out, as the guider could not react quick enough to deal with it. This wasn't a problem at relatively short focal lengths but beyond about 1,200 mm stars became ovoid. The second EQ6 Pro mount, while having a larger overall periodic error did not suffer the same problem and therefore the periodic error could be guided out even at longer focal lengths. The GOTO ability of both mounts was not brilliant at long focal lengths but by synching on stars in the vicinity of the desired object, any object could be brought satisfactorily onto the CCD sensor. The EQ6 Pro was controlled by the fantastic EQMOD, an open source application that enables the mount to be fully controlled from a computer.

The Losmandy Titan proved to be an excellent mount with a smooth periodic error of less than 10 arcseconds and a carrying capacity easily capable of supporting all the equipment used in this book. The mount is controlled by René Görlich's Gemini II Positioning System. Despite being under development during the production of this book it provided excellent control of the mount, via the Gemini II ASCOM driver, and provided near perfect GOTOs even at 3,000 mm focal length (Figs. 10.5 and 10.6).



Fig. 10.5 Losmandy Titan mount.



Fig. 10.6 Gemini II positioning system.

Cameras

A popular entry point into the field of astroimaging is to use a standard digital SLR. These are a good place to start because they are relatively cheap and can also be used for everyday photography. They are color cameras so can produce color images without having to deal with separate color filters. They can be piggybacked on a telescope to capture the large targets, using their own lenses. With a special adapter they can also be used for prime focus astroimaging. Certain models can be modified by removing the IR filter making them more sensitive to the red part of the spectrum, which is advantageous when imaging many emission nebulae. The disadvantage with DSLRs is that they are less sensitive than monochrome cameras. They are also un-cooled (without serious modification), which makes the resultant images quite noisy. While the noise can be reduced by dark subtraction and the stacking of images it can take a lot more exposure time to achieve satisfactory results.

Another way of achieving color images quickly is to use a One Shot Color (OSC) CCD camera. These have the advantage over DSLRs in that they are usually cooled and so produce images with a higher signal/noise ratio. As with the DSLR they are relatively easy to use as you don't have to consider each color separately. One disadvantage with OSC cameras is that they are up to four times less sensitive than monochrome cameras with otherwise similar specifications. Secondly, they are of lower resolution compared to the mono version of the same camera because three pixels are used to create one color pixel. Lastly, with any color camera you cannot use it to undertake narrow-band imaging, as will be discussed in the following chapter. A OSC CCD was used twice in this book, to capture the Emu (Fig. 5.1) and the Galactic Bulge (Fig. 6.1). These images were taken with a QHYCCD QHY12, which has a fairly large sensor and can produce excellent results.

Monochrome CCD cameras have the advantage of being highly sensitive and most of them are cooled thus they produce relatively low noise images. They have a larger dynamic range than OSC and can therefore simultaneously capture faint and bright parts of objects. One apparent disadvantage is that you have to image through separate filters in order to produce colored images. However, this is not really a disadvantage for a number of reasons. Firstly, as they are more sensitive than OSC the extra exposure time required to image through the different filters is not necessarily that significant. Second, and more importantly, monochrome cameras are far more versatile. Not only can they be used for RGB color imaging, they can also be used for narrowband imaging and producing hybrid images. With a little practice they are not much more complicated than using OSC or DSLR. Until recently monochrome CCD cameras were much more expensive than color alternatives but there are now many budget models on the market.

Another factor to take into account is that the sensor in different camera models varies in size – the larger the sensor the larger the field of view for any particular optical set-up. For example, the SBIG STL series sport a sensor that is 36×25 mm in size whereas the QHY9 has a sensor that is only 19.7×14 mm. However, a large sensor is not always better. Due to field curvature it may not be possible to utilize the entire larger sensor, and vignetting may occur if the particular telescope, flattener and



Fig. 10.7 QHY9 Monochrome CCD 8.3Mp.



Fig. 10.8 QSI 583wsg Monochrome CCD 8.3Mp.

accessories cannot handle the larger area. The only way to surmount this is to crop the image, but this negates the reason for using a larger sensor in the first place.

Cameras Used in the Book

Three different monochrome cameras were used in the production of this book, all with the same sensor – the popular 8.3mp KAF-8300. The first was the QHY9 from QHYCCD (Fig. 10.7). This is an excellent camera at the budget end of the monochrome CCD scale, requiring an external filter wheel and guider. The second camera is the Quantum Scientific Imaging QSI 583wsg (Fig. 10.8). This camera not only has a built in five position filter wheel, but also a built in off axis guider. This means that a guide camera can be attached directly to the imaging camera body. The filters are placed close to the sensor and so the camera only requires 1¼" filters thus saving money. The last of the three cameras is the next model up – the QSI 683wsg. It is a similar camera to the QSI583wsg except that it cools to a lower temperature, has faster download times and most importantly has a built-in eight position filter wheel. This means that a full set of LRGB and narrowband filters can be kept inside the camera at all times.

Another camera that is well worth mentioning is the Imaging source DMK41. This is a monochrome video camera especially designed for lunar/planetary/solar imaging and is also an excellent tool for polar aligning.

Filters

For those who live in light polluted areas it may prove advantageous to use light pollution suppression filters. These work by rejecting the narrowband emissions from street lights like the sodium lines (but are not effective against the broadband emissions from common mercury based lamps), while at the same time letting through the light from astronomical objects. Unfortunately they don't really work for all types of objects, such as galaxies and globular clusters, because the wavelength of starlight is similar to the unwanted light that the filters reject. They work best with emission nebula but even in this case one drawback is that they require longer integration. Still, this is a small price to pay if it enables you to image objects that would otherwise be beyond the environmental limits of your location.

If a monochrome CCD camera is used then it is necessary to use separate colored filters if color images are desired. Typically the filters that are required are red, green and blue plus a clear filter to create luminance. They are mounted in a filter wheel that can be rotated to enable imaging through each filter. Many filter wheels are motorized and so can be run via the image acquisition software.

Filters come in various sizes, typically 1.25" and 2" although other sizes are available. The required size largely depends upon the size of the CCD sensor. If the filter is too small for the sensor then vignetting will occur.

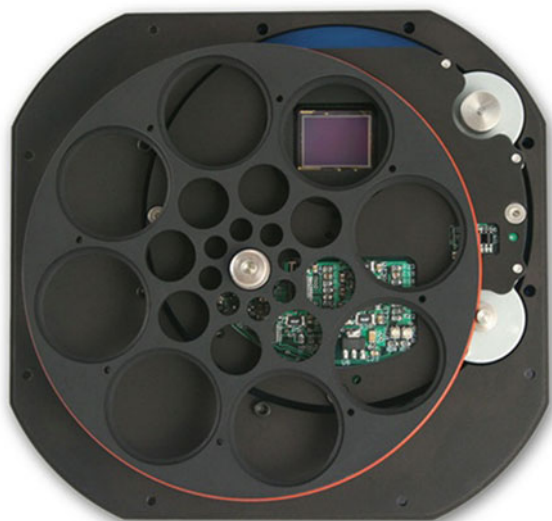


Fig. 10.9 QSI 683wsg Monochrome 8.3Mp CCD with 8 position built-in filter wheel.

Narrowband filters are also common and have been used extensively in this book. These filters pass only a small part of the light spectrum through. Common narrowband filters include Hydrogen-alpha (H-alpha), Oxygen-III (OIII), Hydrogen-beta (H-beta), Sulfur-II (SII) and Nitrogen-II (NII).

Narrowband filters are particularly advantageous because they enable imaging in areas of high light pollution and even moonlight. Although they do allow light pollution through, it is only in the transmission band which is small compared to the object emission light. They only allow light through that is emitted from particular gases and so they cannot be used for reflection nebula or imaging complete galaxies. For emission nebulae, however, they are superb. Narrowband imaging is discussed in more detail in Chap. 12.

The cameras from Quantum Scientific Imaging, used in this book, have a built in filter wheel which reduces the number of separate items in the optical train, making the optical train shorter and therefore more rigid (Fig. 10.9).

Autoguiding

For quality, long exposure astroimages it is paramount that the stars are pinpoint, for which perfect guiding is required. Most people undertake autoguiding, necessitating an autoguiding camera. Autoguiders differ in sensitivity and sensor size. The more sensitive the guide camera the lower the magnitude of star that is usable to guide on, and the larger the sensor the larger the field of view for potential stars. The Starlight Xpress Lodestar was used in this book (Fig. 10.10).

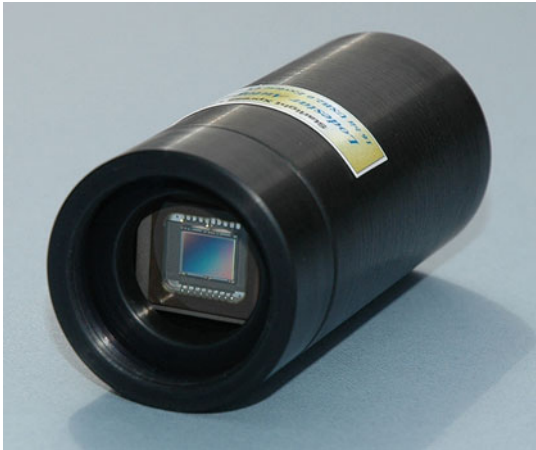


Fig. 10.10 Starlight Xpress Lodestar Autoguider.



Fig. 10.11 Starlight Xpress Adaptive Optics Unit with the Lodestar Autoguider attached to the Off Axis Guider.

There are several methods for autoguiding – separate guide scope, off axis guider (OAG) and Adaptive Optics (AO).

Using a separate guide scope has various disadvantages. Firstly, it necessitates having another scope on top of the mount, which may already have a few telescopes attached. Secondly, if there is any movement in the primary of the imaging scope (due to mirror flop), or flexure in the system, this will not be picked up by the guider. Using a separate guide scope does, however, have the advantage of providing a large area of the sky from which potential guide stars can be chosen. If the guide camera isn't very sensitive then this is essential as it is likely that the guide camera will have to be pointed further a field in order to locate a star that is sufficiently bright to guide with successfully. If this is the case then a separate guide scope will probably be the best option.

With a highly sensitive guide camera this isn't an issue. Using an OAG, in which a small amount of the light from the imaging train is used for guiding, seriously limits the amount of potential sky that can be searched for guide stars. But a highly sensitive guide camera will always find a suitable guide star even in the small area provided by the OAG prism. It should be borne in mind, however, that an OAG adds length to the optical train and some scopes might have insufficient focal travel to support this. If this is the case then a separate guide scope will be the only option whatever guide camera is available.

A form of OAG patented by SBIG uses a separate internal guide sensor, positioned just above the main imaging sensor in the camera. This has the advantage of not requiring a separate OAG to be placed in the optical train and thus avoids any potential problems with lack of focuser travel. However, the big disadvantage with internal guide sensors is that the guide sensor is positioned behind any filters that are used. Color filters, and especially narrowband filters, cut down the intensity of light that reaches the guide sensor and thus reduce the potential number of usable stars on which to guide.

Two of the cameras used in this book have proved to be the best of both worlds. The QSI 583wsg and QSI 683wsg have a built-in OAG port, thus removing the necessity of using an extra piece of equipment that increases the length of the optical train. However, this OAG port is in front of the built-in filter wheel, so guiding is always undertaken with unfiltered light.

A final form of guiding, which has been used for many of the images in this book, involves using Adaptive Optics (AO). The Starlight Xpress AO unit (Fig. 10.11) sits in front of the CCD camera and has a tip-tilt optical window that stabilizes the position of the image. Unlike traditional guiding, therefore, it does not compensate for guiding errors by sending signals to the mount. The tip-tilt mirror can make extremely fast error corrections and is thus especially useful for mounts with a period error that isn't smooth, which would be difficult to guide out using traditional guiding. The Skywatcher EQ6-Pro used in this book had a very uneven periodic error and was therefore difficult to guide at long focal lengths using traditional guiding. However, this was rectified by using the AO unit.

Dew Shields and Heaters

As the night cools down moisture can form on the front lens, corrector plate, secondary or even primary mirror of a telescope. Whether or not this occurs depends upon the environmental conditions of the imaging site. Some areas of the world never experience problems with dew, whereas the site from which these images were taken suffered greatly.

The result of dew forming on the optics is a lack of contrast in the images and, when things get really bad, stars begin to appear bloated. In order to counteract this, a dew shield should be used. This sits on the front of the scope and helps to prevent dew forming on the optics. With many refractors retractable dew shields are built into the design and although dew shields are commercially available for most scopes they are easily homemade from a wide variety of materials such as camping mats.

In situations of heavy dew such shields will only prevent condensation from forming for a period of time. Eventually the optics will begin to fog up. A quick way to deal with this is to use a hairdryer to remove the moisture. If only a quick burst of hot air is required this is an acceptable method, but prolonged use of a hairdryer could result in the focusing being affected and the scope will have to cool down to ambient temperature again before focusing becomes realistic.

A preferable alternative to a hairdryer is a dew heater. These are heated strips that wrap around the outside of the OTA, near the optics, and keep the optics just above ambient temperature thus preventing dew from forming. With refractors and scopes with corrector plates this is fairly easy and they can be very effective. However, with open ended tubes, with the secondary supported by a spider, it can be more difficult to get the warmth to the mirrors. The Vixen VMC260L suffered this problem, which was rectified by sticking the wire along the spider enabling a heating strip to be wrapped around the secondary mirror housing. Much more challenging to deal with is the dewing over of the primary mirror, as dew heaters around the bottom of the scope are much further away from the mirror itself and are therefore less effective at warming it.

Software

For wide field shots of the night sky using a DSLR it is possible to use the camera for image capture without a computer by using the viewfinder and LCD screen. However, if undertaking prime focus photography, or when using a dedicated CCD camera, a computer with various applications to run all the equipment is required. Countless software is available, whether free or commercially sold, but here are some of the more popular ones:

MaxIm DL is a commercially available, sophisticated application that can acquire images, focus and guide. It has a built in planetarium, and can also perform many imaging processes. There are many freely available programs dedicated

solely to guiding, such as **PhD Guiding**, from Stark Labs, **Guidedog** autoguiding software, and **Guidemaster**, which is designed for autoguiding with a webcam.

If a GOTO telescope is being used on its own, then the catalogues contained in its hand-set will enable many of the objects in this book to be found easily. However, if the mount is connected to a computer many other useful features will be available. Here are a few planetarium programmes that are available that can also function as telescope controllers, using the relevant drivers and plug-ins.

Stellarium is an excellent free planetarium programme that produces an extremely realistic night sky. It enables the user to get a good feel for the part of the sky that is presented on screen and it does have limited telescope control capability using the necessary drivers.

TheSky is an extremely sophisticated commercially available software package. Aside from being a planetarium it can completely control most mounts with the correct drivers installed. It enables the user to superimpose the field of view of their equipment on to the sky and allows the users own images to be linked into the sky.

Starry Night is another sophisticated commercially available software package with similar features to TheSky.

Chapter Eleven



At the Telescope

Positioning the Mount

Before any imaging can be undertaken the mount must be placed on a solid footing. The strongest, most accurate mount in the world will be no good for astroimaging if it wobbles because it is not securely in contact with the ground. If the mount is supported by a tripod then placing it on something solid is preferable to placing it directly onto grass in order to prevent it from sinking into the ground. Specialized feet can be purchased to spread the weight if grass is the only ground that is available. If possible the mount should be isolated from the area being walked on in order to minimize the effect of vibrations.

If imaging is always undertaken from the same place then the next best option is to install a permanent pier on which to place the mount. If the idea of leaving the expensive mount in situ is unattractive, albeit wrapped in a protective shroud when not in use, then a permanent pier can be left in the perfect polar aligned position and then the mount can be placed on top of the pier each imaging session.

If neither space nor budget is an issue then the ideal situation is of course the home observatory. This allows all gear to be left set-up so that imaging can begin immediately each session. For a concise introduction to building a permanent observatory see David Arditti's "Setting up a Small Observatory", another book in this series.

Serious consideration should be given about where the permanent pier/observatory should be positioned. As the objects in this book are all south of the celestial equator, the clearer the view towards the south the greater the number of objects can be considered. If living in the southern hemisphere it is important that the south celestial pole (SCP) can be observed from the mount position in order to be able to image all circumpolar objects. If this is the case, and you can see at least part of the celestial equator as well, then all objects in this book will be available at some point during the year.

In the northern hemisphere, the number of objects in the book that are available will depend upon the latitude of the imaging site – the farther south, the more objects.

Polar Alignment

In order to take good quality long exposure astroimages the mount must be accurately polar aligned. Accuracy becomes more and more crucial with increases in the focal length of the telescope and the length of the exposures taken. On an unguided image the effect of bad polar alignment will be trailed stars in the Dec axis. However, accurate polar alignment is still essential when undertaking guided imaging as without it field rotation will occur, that is, the stars in the image will appear to rotate around the position of the guide star.

A mount is polar aligned when its RA rotational axis points directly towards the celestial pole. In the northern hemisphere this is the north celestial pole (NCP) and in the southern hemisphere the south celestial pole (SCP). Many equatorial mounts

have a built in polar axis scope, which can be used to point the mount at the relevant celestial pole. In the northern hemisphere the second magnitude star Polaris sits at present within 0.7° of the NCP so it is useful for rough alignment purposes. In the southern hemisphere there is no bright star available within a close contact to the pole. The nearest visible star is the faint magnitude 5.6 Sigma Octantis and is about 1° from the SCP – this makes using a polar scope much less useful.

Once a rough alignment has been achieved it can be improved using the ‘drift method’ – this can be done visually by watching the drift of a star through the eyepiece, or, if a computer is at hand, using a webcam or CCD camera and watching the drift on the screen. Adjustments to the azimuth and altitude settings are then made depending upon the movement of the guide star. A detailed description of this method is beyond the remit of this book but there are numerous excellent tutorials on the internet demonstrating how to undertake this.

If using a computer there are plenty of software applications available designed to assist with polar alignment. EQ Align is freeware. PoleAlignMax is also free but is used in conjunction with MaxIm DL or CCD Soft. Tpoint works in conjunction with TheSky, and PemPro has a polar alignment tool built into it.

Choosing a Target

Field of View

Before choosing which of the objects in this book to image it is essential to know what amount of sky can be successfully captured with your particular telescope/camera combination. If the object is too small for your set-up it might end up looking like an indeterminate shape surrounded by empty space with no detail showing. Likewise, if the object is too large for your set-up then the final image might simply be a red area of nebulosity showing nothing of interest.

As a rule of thumb short focal length telescopes are good for large extended objects, medium focal length scopes are good for many medium size nebulae and large galaxies and long focal lengths are required for small galaxies, planetary nebula and small nebulae. However, this does depend upon the size of the sensor of the camera used. So it is worthwhile determining the size of field that your particular telescope/camera combination will give you before choosing a target.

The amount of sky that will be available for imaging with a particular scope/camera combination is determined by the physical dimensions of the sensor and the focal length of the scope. The amount of sky is usually given in arcminutes (symbol is ') or degrees (symbol is $^\circ$). There are 60' in 1° .

For determining the field size of a particular scope/camera combination, in arcminutes, the formula that is used is:

$$\text{Field of view} = \tan^{-1} \left(\frac{L}{fl} \right) \times 60$$

Where L is the length of a side of the sensor and fl is the focal length of the scope. (Both L and fl need to be in the same units).

An easy, shorthand approximation is:

$$\text{Field of view} = (L \times 3,438) / \text{fl}$$

(Although this shorthand is useful it should be noted that it becomes less accurate at shorter focal lengths for a given sensor size.)

For example, the main camera used in this book, the QSI 583wsg, has a sensor that is 17.96 mm × 13.52 mm. The Vixen VMC260L has a focal length of 3,000 mm. So, to work out the area of sky, in arcminutes, that is available for imaging with this combination:

$$(17.96 \times 3,438) / 3,000 = 20.58' \quad (13.52 \times 3,438) / 3,000 = 15.49'$$

So the area of sky that this combination of scope and camera offers for imaging is 20.58' by 15.49'.

It is important to enter the *effective* focal length into the equation. The Vixen VMC260L was not used at 3,000 mm for this book, but rather using a focal reducer, at 2,010 mm. For the purposes of this book, therefore, the field of view that was available for imaging with this camera and scope was actually:

$$(17.96 \times 3,438) / 2,010 = 30.7' \quad \text{Height : } (13.52 \times 3,438) / 2,010 = 23.13'$$

So the area of sky that this combination of scope and camera offers for imaging, with a focal reducer, is 30.7' × 20.13'. (This shows how purchasing a focal reducer for a telescope can effectively give you two different telescopes.)

With a much shorter focal length scope, the field size would be stated in degrees rather than arcminutes. There are 60 arcminutes in one degree so you would simply divide the results of these calculations by 60 to give an answer in degrees.

Once you have determined the field of view for your telescope/camera combination, it will be easier to choose which of the objects in the book are suited to your equipment. Each image has the field of view given at the end of the 'technical details' section. By comparing this with your field of view you will get a fairly accurate idea of what the object will look like if imaged using your own equipment. Another method is to use 'field of view indicators' in planetarium software such as TheSky.

Working out the field of view of your particular equipment will also help you decide how to frame the object, once chosen. An astroimage can be vastly improved if it is framed well – a nebula that is half out of the image won't be very impressive. By comparing your field of view with the image in this book you will be able to decide where on your sensor to place the object. Likewise, if your field of view is smaller than that used in the book you may decide to frame the image such that the most interesting part is imaged, e.g. you might decide to only image the Keyhole

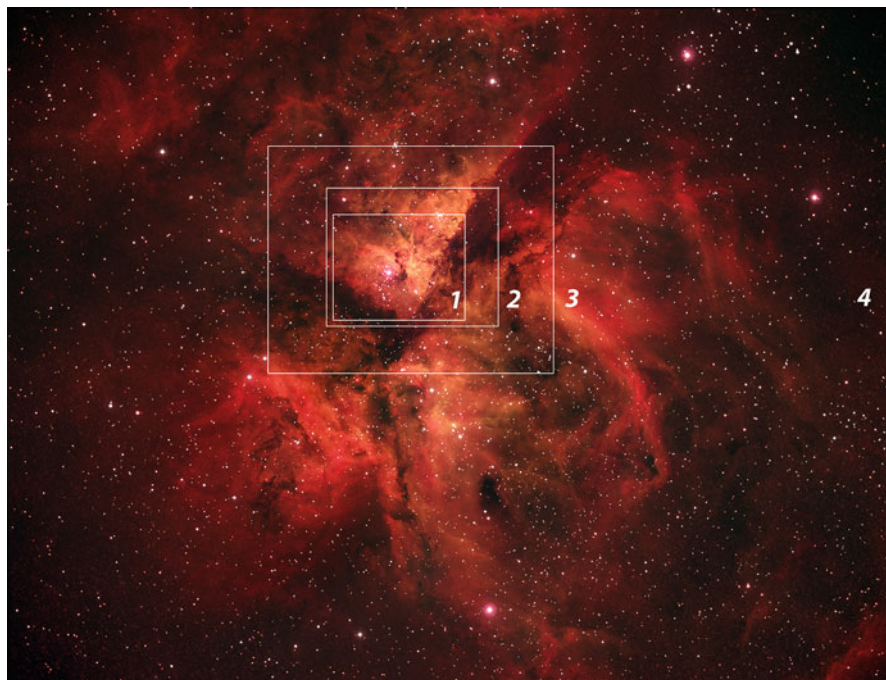


Fig. 11.1 Eta Carinae Nebula showing the different field sizes available for the telescopes used in this book using the QSI 583wsg CCD camera.

nebula rather than the whole of Eta Carinae. Fig. 11.1 shows the fields of view that were used in this book.

1. 10" Vixen VMC260L, f/l 3,000, gives a field size of $20.58' \times 15.59'$.
2. 10" Vixen VMC260L with 0.67 $\times$ reducer, f/l 2,010, gives a field size of $30.7' \times 23.13'$.
3. 7" Intes-Micro Mak-Cass with 0.67 $\times$ reducer, f/l 1,206 gives a field size of $51.2' \times 38.54'$.
4. 90 mm William Optics refractor with 0.8 $\times$ reducer/flattener, f/l 446 mm, gives a field size of $2.3^\circ \times 1.73^\circ$ (the entire image).

Other Factors

On the title page of each chapter is a list of the constellations in which the objects in that chapter can be found. It is necessary to ascertain which constellations are visible from your particular location at a given time of year. Ideally an object

should be imaged at its highest point in the sky, as that is usually the area of best seeing. However, depending upon latitude many of the constellations may be fairly low in the sky anyway so this might not be an issue. Also local obstructions – trees, buildings, neighbor’s security lights and so on – may mean that objects cannot be imaged when they are on or near the Meridian.

Once a choice of ideal constellation has been determined it is a case of leafing through the relevant chapter until an object of interest captures your eye. You then need to determine whether the object is a suitable target for the local environmental conditions. For example if you are imaging in bright moonlight you will need to ignore the faint galaxies, or if there is a high level of light pollution it might be advantageous to consider a bright nebula and use a light pollution suppression filter. Alternatively, if it is an option try imaging an emission nebula with narrowband filters. Likewise, if there is cloud around, and so sucker holes will be chased, it might be worth considering a bright cluster that only requires short exposures.

The development of GOTO mounts has revolutionized astroimaging due to the ease with which objects can be located. Not all GOTO mounts are equally accurate but with precise polar alignment and ‘synching’ on nearby bright stars most of the objects in the book should be relatively easy to find. Some of the more obscure objects might not be in the catalogues of all mounts or planetarium software, but if they aren’t, or in the case of non-GOTO mounts, the RA and Dec coordinates that are provided can be used.

Telescope and Camera Cool Down

One of the most crucial aspects of producing a decent astroimage is accurate focusing. An image that is out of focus will have bloated stars and will lose detail in the fine structure of the object. As the focal length of a telescope changes slightly with temperature (due to expansion and contraction of the mirrors, glass and tube) so will the focal point.

In folded optics, such as Schmitt-Cassegrains, the effect of temperature is multiplied threefold with the focal point moving out of the focuser as the temperature drops. This can be reduced by using a carbon tube. In refractors, the major effect of temperature is on the lens cell itself with the focal length reducing as the temperature drops. A metal tube goes some way to correcting this but the net effect is the focal point moves into the focuser as the temperature drops. A carbon tube on a refractor can make the situation worse.

It is important, therefore, to allow the telescope to cool down to ambient temperature before any serious focusing is attempted. This is especially the case with large aperture scopes. Many such scopes have fans to assist cool-down time but it is always worth leaving a large scope for at least an hour before imaging begins (note that this time need not be wasted as it can be spent undertaking other essential preparations such as polar aligning, finding the target, calibrating the guider and so on.)

If you are using a temperature regulated CCD camera it is also important to allow the temperature to slowly drop until the desired imaging temperature is reached and stabilizes. Depending upon local conditions this might take 20 min. If the temperature drops too quickly ice can form on the glass in front of the sensor. If this occurs the temperature of the camera will have to be raised again until the ice disappears.

Even with an un-cooled DSLR it is worth leaving the camera outside to reach ambient temperature before imaging in earnest.

Focusing

Once the scope and camera have cooled down, a focusing star must be chosen. How bright the star needs to be depends upon the imaging equipment. If focusing through the viewfinder/live view of a DSLR then it is likely that a first magnitude star or brighter will be needed in order to see anything at all. However, if focusing is to be achieved using software – such as MaxIm DL or FocusMax – then the star should not be too bright as it might saturate and thus give inaccurate readings. A magnitude 5 star will usually suffice. It is best to choose a star at a high altitude as this is where seeing conditions are usually the best and so stable readings will more likely be attained. Ensure that the star is close to the center of the field of view – if the field of view is not perfectly flat then you need the center to be at optimum focus as this is likely to be where the object of interest is positioned.

A Hartmann mask in front of the lens or scope can be a useful aid to focusing. This is a mask with two holes cut into it. When the star is out of focus it will appear double. When focus is achieved a single star will result. There are many variations on the Hartmann mask that are also successful.

Another method of focusing is to use the focusing algorithm provided in capture software. The idea is to get a star to the smallest FWHM (Full Width at Half Maximum) value possible. This is the width of the star at half its maximum value, measured in pixels. Similar results can result from monitoring the half-flux diameter (HFD) of stars.

The FWHM value will fluctuate if the seeing conditions are not perfect so it might take time and patience before focus is reached. A scope with an autofocuser is advantageous as the software does this automatically.

Focusing must be redone at frequent intervals. As the temperature changes during the night so will the focal point. Therefore the average FWHM of each exposure must be monitored and if it increases then it is time to refocus. This can be as often as every half an hour with fast scopes. Carbon fiber tubes help to minimize changes in focus but it is still important to monitor it. Likewise, with an autofocuser, temperature probes can be used to adjust the focuser with changes in temperature but it is still important to monitor the FWHM to ensure it is working – no one wants a collection of out of focus exposures at the end of the night. This is why programming a series of exposures and then going off to bed isn't a good idea.

While tempting, especially when it's a beautiful night on a week day, it's important to avoid waking up to find a whole string of out of focus images.

If using a monochrome CCD, with a color filter wheel, only use par-focal filters, otherwise focusing will have to be adjusted for every filter change.

Guiding

As well as accurate polar alignment and focusing, successful results will only be achieved with very accurate guiding. This is necessary in order to keep the object in one position throughout the exposure. Guiding may not be necessary for short exposures with a short focal length scope. However, if long exposures are desired accurate guiding is essential.

Signs of poor guiding are either elongated or bloated stars. Although guiding can be done manually, autoguiding is now the norm. Guiding is required to correct for errors in the mount's drive system, which can be greater or lesser depending upon the quality of the mount. The smoother the periodic error in the mount the easier it is to guide out. In order to minimize guide corrections the mount should be accurately polar aligned. If this is done then most corrections will occur in RA and few in Dec. The fewer guide corrections necessary, the finer the end result. Although errors in Dec can be guided out, field rotation will occur if the mount is badly polar aligned.

The longer the focal length of the scope, the greater the image scale and thus the more accurate the guiding needs to be. This is why guiding a short tube refractor is easier than a long focal length reflector. If possible it is a good idea to learn how to guide proficiently using a short focal length scope before purchasing a larger one. Up to a point, the actual size of the periodic error of the mount isn't too important for successful guiding. Rather, it is how smooth the periodic error changes over the worm cycle that determines how successful guiding will be. A mount with extremely erratic periodic error might be impossible to guide satisfactorily as too many quick corrections will be needed to keep the guide star from wandering.

When calibrating the guide camera a star must be chosen which isn't too bright – a saturated star will be more difficult for the software to pinpoint its center. However, a guide star that is too faint might be mistaken for a hot pixel, or else get lost in the noise produced by the guide camera. Different software use slightly different ways to calibrate autoguiders but in all cases it is important for the star to move a sufficient distance in order for the software to determine how much correction is needed for a particular movement of the star. Some software can compensate for change in Dec and so calibration should be undertaken at 0 Dec. However, if this isn't the case then autoguider calibration should be undertaken with a star in the vicinity of the object to be imaged.

When commencing guiding it is important to set the length of exposure of the guide camera correctly. Bad seeing conditions can cause the guide star to dance around and you don't want guide corrections being made that are due to 'chasing

the seeing.' If seeing is bad then exposure time should be increased, as this will reduce the variation caused by seeing per guide correction. Likewise, exposure time will have to be increased if there are no bright guide stars in the autoguider's field of view. If necessary guider exposures can be increased up to 10 secs and still produce good guiding results, depending upon how erratic the periodic error of the mount.

Having the mount slightly unbalanced in both Dec and RA can be beneficial as it ensures that the gears always mesh and thus reduce the effect of backlash, which in some mounts can occur when the gears reverse direction and momentarily lose their connection. Some software packages have backlash correction settings that can help to minimize this effect.

Autoguiding software usually includes settings such as aggressiveness, that is, how much of any detected movement is actually applied to the corrections, and minimum/maximum move, i.e. how large or small a movement can be applied. The optimum values of these parameters are completely dependent upon the particular mount, and the focal length of the optical system and it is really a matter of trial and error to determine them.

Assuming that dithering is being undertaken it is important to wait for the guider to settle back down between exposures (see below).

Sub-pixel guide errors should be aimed for but what is possible will really be dependent upon the quality of the mount and the individual character of its periodic error.

Locating and Framing the Object

Once focus has been achieved, and the autoguider has been calibrated, it is time to locate and frame the chosen object.

With an accurate GOTO mount most of the objects in the book will be easy to find. The majority of objects have common catalogue numbers, such as M, IC or NGC. Any planetarium software, or mount handset, will be able to easily locate these objects. However, some of the more obscure objects are not in these catalogues. The Gum, RCW, Menzel, Shapley, Bernes, Barnard, Integrated Flux, Kont, Sandqvist, Trumpler and Henize catalogues are less common and are often not included in handsets and planetarium software. In these cases it is important to use the RA and Dec coordinates provided in this book.

If the GOTO mount is inaccurate it may be possible to 'synch' on a star in the vicinity of the target. Once done, using RA and Dec coordinates will be more accurate.

The longer the focal length of the scope, the smaller the field of view, hence the more accurate the mount has to be in order to bring an object on to the sensor. With some mounts GOTO accuracy can be improved by building up a model of the sky using many alignment stars. Once the object has been located it is important to spend time framing it effectively. An image in which the object of interest is far off

center will not present as good as one that has been placed well. Sometimes, however, this is unavoidable. For example, if there is a bright star close to the object then the only way of avoiding internal reflections may be to image the object off to one side of the frame thus leaving the bright star well outside. If this is done then focus should be undertaken near where the center of the object is, even if that isn't in the center of the field.

In some cases the object is so vast that it may take time to move around until a satisfactory field has been found. For example, the Vela SNR contains so many beautiful areas that it is really trial and error locating a field that interests you. The fields imaged in Chap. 2 are a good start and the coordinates for the center of these fields are provided. But the real fun to be had with such large objects is to find your own unique field.

Exposing

Astroimages always improve with longer total exposure time because it provides a greater signal to noise ratio. This can be achieved by either taking one very long exposure or stacking many shorter exposures, or 'subs', using software. It is usually the case that the latter is chosen for the reasons set out below. Ideally individual subs should be as long as possible to maximise s/n ratio but in reality the ideal length of subs is also affected by the following factors:

Guiding accuracy: A mount that guides poorly will not be capable of producing acceptable long exposure images. It will be obvious what the maximum exposure time for the particular mount is – as soon as stars start to trail, or become bloated you know that the maximum exposure time has been reached. When this occurs attempts should be made to improve the guiding accuracy by changing the guider settings in the software. If this makes no difference then it is important to check that cables are not dragging, that everything is locked down tightly and that the mount is properly stable. If the issue is caused by a mechanical problem with the mount, and this cannot be overcome, then the longest sub possible for the mount will be that which can be obtained before stars begin to trail or appear bloated, which with a very poor mount could be less than a minute.

Polar alignment: As discussed above, inaccurate polar alignment will result in field rotation in long subs. If this occurs then ideally polar alignment should be improved. However, if imaging with a portable set-up there is a limit to how long you want to spend polar aligning rather than imaging. In this situation the best option may be to stack a greater number of short subs instead.

Sky glow: If imaging from a light polluted area, or in Moonlight, then the CCD will saturate fairly quickly. Therefore many short exposures might be necessary.

Saturation: This occurs when bright objects saturate the sensor. Objects such as the Tarantula Nebula, M 42 and Omega Centauri have very bright cores. Once these cores have saturated any data in them is lost and cannot be recovered. In these situations it might be possible to take a set of long and short exposures and then

subsequently combine them. Sometimes, however, this is not successful and, if this is so, then exposure length should be limited so that the object doesn't saturate.

Aircraft, satellites and meteors: If you live near a busy flight path it is likely that many subs will have aircraft trails going across them. However, even living in the most deserted place on Earth doesn't protect you from satellites and meteors passing through the images. If sufficient short subs are taken then this isn't a problem because when the images are combined in processing software, using median or preferably sigma-clip combine, these trails will cancel out and disappear. However, if only a couple of long subs have been taken then even during combining the processing software will not be able to remove the trails and thus they will appear in the final image.

Some targets simply require long subs in order for any data to register on the sensor. Likewise, narrowband imaging necessitates long subs as the filters block out so much light that no data will register without sufficient exposure length. If some of the above factors are limiting for you then such objects may simply be beyond the capability of your location and set-up.

If using a monochrome CCD to do LRGB imaging then it is important to get more luminance data than color data. A good rule of thumb is half the luminance exposure time per color filter.

Many dedicated CCD cameras have the capability of binning pixels on the CCD during the readout process, i.e. they can combine the signal collected from neighboring pixels thus producing what is effectively a larger pixel. Typical binning modes are 2×2 , 3×3 and 4×4 . Binning can improve the s/n ratio by lowering the level of read-out noise but as this is only marginal with the cameras used in this book, and binning pixels reduces the resolution of the image, all the images taken in this book were un-binned.

Dithering

All CCD cameras have defects in the sensors – such as hot pixels and columns – that are not removed by dark subtraction and thus will be treated as signal in the subsequent image stacking process, and so will appear in the final image. The way to avoid this is to 'dither' the scope between exposures. This means moving the scope a few pixels in a different direction for each exposure. When the images are stacked these pixels will therefore be averaged out and will not appear in the final image. Many imaging software packages can be set to automatically dither between exposures by moving the guiding centroid a random distance in a random direction. The movement doesn't have to be much – just a few pixels. Dithering can also help remove the effect of dust motes that are very close to the CCD surface. While the ideal way to deal with these is to take flat frames, if for some reason this isn't possible then dithering will go some way to reduce the effect of them on the final image.

Acquiring Calibration Frames

Dark Frames

All astroimages contain noise ('graininess'), which detracts from the overall quality of the image. In order to produce the best image we need the greatest signal from the object being imaged possible and the lowest noise possible, i.e. we want a high *signal to noise ratio* (s/n ratio).

There are three different sorts of noise – thermal or dark noise, which is produced by the CCD sensor itself; read noise, which is generated when the data is read from the camera; and shot noise resulting from skyglow.

Dark (or thermal) noise is a function of temperature and so the lower the temperature of the sensor the lower the dark noise, hence most dedicated CCD cameras are temperature regulated. Standard DSLR cameras don't have cooling at all and can therefore be very noisy. But even cooling CCD cameras will not remove all the dark noise.

In order to minimize dark noise it is important to take dark frames. A dark frame is an image taken with the camera shutter closed or with the lens cap on. Such frames detect the noise resulting from the dark current and as such can be subtracted from the 'light' frames and help to reduce the overall noise of the astroimage (see Chap. 12). It is always best to take a number of dark frames – a minimum of 12 – and medium combine them to produce a master dark frame.

As the level of dark noise is a function of temperature, and increases linearly with exposure length, it is important to take dark frames at the same temperature, and the same exposure lengths as the lights. With a CCD camera with temperature regulation this can be done at any time of day, whereas with unregulated cameras and DSLRs this should be done when the ambient temperature is similar to that when the lights were taken. (This is best done on cloudy nights so no valuable imaging time is wasted. Some DSLRs have the capability of autodark subtracting within the camera but this effectively doubles the exposure time and therefore also wastes good imaging time.) If using a DSLR, darks should also be taken at the same ISO setting as the lights.

CCD sensors are also rarely perfect – they suffer from hot or cold pixels and columns. As these will be present in both light frames and dark frames, dark subtraction will help remove them from the final image.

As dark noise stays reasonably constant over a short period of time for a particular sensor, it is unnecessary to take new dark frames every imaging session. They can be reused so it is worth building up a darks library – darks of different exposure lengths and at different temperatures – that can be used with future images. If binned exposures are used then dark frames in the same binning mode must be taken. After a few months dark frames should be redone as dark noise does eventually change.

Some software applications have the capacity to scale darks, e.g. the software will use a 10 min dark frame and calculate what noise would be present in a 20 min

dark frame. While this may appear to be a useful shortcut, as it means lots of different darks at different exposure lengths don't need to be taken, it isn't recommended. Scaled darks are only ever an approximation. For the best possible calibration it's best to use darks of the same exposure length as the lights to be calibrated. It is unnecessary to collect bias frames if dark scaling is not undertaken.

Flat Frames

Telescopes never illuminate the CCD sensor evenly (unless the sensor is tiny). Therefore there will always be gradients – uneven brightness across the field. This is known as vignetting. It is also the case that there will usually be dark circles, or 'doughnuts', on the image due to out of focus dust particles in parts of the optical train close to the CCD such as filters and focal reducers. Dark shadows can also be present and these are caused by dust on the sensor itself. The dark doughnuts rarely result from dust on the telescope lenses or mirrors so cleaning them will not remove them. While having clean equipment is ideal, these dust problems can be dealt with in the same way as the uneven gradients – by dividing the light frame with a flat field frame.

A flat field frame, or flat, is an exposure of a perfectly evenly illuminated light source. This can be an illuminated sheet of paper, a light box, an electro-luminescent panel or even the sky at dusk or twilight (these are known as 'sky flats'). In order to minimize noise in the flats the CCD should reach between 30% and 50% saturation. Noise can also be minimized by taking dark frames of the same length as the flats and subtracting these prior to using the flats. Dark subtraction is in fact essential otherwise the lack of bias correction will stop the flats from working properly. As with dark frames, a master flat frame should be produced by combining a number of flat frames – at least 12 if possible.

Once the master flat has been produced it can be used to remove the uneven illumination and dust rings using many different image processing applications (see Chap. 12).

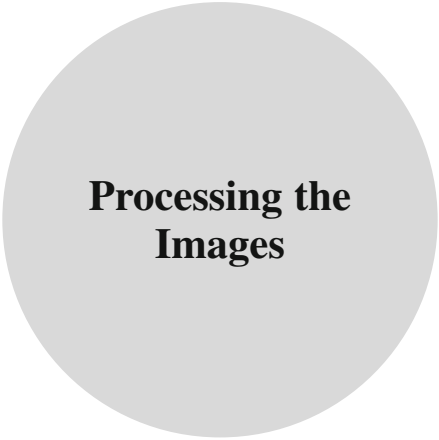
If imaging through filters with a monochrome CCD camera it is possible that the dust doughnuts will vary substantially from filter to filter. If these dust doughnuts are very bad it might be necessary to take different flats for each filter. However, if there is little difference between them then only one set of flats, preferably through the luminance filter, will be needed.

It is often the case that the same flats can be used for a few different imaging sessions as long as the camera isn't moved from the scope or reoriented in the optical train. As the dark doughnuts result from dust near the CCD sensor then so long as the camera/filter wheel/focal reducer are not pulled apart it is likely that no new dust will be able to get in. It will be obvious if new flats are necessary so it is always worth trying ones from the previous imaging session before embarking on producing a whole lot more.

Using flats is not always necessary. If imaging from a very dark site, where there is little sky glow, uneven illumination of the field may not be an issue. As the images in this book have been taken from a very dark site, flats have not been used with all of them. Of course, if the Moon is present then even from a dark site uneven illumination will be present. Furthermore, flats are not always necessary with narrowband imaging, as much of the sky glow is cut to a minimum due to the narrow bandwidth of the filters. This assumes that the optical train is clean. Even from a dark site flats will be necessary if there are sufficient dark rings caused by dust.

Once all the lights, darks and flats have been taken it is time to begin processing the data.

Chapter Twelve



Processing the Images

Processing Software

Once all light, dark and flat frames have been taken it is time to begin processing the data. There are numerous software applications that can be used for this:

MaxIm DL: This software can be used for image acquisition and processing. Its capability for alignment, stacking and combining images, as well as color combining, is excellent. However, further processing is limited so once the aforementioned tasks have been performed it is worthwhile transferring the image to more sophisticated processing software such as Photoshop. This should be done in a 16 bit format such as TIFF.

IRIS is a free program by Christian Buil. This software allows you to make master calibration frames and to calibrate, align and stack images. It also has many processing capabilities such as removing gradients, image mosaic-ing, deconvolution and color adjustment. It can also be used for remote control of DSLR and is particularly useful for processing Camera RAW images.

ImagesPlus, by Mike Unsold, is another popular commercial program. As well as having image capturing capability it is also excellent processing software. It handles all calibration and stacking well and contains many other processing features including sharpening, digital development, color correction, curves and a clone tool.

AstroArt can control all major cameras, focusers and autoguider and, having calibrated and stacked files, has a large range of processing filters and functions.

DeepSkyStacker is an excellent free program for calibrating, registering and stacking images. It also has a limited range of processing tools.

Photoshop: While not used for image acquisition it can be used for calibration and stacking. However, it is usual to perform these functions in other programs and then use the extensive processing features that it offers on the final image.

As there are so many different image processing applications this chapter will now outline the general workflow necessary when dealing with acquired images.

Choosing Light Frames

It is usually the case with astroimaging that numerous light frames (those containing the imaged object) will be stacked in order to increase the signal to noise ratio (s/n ratio) and thus produce a superior final image. The first step is to choose which light frames, or 'subs', are to be used in the stacking procedure. Some software can automatically measure the average FWHM (full width at half maximum) of the stars in the image and this gives a good indication of which subs are worth using in the final stack. FWHM is the width of the star, in pixels, at half its peak value.

(Some software will measure FWHM in arcseconds if it has been calibrated). Others use HFD (half flux diameter) to judge image quality.

FWHM is affected by four factors – focusing, seeing, guiding and condensation. The more out of focus a star is the larger its FWHM. The worse the seeing is the more stars will ‘smear’ and so the larger the FWHM. Likewise, the less accurate the guiding the more the stars will smear. Lastly, condensation on the optics can cause stars to bloat. The actual FWHM value, measured in pixels, will vary with the focal length of the scope and the physical pixel dimensions of the CCD sensor. If the sensor has small pixels then each star will be spread across more pixels and so the average FWHM value will be higher. Also, the longer the focal length of the scope the greater the image scale and therefore the greater the effect of seeing and guiding errors on the stars, hence the higher the FWHM is likely to be. However, for any particular optical system, the lower the average FWHM, the better the sharpness of the final image.

The average FWHM of all subs should therefore be compared and ideally only those with the lowest values should be stacked, otherwise the final image will be degraded. Some software applications will give you an average value for the FWHM in an image and so it is easy to distinguish poor images from good ones. However, without this capability it may simply be a case of comparing the subs manually and discarding any that have stars bloated to a significantly greater degree. How ruthless you are depends upon how many subs you collected. For example, if 20×3 min subs were collected, and 5 of them have significantly larger average FWHM, then it is worth discarding these frames. However, if only 3×10 min frames were taken then it is tempting to include all the subs in the final stack as the increase in s/n ratio might outweigh the reduction in sharpness of the image. There is a limit however – if the average FWHM is significantly higher in one of the images then it should be discarded anyway at the expense of higher noise in the final image.

There will, however, be some imperfect images that can still be used in the final stack. If there was a momentary jump in the guiding at some point, leaving faint ‘ghost’ stars beside only the brightest stars, then these subs may still be useable as the ghost star may be cancelled out in the stacking process, so long as median or sigma clip is chosen as the combine method. This assumes the jump in guiding was quick enough not to blur the main object being imaged. Likewise, images with satellites or meteors passing through them maybe usable so long as there are enough subs in the stack and they are combined by median or sigma clip. All data is valuable and should therefore not be discarded unless absolutely necessary.

Apart from discarding subs containing stars with relatively larger FWHM it is also important to reject subs that have significantly lower contrast. A reduction in contrast can result from high cloud passing over during the exposure, or condensation forming on the lens or mirrors. These subs should be discarded as they will lower the contrast in the final image and effectively decrease the s/n ratio.

If using a camera with a non anti-blooming gate sensor it is important not to discard subs that have stars that have bloomed (that is, that have vertical streaks going through them). This is a characteristic of that type of sensor and the blooms can be rectified later in the processing sequence.

Creating Master Calibration Frames

Master Darks

As all individual dark frames differ slightly, due to statistical variations, all the dark frames that have been captured should be combined, using median or sigma clip, to produce a master dark. This master dark provides a more accurate approximation of the dark noise in the light frames than a single dark and also removes any cosmic rays that may have been picked up on a particular dark. Ensure that all the dark frames are of good quality first, discarding any affected by light leaking into the camera during the exposure. If light is present in one corner, due to an on-chip amplifier, this is OK as it will also be present in the light frames and will be removed by dark subtraction. Also, care must be taken to ensure that the correct dark frames, for the particular light frames, are being used – same temperature, exposure length, binning value, gain, and with DSLR ISO value.

If possible, a stack of at least 12 dark frames should be used. However, if very long exposures have been used this might sometimes be impractical – imaging 12 20 min dark exposures takes a lot of patience when you are itching to process the final image. This is why it is a good idea to build up a darks library on cloudy nights, as doing so ensures that a sufficient number of darks are always to hand.

An example of a typical master dark is Fig. 12.1.

Master Flats

Producing the master flat frame is a little more complicated. Firstly the darks that have been taken to calibrate the flats must be combined into a master flat-dark using the same method outlined above. If using a monochrome CCD it is likely that more than one master flat-dark will be needed to calibrate the flats, as flats taken through different filters are usually of varying exposure lengths. For example, if you have lights for a hybrid HaRGB image then the flats taken through the H-alpha filter will be of significantly longer exposure length than those taken through the color filters. Thus, separate flat-darks for these different flats must be taken.

Once the master flat-darks have been produced these can be used to calibrate the flat frames (in the same way that light frames are dark calibrated, as will be discussed below). It is only then that the flats can be stacked to produce a master flat. An example of a typical master flat is Fig. 12.2.

Assuming that dark subtraction has been performed on both the lights and the flats, bias frames need not be used. These are only important if scaling darks is to be undertaken.

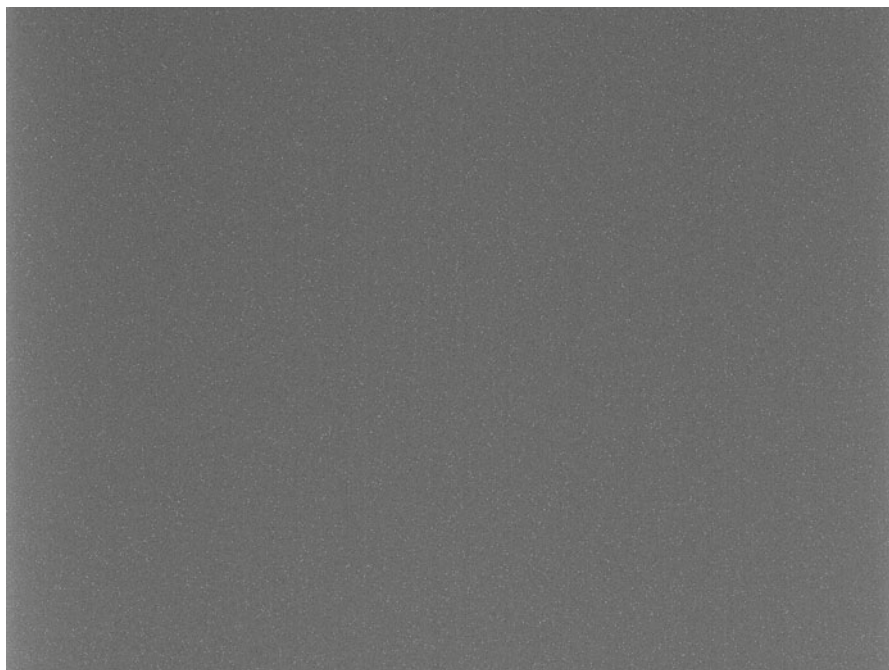


Fig. 12.1 Typical master dark.

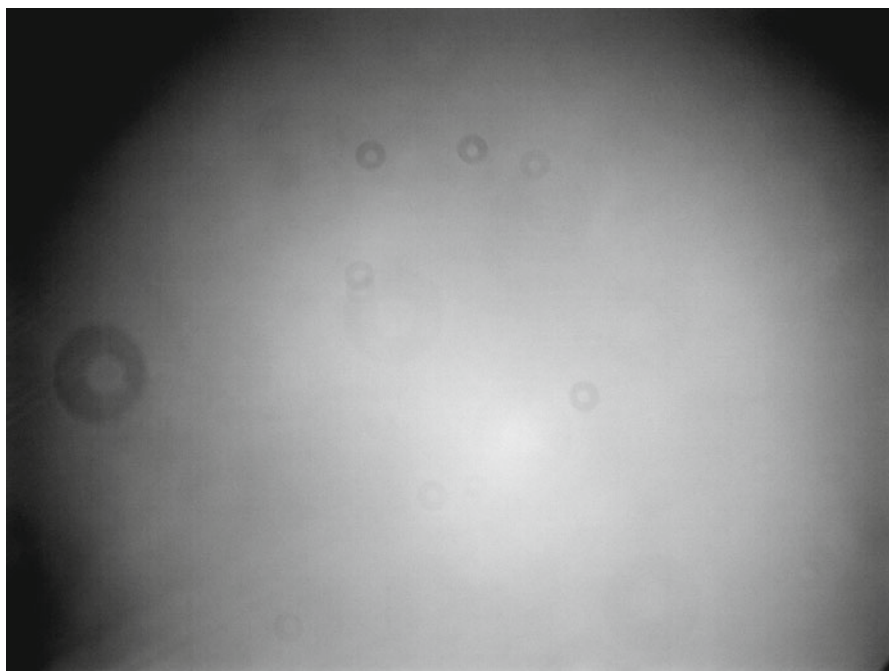


Fig. 12.2 Typical master flat.

Calibrating the Light Frames

Some software can calibrate and stack images in a single process, but the procedure can be broken into three parts. Firstly, the light subs should be calibrated using the master dark frame. Assuming that the master dark was good quality there should be an immediate improvement in the s/n ratio in the light subs.

Secondly, the light subs need to be calibrated using the master flat frame. If this is successful it should significantly reduce any gradients found in the image, as well as removing rings and dark shadows caused by dust in the optical train. The result may not be perfect, depending upon how bad the gradients are, but hopefully there will at least be some improvement. If different master flats have been produced for each filter then make sure the correct one is used. If the software has automatic registration make sure this is switched off when stacking darks and flats.

Once these two processes have been undertaken the third process can be undertaken – stacking the calibrated light subs.

DSLR and One Shot Color CCD Cameras

If possible, DSLR exposures should always be taken in RAW mode, as it is the only mode that doesn't compress the files and thus preserves all the data, with high bit depth, as acquired by the sensor. Assuming the software allows it, with both DSLR and OSC CCD, calibration should be performed on the RAW black and white images and then they should subsequently be converted to color.

When using flat frames, the flats should have all color data removed from them first – otherwise they can upset the color balance of the final image.

Registration and Stacking

Once all the light frames have been calibrated they can be combined to produce the final image. This process has two stages – registration and stacking.

Registration, or alignment, is the process of aligning all the images so that when they are stacked the same stars in all images line up properly. Many dedicated astromaging applications will do this automatically or semi-automatically. When it is done completely automatically the software tries to recognize star patterns common to all the images and then transforms each in such a way that these star patterns align. If the process cannot be performed automatically then it is necessary to manually choose stars as reference points, at opposite sides of the image, and click on the same stars in each image. The software will then align them.

Once the images have been aligned they are ready to be combined to produce a final stacked image that contains the entire signal from the individual subs.

Processing software usually provide different combine methods for stacking light frames, such as sum, average, median, Sigma Clip and SD mask. Each of these combines the data in slightly different ways. In order to decide which is best for your particular data you should consult the help files of the particular software being used. There are, however, a few general guidelines to follow. Averaging the images can result in low noise but doesn't remove unwanted signal from airplanes, satellites and meteors crossing during the exposure. If averaging is to be used then any sub with these defects should be discarded first. Median combine (which requires at least three subs) will deal with this problem, but does produce a slightly noisier image. Sigma Clip and SD Mask also deal with this problem while at the same time keeping the noise level low. However, Sigma Clip requires a large number of subs to be effective. With a small number of subs the best result can usually be achieved combining the light frames using SD Mask, if available in the software.

Color

Creating color images from subs taken with a color camera is undertaken in different ways depending upon the software used. Some software will automatically calibrate images and then produce a final color image. In other applications, such as MaxIm DL, you have the freedom to calibrate the images first and then convert the data to color. These color images can then be aligned and stacked to create the final image. The image can then be moved to another application for final image enhancements.

If a monochrome camera with filters has been used then the data acquired through each filter must be calibrated, aligned and stacked separately using the methods outlined above. The result will be three black and white images, each containing data corresponding to the different colors found in the astronomical target. It is at this point that the three black and white images can be combined into one color image. All software handles this differently. The first step is for the three images to be aligned.

Once aligned, the software might ask for information regarding the varying sensitivity of the CCD sensor to different colors, i.e. the sensor's spectral response. Many CCD sensors are more sensitive to red light than to blue and so the software needs to know the relative sensitivity to the different wavelengths in order to weight the different colors in the final image correctly. Without this data the final image can appear unnatural. It is often the case that the manufacturer of the camera will provide details of the spectral response of the sensor. However, this data is not necessarily reliable as different manufacturers' color filters can produce different results. There are other methods of determining the spectral response of the sensor, such as G2 star calibration.

In software that doesn't offer this option, or if the spectral response is unknown, it might be a matter of weighting the different colors by eye. If Photoshop is used

the three black and white images can be combined into a single RGB image and then, by using a combination of levels, curves, color balance, etc., the weighting of the color data can be achieved. Assessing the colors of the stars is a good way of doing this – if the stars have a natural appearance then the weighting of the three colors is probably close.

Luminance Layering (LRGB)

If you also collected data through a clear filter – called luminance data – then this can be used to produce a luminance layered image. This luminance layer should be aligned with the colors and layered on top of the RGB image, using a ‘luminosity’ blending mode.

The advantage of luminance layering (LRGB) is that it can produce an image containing far greater detail. Data collected through color filters is often weak and so tends to have a low s/n ratio whereas data through a clear, luminance filter tends to be much stronger and brighter and therefore has a high s/n ratio. The trick is then to use the data from the luminance filter and layer it over the RGB. This means that the final image benefits from the brightness and contrast present in the luminance data and the color from the RGB.

If the data through the color filters is strong, and therefore does have a high s/n ratio, then there is little advantage in luminance layering. The time that would be taken gathering luminance images is best used taking more RGB. This is particularly the case with star clusters.

Once the colors, and luminance, have been combined it is really a matter of using further processing tools – levels, curves, saturation, sharpening and so on – until you are satisfied with the result.

Combining Narrowband Images

As narrowband filters only allow through light from a very small part of the spectrum, any color images formed by combining data taken through different narrowband filters will, in effect, be false color images. In the processing software the three filters have to be assigned to one of the RGB channels in order for a color composite to result. The advantage of this is that it requires a lot of creative input because how these filters are assigned, or mapped, is ultimately a matter of subjective taste.

Common narrowband filters that are used are Hydrogen-alpha (H-alpha), Oxygen-III (OIII), Sulfur-II (SII), Nitrogen-II (NII) and Hydrogen-beta (H-beta). These can be mapped to any of the RGB channels to produce the final color image (even mapping the same filter to more than one channel). As H-alpha is very strongly emitted in emission nebula, and is largely responsible for the red color

found in RGB images, then mapping it to the red channel will help to make a narrowband image approximate its RGB equivalent. In this book H-alpha has been mapped to red, OIII (which is at the blue end of the green part of the spectrum) mapped to green and H-beta (which is present in the blue part of the spectrum) mapped to blue. In many cases this produces a narrowband image that closely resembles its RGB equivalent.

However, as narrowband images are false color it is perfectly acceptable to map the filters differently. A common way to do this is to use the ‘Hubble Palette’ (so called because it has been used in some of the Hubble Space Telescope’s iconic images – such as the ‘Pillars of Creation’ in the Eagle Nebula). Here SII is mapped to red, H-alpha to green and OIII to blue. This can produce some very strange, but interesting variations of common objects.

Once the narrowband images have been combined into a false RGB image, the image can be further processed in the usual way.

Hybrid Images

If data has been collected through both RGB and narrowband filters then it is possible to combine the data to produce a hybrid image. As with basic narrowband imaging, there are many ways in which this can be achieved depending upon how the different filters are assigned.

A common way is to use an H-alpha image as the luminance layer with RGB to produce an HaRGB hybrid. Care has to be taken here, as the H-alpha can overpower the RGB resulting in a weak salmon-pink colored image. The color can be somewhat strengthened by blending some of the H-alpha data with the red data or even replacing the R with H-alpha to give HaGB images.

There are countless other ways that hybrid images can be produced. For example, Fig. 12.3 is an RGB image of the area of the sky in which the Gum Nebula is found. As you see, very little nebulosity is even registering. Fig. 12.4 is the same RGB data but with H-alpha data blended into the red channel. If it wasn’t for the presence of Canopus at the top of the images you would be excused for thinking that they weren’t of the same part of the sky at all.

The trick with hybrid imaging is to experiment. As with straight narrowband images there is no right or wrong way. Just play around until a satisfactory image is produced.

File Types

With most dedicated CCD cameras, the camera software downloads data as raw 16 bit binary, which can then be saved as FITS for subsequent processing including image calibration and stacking. Not only are FITS files lossless, they also can contain important information about the image – width, height, date captured,



Fig. 12.3 A basic RGB image of the Gum Nebula.

temperature of sensor, binning value, length of exposure and so on. If the software with which the image is taken has the capability, it can also store data regarding such aspects as telescope, object name, RA and Dec coordinates.

In some software further processing can be undertaken in the FITS format and, with old versions of FITS liberator these files can be directly opened in 32 bit Photoshop. (FITS liberator version 3 is a stand-alone application and is not a plug-in for Photoshop). However, at some point the files need to be converted to 16-bit



Fig. 12.4 The same image as Fig. 12.3 but with H-alpha data blended into the red channel.

TIFF files for display or processing using other software. Likewise, RAW files from a DSLR can be subsequently converted to 16-bit TIFF files for further processing. However, always keep your image library in FITS, or RAW format, as you may wish to reprocess your images in the future, as your image processing skills develop. Also, future software may introduce new processing techniques that may well improve your images.

If JPEGs are required, for example for posting images on the Internet, then conversion should be done after all processing has been completed, as data is lost when the lossless TIFF format is converted to the compressed JPEG format.

Further Processing

Once the images have been calibrated, aligned, stacked and converted into color, work is then needed to turn the data into aesthetically appealing images. Stretching the data, sharpening, deconvolution, removal of residual gradients, noise reduction, color correction and so on can all be undertaken using software. Some software, essentially designed for image acquisition and calibration, such as MaxIm DL, provide some basic processing tools but much more sophisticated processing software, such as Photoshop, ImagesPlus, AstroArt, Iris (freeware) and PixInsight can help you get more out of your images.

It's beyond the remit of this book to discuss how these different processes are undertaken. However, there are many books and DVD tutorials available outlining how further image processing can be achieved. Here are a few good examples:

Creating and Enhancing Digital Astro Images (Springer, 2007) by Grant Privett is an excellent jargon-free introduction to astro image processing and is another book in this series.

Photoshop Astronomy (Wilman-Bell, 2009) by R. Scott Ireland is an extremely thorough resource packed with tutorials to help the astroimager learn all the tools and tricks available in Photoshop to produce top quality images.

Powerful Processing in Photoshop is a DVD by Adam Block. He says "this is a tutorial tell-all volume. If you were seated behind me while I process images in Photoshop – this is what you would see."

E-Z CCD by Tony Hallas is a set of four DVDs containing video lectures on all aspects of image processing. The final one contains many tips for narrowband image processing.

The Internet is an abundant source of different people's approaches to and ideas about image processing and, as always, is a great place to start.

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