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CONTEMPORARY PHYSICS PLAYS

Making Time to Know
Responsibility

Jenni G. Halpin



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Jenni G. Halpin

Contemporary Physics Plays

Making Time to Know Responsibility

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CHAPTER 1

Introduction: Ethics and Physics in Contemporary Plays

Abstract The introductory chapter establishes the relationships among science, science drama, and the history of science through which the arguments of the ensuing chapters will proceed. I argue that recent physics plays make a return to the metaphysical concerns of the early-twentieth-century physicists who were developing quantum theory and relativity. Moreover, they do so while engaging in what Kirsten Shepherd-Barr has characterized as enaction of the science they discuss: producing dramatic forms that manifest scientific content. A concern throughout is the manner in which these enactions alter the ethical stakes for the characters' decisions.

Keywords Science play • Cold war • Ethics

The physics of the stage, for much of the Cold War, was the physics of warfare and massive destruction; these anxieties gave rise to a substantial body of dramatic work dwelling on the destructive possibility of atomic weapons.¹ In such plays scientist-characters wrestle with the implications of dangerous discoveries, or ordinary citizens huddle in terror, dissolving the social contract within the confines of fallout shelters. The horror of nuclear weapons grew from the Soviet Union's August 1949 atomic bomb

test to a peak in 1962 with the Cuban missile crisis and was revitalized in the 1980s but then subsided as the forces leading to the falls of the Berlin Wall and of the Soviet Union brought the Cold War to a close (Kuznick and Gilbert 2). In its wake, a new post-Cold War genre of science play has emerged, in which science remains a major theme without the plays being dominated by or even concerned with the possibility of another nuclear war.

Also fading, or at least changing substantially, is the interest the Cold War's drama had taken in casting blame on the scientists who developed the bomb and on the politicians and military personnel who had put it to use. In mid-twentieth century plays such as *The Burning Glass* (Charles Morgan), *The Traitor* (Hermann Wouk), *The Tragedy of King Real* (Adrian Mitchell), and "Pilot Lights of the Apocalypse" (Louis Ridenour), the dramatic action often moved inexorably to condemnations, as if the discovery that a weapon could be used were concomitant with making catastrophic use of it. The nuclear arsenal became Chekhov's gun on the world's mantel, necessarily to be fired before the resolution of the plot; the imagined inevitability of nuclear destruction called out for blame to be cast before the shot even went off. With the ending of the Cold War and the resetting of the Doomsday clock, nuclear physics becomes more than a weapon, and dramatists' treatments of it often reframe questions about blame and responsibility in terms that no longer immediately indict scientists for inventing the bomb. The nuclear imaginary ceases to be quite so terrifying, but it is a domain rich with possibilities that had been virtually ignored in drama for most of a century.

As a general category, "science play" has been under some dispute. How much science, of what kind, in what way, and to what effect must there be in a play for it to count as a "science play"? The answers are varied and vehemently argued. Acknowledging that there are at times very good reasons to focus more narrowly, I follow Kirsten Shepherd-Barr's deliberately broad definition offered in her inaugural book on the subject, *Science on Stage*: any play in which scientists or scientific concepts appear as such. Shepherd-Barr's chief focus, however, is the plays' "integration of form and content" (5). As she emphasizes, "the best [of the science plays] successfully employ a particular scientific idea or concept as an extended theatrical metaphor. They literally *enact* the idea that they engage" (6). My own argument develops in relation to a narrow class of science plays, those that "enact" theoretical physics. These plays differ from their Cold War precursors, including those Charles A. Carpenter addresses in his

bibliography of “Nuclear Age” plays, not only through their more philosophical engagement with the science but also by their greater tendency toward enacting the physics in their forms rather than simply engaging with the bomb in their themes. While Cold War-era plays engaging with physics typically treat the discipline primarily as the source of nuclear weapons, after the Cold War a wider array of the pursuits and considerations of physics are allowed to enter the theater. Significant among these are concerns about time and causality.

The new physics of the twentieth century—quantum physics and relativity—fundamentally changes the relationship of space and time. When Albert Einstein’s “On the Electrodynamics of Moving Bodies” was published in 1905, our ability to measure time, and even what it means to measure time, fell under new questions. As the mathematician Hermann Minkowski said of the changes introduced by relativity theory, “space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality” (75). Minkowski here underscores the striking shift in our understanding of what time is: it is no longer an independent dimension; instead it is formed by and formative of a network of space-and-time. “When” ceases to be meaningful absent a knowledge of “where.” On stage, many plays enter into these alternative networks of space-and-time by enacting temporalities other than the familiar one-directional, steady movement from past through present toward future. This book is an analysis of the troubling of temporality arising in post-Cold War drama using concepts from physics to inform or even dictate the dramatic flow of time.

Moreover, Minkowski’s formulation underscores another commonality between twentieth-century physics and dramatic enactments thereof: how we look at them matters. He suggests that space and time had been previously distinguishable from one another and that Einstein’s observations (codified as the theory of relativity) are what produce this “fading away.” Such an implication (not at all intended in Minkowski’s analysis) bears analogy to the effect of observation in quantum physics. Erwin Schrödinger’s famous thought experiment—his cat—may provide a helpful illustration. Schrödinger envisioned a closed box into which one could not see. Into this box are placed a living cat and a device that will kill the cat if a single radioactive atom decays (an event engineered to be exactly as likely as not to happen within an hour); at the end of the hour, before the box is opened and the cat observed, is the cat alive or dead?² The upshot of the experiment is that in the moment before the box is opened,

the cat exists not as a living cat or as a dead cat but as a cat both alive and dead *and* neither alive nor dead. It has no particular state of being. Both the cat and the radioactive particle for which it is an analogy are spread across all of the more-and-less probable ways they could be.

By contrast, consider a tossed coin that has been covered before its result can be seen. This coin (much larger than the quantum scale) really has either heads or tails upmost. Although we have not yet looked, we know that it is one or the other, and, before we look, it already is whichever one it is. At the quantum level, things are very different. Looking to see how Schrödinger's quantum cat is doing does not simply show the observer what has been established—on the contrary, the cat *becomes* alive or dead and ceases to be a probabilistic blur of 50–50 living-dead-ness in the act of becoming observed: an ontological shift and not a straightforwardly epistemological one occurs.

Delving into subatomic physics made metaphysicians of many physicists as they attempted to explain the weird reality they were encountering, giving quantum theory many philosophical interpretations of quantum physics. In the early and ongoing discussions among physicists about how things work at the quantum level, “What does it mean?” is a frequent concern. Among the answers, the Copenhagen Interpretation holds the widest sway (although its precise features, and the degree to which its inventors Niels Bohr and Werner Heisenberg themselves would agree with its current iteration, are a matter of debate). The Copenhagen Interpretation holds that the probabilistic events at the quantum level are ontologically unknowable. Our lack of certainty is not a failure on our part or on the part of the equipment; it is, as Schrödinger put it, “a distinction between a spoiled or badly focused photograph and a snapshot of clouds and damp fogs” (812, my translation). The former is blurry because we do a poor job of photography while the latter is blurry because clouds of fog are blurry. The uncertainty about fog is inherent to reality; quantum uncertainty is a real blur, not a failure of our apparatus. But observation makes things take on observable features. The quantum world appears to be “made” by being seen.³

Similar to an observer's bringing of a quantum element into a determinate state of being, the plays I consider enforce spatio-temporal states on their characters. The conditions of possibility within which their characters act are created by the plays' obedience, in their very structures, to scientific theories and practices. By enacting principles of theoretical physics, the plays reorganize the shape of time, moving away from the metronomic

forward march we commonly consider time to follow; characters moving through these unusual temporalities experience changes not only in what they are capable of effecting but also in what they can know about both the contexts in which they act and the possible outcomes of those actions. These changes in the characters' knowledge and power, traceable to the alterations in the temporality at work in these plays, are legible as alterations in the ethical conditions of the characters' decision-making processes.

Arkady Plotnitsky and others have seen in the metaphysical considerations of quantum physics a connection to Jacques Derrida's ethical writings, particularly the aporia of decision-making. Derrida asserts that ethical responsibility adheres in the freedom of decision involved in one's being uncertain which choice might be the correct one. As he writes, "to exercise justice or to transgress it I must be free and responsible for my action" ("Force" 251). The freedom specifically comes from not having the time or the knowledge (or both) to be certain of a determination. Moreover, justice inheres in responsibility. Following a rule of law does not produce a decision; it produces the result of a calculation.⁴ The absence of determination is a manifestation of what Arkady Plotnitsky has analyzed as an "anti-epistemology." Plotnitsky argues at length for the commonality of such an anti-epistemology to the works of both Derrida and Niels Bohr. As decisions made in urgency or incompleteness, ethical decisions find resonances in Einstein's writings on relativity. For Einstein, the tensions generated in relativistic contexts are inflicted on space and time themselves. Time is subjected to spatiality and vice versa. For all that relativity is touted as a game-changing breakthrough into new realms of physics, it is also an attempt merely to fill in a recognized gap in early-twentieth-century physical knowledge. In setting up his argument, in "On the Electrodynamics of Moving Bodies," Einstein is at pains for his reader to "bear carefully in mind that a mathematical description of [the kind he is making] has no physical meaning unless we are quite clear as to what we understand by 'time'" (39). To know what physicists are describing, they have to effectively describe the temporal dimension. Einstein goes on to say that if one were concerned only with time in a particular place then the physical display of a wristwatch could provide a sufficiently rigorous definition of "time," but this does not work when one considers events in separate locations (39). Relativity theory is meant to remove uncertainty and immeasurability. The mathematics allow one to enter into calculation and determination about whether two things happened at the same time.

Special relativity turns space and time into spacetime, as Minkowski observed, which rearticulation is at work to re-subject the events described by physical law to calculation (75).

For Derrida, justice happens in the aporia of the unknowable and incommensurable. In the metaphysics of quantum physics, another incalculability arises. Niels Bohr and his protégé Werner Heisenberg developed two principles that would become the foundation for the Copenhagen Interpretation of quantum physics. Heisenberg's uncertainty principle argues that the more precisely one can determine one property (such as position) the less certain one can become of another (such as momentum).⁵ Bohr's principle of complementarity responds to and refines the relationship between such paired properties. As the physicists involved in the quantum revolution developed a new metaphysics, a great deal of emphasis was placed on the nature of the imprecision (or uncertainty or indeterminacy) of such measurements. One of the crucial points for the Copenhagen Interpretation is, as Schrödinger has also argued, that the lack of precision is not a straightforward problem of engineering: an electron whose precise position is known *does not have* a precise momentum.

When a particle's location could be understood not as a pinpoint but as a cloud of more-or-less likely places, probability came to a more central role in physics. This led Einstein famously to criticize that "god does not play dice with the universe." His was to be a long-running battle against those physicists (many of them) who favored the probabilistic interpretation. A joking riposte, "No, god plays poker," usefully elaborates the criticism's point of contact with the central concerns of many science plays: taking ethical action. Rolling dice is a game of chance, and Einstein's objection figuratively invokes a god who, unlike the Derridean judge, takes action which "simply consists of applying a rule," and who thus makes no decision: god rolls ten and grants your petition; god rolls four and destroys a city ("Force" 251). On the other hand, a god who plays poker is a strategist: this god may be attempting to calculate the likelihood of having the best hand, but probability guides rather than controls the plays god makes. Such a god, with limited knowledge, chooses what actions to take.

What the broader class of science play has often done is to ascribe this kind of godlike power to scientists: either the play is fantastical and the scientist is able to do things by quasi-mystical forces (as when Dr. Faustus summons Mephistopheles to do his bidding) or the scientist marshals more realistic knowledge and abilities to take actions equally ill-understood

(as when Brecht's Galileo visually spans vast distances with a telescope). As fantasy or as science fiction, the tension between the pursuit of knowledge and the means or results of that pursuit particularly complicates the judgment cast on the scientists for their choices.

The archetype coupling dangerous scientific experimentation and moral culpability is Faustus. From the first of the Faustbooks in which he appears, the stories emphasize Faustus' psychological context: his interiority matters (Butler 4). This complexity of characterization helps Christopher Marlowe's *Doctor Faustus* to move beyond typical earlier science plays' mockery of the stereotypical foibles of a scientist (or even of a pseudo-scientist), a mockery which continues to be exemplified in Ben Jonson's *The Alchemist* or Thomas Shadwell's *The Virtuoso*, into a new focus on scientists' moral culpability. Shepherd-Barr examines the shifts inaugurated by Marlowe's play in the canon of science plays and identifies one as most significant: "science itself, or the scientist, becomes the embodiment of the problem, not just a metaphor for it" (16). Faust's story could merely have been a parabolic warning against other follies, taking his efforts to know more as a figuration of any vain or excessive pursuit. Instead, the work of the scientist becomes the problem, which becomes central to the "negative image [of the scientist, and] signals a distrust of science that becomes one of the defining characteristics of science plays for centuries" (Shepherd-Barr 16, 17).

When drama begins to take scientists seriously, it regularly indicts them for misuse of their abilities. Just when a scientist *per se* comes to the fore as a dramatic character, the epistemological work of doing science begins to be portrayed as a dangerous, and therefore unethical, characteristic of scientists on the stage. Faustus and his successors explore dangerous ground because they are scientists, and the ground scientists explore *is dangerous*. The psychological underpinnings of Faust's story suggest, in Elizabeth Butler's phrasing, that his "incurable thirst for knowledge" is definitive of the "spirit of scientific enquiry" (4).

These Faustian scientists in drama are thus regularly poised between their drive to know and the potential consequences of attaining knowledge. In Georg Büchner's incomplete play, Woyzeck's doctor studies the effects of a diet rich in peas, learning that a homicidal obsession is a result. Henrik Ibsen's Dr. Stockmann becomes *An Enemy of the People* through wanting to know whether the town's waters are healthful; as well as damaging his social standing, Stockmann's efforts to save lives provoke serious economic consequences for the town. Roslynn D. Haynes notes that the

fear of excessive knowledge being dangerous predates the written word, emphasizing that “from the Middle Ages to the twentieth century, scientists as depicted in literature have, with few exceptions, been rated as ‘low’ to ‘very low’ on the moral scale” (4). And throughout the twentieth century physicists were particularly dangerous, not only pressing against the limits of knowledge in their efforts to understand the structure of the universe but furthermore overturning longstanding physical “laws” which no longer held up in the face of their increased technologies of observation and experiment.

Like Faustus, the early quantum physicists wanted to know. Having gained insight into the fundamental structure of the atom, in the middle of the twentieth century physicists would learn to develop atomic bombs powered by tearing that structure apart. Like the shaped charges impelling a fusion bomb, the atomic bomb directed a force of moral judgment against scientists, physicists in particular. Before the dropping of the bomb, the Faustian tradition in the science drama had largely staged the dangers of a scientist to himself: he either tragically fell through his hubris or was comically taken down for his pedantry. Dangers to those around him were secondary, dismissed, or completely unrepresented. Fausts generally fell alone (though, certainly, other individuals around these characters experienced consequences); after the Second World War, Fausts were considered (perhaps like Oedipus) to have the power to take their societies down with them, or even destroy the planet. As Kirsten Shepherd-Barr has written, “the theme of intellectual curiosity leading to Icarus-like overreaching recurs throughout the science play canon [...]. [M]odern science plays [...] invoke the hell motifs of *Doctor Faustus* to convey the enormity of the implications of postwar science” (18). In science plays after the bomb, when the Faustian problem of scientists disrupting a social order by their practice arises, they not only endanger—as Goethe’s Faust mocks—their afterlives, they also have such power in their labors that the societies they inhabit are likewise endangered.

Such high stakes as are raised by the tools of physics are matched by the manner in which, in the post-Cold War plays under my consideration, physics itself often provides the rupture rendering the characters’ decisions subject to ethical evaluation. How Faust approaches his use of time—“Be orderly, and time is won”—suggests already its variability (I.1909). When time-and-space become one, the range of possible variation broadens.

And these plays of the post-Cold War period, with their invocation of real historical figures and their genuine decisions—for all that they appear

to undertake a representation of that history, those people, such decisions—are always addressing themselves instead to another question, a question of whether and how science, the new science of the twentieth century, changes the game in which their characters are engaged. The fooling about with time undertaken by these plays restages and reevaluates the decisions undertaken within them, making realizations of the physics of the twentieth century into the context against and within which those decisions are accomplished.

To frame my analysis of these more recent plays, a brief look at typical physics plays of the Cold War is useful. Many of them were responding to the science of the bomb as well as to the political and broader cultural developments arising from it. These plays are, in this sense, driven by the science. But the plays' treatments of the science are generally topical rather than structural, engaging with the social and political realities emerging from the possibility of nuclear war. As Stephen Lowe writes of the many plays on the Theatre Writers Union's Peace Play Register, the likely "starting point of these plays is all FEAR" (vi). An unfamiliar nihilistic force had arisen, and, just as the Cold War remained *cold* out of fear, so the dramatic response to the bomb was shaped amid fear of the bomb's use. Anti-proliferation rallies regularly included performances of plays written for the occasion, especially in England.⁶ The anxiety of a "duck and cover" culture manifested itself on stage, particularly in plays set in bomb shelters. In addition to these bomb shelter and more broadly anti-proliferation plays, which tended to present characters who were "ordinary citizens," other plays explored the responsibilities of those who might be considered to have power: scientists and government agents. Generally, but not always, scientists appearing on stage were indicted for creating nuclear terror. Frequently the plays' moralizing efforts to stir their audiences to action operate in opposition to a nuclear bogey-man understood either as a Frankenstein's monster for which scientists should be held responsible or as a horror arising from politicians' misuse of scientists' labors. In either case, whether foregrounded or not, scientists are understood as culpable for the fear covering over the Cold War period. At the same time, military officers, government officials, and spies appeared on the stage to embody emerging protocols for the use of nuclear weapons. These Cold War-era plays express a political context on the decline through the late 1980s; in this regard they also stand in marked contrast to the post-Cold War physics plays, which do not always (or even often) address themselves to military questions attendant upon scientists of the atomic age.

Louis N. Ridenour's "Pilot Lights of the Apocalypse," which Charles A. Carpenter identifies as "the first drama of the actual Atomic Age," dramatizes the speed and (near) inevitability of nuclear counterattack.⁷ Ridenour's brief sketch opens in the counterattack area of a command center underneath San Francisco, while the President is touring the facility. Explaining the function of counterattack officers, a General stresses that both speed and political acumen are necessary in launching a counterattack, but, as the play makes clear, in practice the process drives itself without effective human decisions entering into the speedy process. As the President departs, an incident begins and annihilation follows annihilation, as a succession of nations launch their own counterattacks with varying degrees of accuracy in their assessments of whom they ought to retaliate against. Both the speed of war and the size of its potential destruction increase significantly in the nuclear age. Both lead away from thoughtful, human consideration and toward computerized fast-response plans. In effect, the human thinking serves to defer the decision, whereas programming by its very existence has decided in advance the ways in which war is to be made. As historian Martin Walker puts it, "the Cold War had one great merit: it became an institution, marked by a kind of warped stability and an evolving code of acceptable behaviour" (1). This codification sought to make nuclear war programmable in large part because there no longer seemed to be time enough to make decisions, which Ridenour's opening salvo calls centrally into consideration. "Pilot Lights of the Apocalypse" has the burners of war ready and waiting to turn what was not yet known as the Cold War destructively hot. It was also already implicitly arguing against the dangers of speed, automation, and computerization in the war machine.

After "Pilot Lights of the Apocalypse" laid out the various participants, an array of dramas throughout the Cold War put under pressure the differing agents and objects operating in nuclearized time. One particular subset is the espionage plot.⁸ Herman Wouk's *The Traitor* is representative of many of the features of such plays. As Wouk has written, the play's protagonist is "a thoughtful young atomic scientist, [...] who sincerely believes that the best way to stop the coming war is to let the Russians in on the secret of the atom bomb. With both sides possessing such a terrible weapon, he feels that they would have to get together to work out a way to avoid the mutual suicide of a new world struggle" (6).⁹ The moral struggle over political affiliations (and over the tension between freedom and security) is not the only characteristic of Cold War nuclear dramas

evidenced in *The Traitor*. The play also exhibits the didactic effort of many of the period's science plays: Carr keeps thorium in the writing desk at the home of his mentor; the sample fogs some undeveloped film left on the desk, and when this is discovered a Naval intelligence officer brings in a Geiger counter. This discovery of radiation in the apartment comes about accidentally during a demonstration of how the Geiger counter works, not as part of a serious search of the apartment. As this scene demonstrates, through the nuclear plays of the Cold War, audiences were educated about the science not only of nuclear weapons but also of nuclear detection, which education subtly implicates the audience in the ongoing nuclear standoff, suggesting a duty to be on the lookout for this dangerously marketable science.¹⁰

Scientists and government agents are not the only ones who have to play politics with the bomb. Ewan MacColl's *Uranium 235* tries to teach its audience more than simply how radiation and atomic bombs work; it tries to show scientists as a part of society, not separate from it. MacColl offers an artistic education focusing on the efforts of the public to ignore scientists' warnings about nuclear power. The main plot of the play is a scientist's explanation to various members of an audience about the scientific history of the atomic bomb (going back to Democritus and the idea of atoms but centering on the last 200 years), emphasizing both the progress scientists have made in learning atomic physics and the efforts the public has made to ignore or misunderstand the dangers involved.¹¹

Part of a significant minority of science plays of the period, *Uranium 235* is at work to shift some of the responsibility for the use and development of atomic power to the citizens who have, sometimes willfully, failed to comprehend what scientists and politicians have been doing. One part of this shift in responsibility involves a reconstruction of the view of scientists, seeing them not as separate from but rather as a part of (and subject to) society as a whole.¹² Such alterations continue pervasively in the post-Cold War science plays, as when Jon Klein and Paul D'Andrea humanize and personalize their Einstein, for example, as I will discuss in Chap. 3. Making the metaphor of actors for political players obvious, MacColl still leaves the scientist characters with the inherent power of a tremendous knowledge gap compared with the acting members of the audience. They direct the action by their teaching, and this lessoning quickly palls on the audience, one of whom, The Dissatisfied Playgoer, complains that science does not belong in the theater, to which the Scientist responds by calling for the lights to be cut (42). As the scientist explains when the Dissatisfied

Playgoer complains of not being able to watch the plays with the lights out, stage lighting is also a product of science. Throughout the play, scientists produce their work in express response to others' demands (though not always creating what is asked). Thus, MacColl carries out the indication that the destructive capacity of scientific discoveries is something for which society at large, and not only scientists, is responsible. Insofar as science is turned to entertainment, the Scientist promises that the story of the atom will deliver both "the most enduring love story in history, the love of the proton for the neutron" and "the greatest killing the world has ever seen, with the most efficient murder weapon" (43). The atomic bomb thus appears as spectacle for the masses.

Society's best efforts to survive in the face of human capability for mass destruction are the didactic object of Charles Morgan's *The Burning Glass*. In it Christopher Terriford is working on a climate control system, to help crops grow. What he actually develops can also be used to target and destroy whole regions of the planet. Set "soon," the play shows Terriford's struggle to be a good citizen whose work will contribute to the war while remaining a good person who would not allow such wholesale destruction untempered into the world. Morgan writes of his play that he wrote it out of a belief that a new kind of change was approaching humanity, a change he considers dependent on the "great lie" that "each development of man's power over Nature, unless it happens to threaten his body with injury or death, is necessarily beneficent" (viii). Morgan's didactic approach is representative of a significant body of Cold War plays that hector their audiences to seek the right path away from dangerous scientific advances, especially the bomb.

Rather than asking what a scientist owes his government or how scientific advance can be kept under control, Elaine Morgan's *Licence to Murder* asks whether nuclear crises are by definition states of exception. An extraordinary drama centered on a survivalist, Rousseauian attitude toward one's own fallout shelter, *Licence to Murder* is a courtroom drama of a man on trial for killing his neighbor when the neighbor attempted to invade his shelter. The defense's argument is, primarily, that at least in the event that the shelter has reached its intended occupancy level, one is entitled to repel others from entering one's fallout shelter. Ultimately, the play makes a case for considering the Cold War an exceptional time and then dodges answering the question. It invokes nuclear warfare but does not address or make use of the science behind the bomb. Although Morgan's characters are able to avoid facing the central question, the

audience is left pondering it. As the prosecution concludes, “But *you*, who tried to exploit the fears and confusions of the last fifteen years for your own petty and vindictive ends? Oh no, Mr Foster. Nobody’s going to help you now” (65). The play condemns a misappropriation of Cold War fears, but it neither quiets them nor tells us whether a fallout shelter comes (or should come) with a “license to murder.”

In summary, the nuclear dramas of the Cold War are regularly filled with a fear of the bomb. And even as the plays attempt to educate their audiences into understanding the mechanics of an atomic weapon and the political operations surrounding their use or control, they also explore the social changes emerging from this technology. Many plays simply deploy the fear, but the best of the Cold War dramas consider the source of that fear and ask whether scientists, politicians, or society bear differing responsibilities for producing and alleviating it. From the beginning, the thoroughness of nuclear destruction seems to call, in drama, for an automated response rather than a decision.

Chapter 2 opens on two late-Cold War plays questioning this automation. Both Steven Dietz and Tom Stoppard have written plays that enact modern physics to rupture the ordinary logics of spatio-temporal causality within their plots. Dietz’s *Foolin’ Around with Infinity* breaks the classical unities of time and space by drawing together on a single stage disparate times and places from the notional pasts and futures of the play’s central characters. Though reliant more on its pursuit of the social peculiarities of fallout shelter culture and mutual assured destruction than on its more limited enaction of relativistic physics, *Foolin’* marks the beginning of a transition in drama to a new engagement with the metaphysical concerns of early twentieth century physicists. *Hapgood*, premiering the following year, takes theoretical physics further, directly engaging with quantum physics and using some of its more baffling features to undermine its characters’ understandings of their perceptions of the espionage game in which they are engaged.

Viewed together, the two plays suggest a gamification of nuclear warfare and, more generally, international relations. As the stakes have been elaborated throughout the Cold War, both plays turn from those to concerns with the players of these games and the effects not of winning or losing but of the game itself. Ultimately the limitations of knowledge experienced by the characters, limitation created by the disarrayed space-time accepted and created within the plays, work to alter both the decisions the characters can make and the judgments audiences might cast on those characters.

In the third chapter I turn to the figuration of Albert Einstein, an iconic scientist made rather more ordinary in Paul D'Andrea and Jon Klein's *The Einstein Project*. In particular, the character is highlighted as an individual engaged in decision making about his science and also about his friendships. He does not do equally well on these two fronts. The play takes up a variety of linkages from one scene to another, using memory, news reporting, and relativistic physics to produce a spatio-temporal field in which the various decisions for which the historical Einstein can be given responsibility are interrogated together. Perhaps most famously, Einstein signed off on a letter to then-President Roosevelt encouraging the USA to undertake what became known as the Manhattan Project, making himself one of the fathers of atomic weaponry. In another register, he was unfaithful to his wife and (according to the standard biographies available when the play was written) effectively abandoned her and their children. In the lead-up to the second World War, he also abandoned his nation, emigrating to America. As well as using discontinuous temporal sequencing to bring these three decisions into parallel for judgment, the play offers up a clear foil in Fritz Haber, the patriotic German scientist who turned his research into fertilizers and pesticides into the gasses used in World War One's trenches and World War Two's death camps. The moral judgment placed on Haber is couched explicitly in terms of understanding and of love, and the play's judgment of Einstein proceeds on the basis of whether he has had time to understand how his science and his choices will affect those whom he loves. Ultimately the audience's difficulty, following the causal sequence of the play's plot rather than reorganizing events into their historical order, pulls apart cause and effect to undermine efforts to assign blame in the absence of adequate understanding.

All three plays from the early post-Cold War (*Foolin' Around with Infinity*, *Hapgood*, and *The Einstein Project*) are at work to place science in social contexts. Alongside the Cold War plays, these three help to mark out a continuum from drama about science through literary engagements with science to drama enacting science not only in its topic, or even via figuration, but particularly in the forms given to space-time as it exists on the stage.

The fourth chapter analyzes two small academic communities represented in Penny Penniston's *Now Then Again* (a few physicists at Fermilab) and in Tom Stoppard's *Arcadia* (literary, cultural, and mathematical scholars at Sidley House in England). I find in these plays the argument that that responsibility (to enact justice) especially obtains in the face of

the (scarcely perceived) possibility of total knowledge, that although partial ignorance is a constituent element of the decision this is not a mandate to preserve ignorance at all costs, and thus that frame of reference (as a limit on what knowledge you can access) makes possible the sort of limited-knowledge human action that can sometimes be described as just.

For a concluding chapter, I study Michael Frayn's 1998 play, *Copenhagen*, in which complementarity works not only as an extended metaphor but also as a topic of discussion for the characters, while Frayn's fictional versions of Niels and Margrethe Bohr and Werner Heisenberg iteratively discuss and reenact the events (always changing slightly) of the night of their 1941 meeting in Nazi-occupied Copenhagen. Their unsatisfactory explanations for their motivations increase rather than reduce uncertainty about the reason for and content of the meeting. The complementarities abound not only between each character's memories but also between their remembered or reconstructed pasts and the counterfactual possibilities they explore. Rather than fulfilling the hope shared by these characters, the play shows that their effort—the building up of an incomplete picture from multiple frames of reference—and the preservation of uncertainty are what allow the play to end with a more complicated definition of justice than that with which it began and with the suggestion that this more-complicated justice has been obtained.

NOTES

1. I follow Peter J. Kuznick and James Gilbert in acknowledging the debates surrounding the starting date of the Cold War but considering "August 6, 1945, the day the United States dropped the first atomic bomb on Japan and introduced nuclear terror to the world, [...] as good a starting point as any" (1). The term "Cold War" itself was coined in 1946 by Bernard Baruch (*ibid.*).

For an instructive listing of some of the physics plays of the Cold War, consider Charles A. Carpenter's bibliography of seventy-six published, English-language plays appearing between 1946 and 1989 "that deal directly and significantly with [...] major aspects of the Nuclear Age that relate to atomic weapons (but not to nuclear power)" (2).

2. It is worth noting Schrödinger's initial offering of this thought experiment as a *criticism* of some of the uses to which thought experiments were put. He introduces his cat, writing,

Man kann auch ganz burleske Fälle konstruieren. Eine Katze wird in eine stahlkammer gesperrt [...] (Schrödinger 812).

One can also construct entirely farcical cases. A cat is enclosed in a steel chamber (my translation)

Schrödinger's criticism is of models at work to shift uncertainty from an ontological category to an epistemological one.

3. This is a problematic way of expressing the idea, as quantum-level events do exist in their indeterminate way, without being observed. Another aspect of the observer effect, the one most commonly associated with it, comes up in analysis of light. When looked at as a particle, light exhibits particulate characteristics, but when light is studied as a wave, it appears to behave as a wave.
4. This is not to say that the decision to follow the law, to undertake the calculation, cannot itself be a responsible and ethical decision. As Derrida writes, "To be just, the decision of a judge, for example, must not only follow a rule of law [...] but must also assume it, approve it, confirm its value, by a reinstituting act of interpretation" ("Force" 251). In effect, the just judge decides that *this* will be the law by which the determination is made and is just (or unjust) in choosing to adhere to the law.
5. Heisenberg's principle is also known as the indeterminacy principle.
6. In the introduction to volume one of *Peace Plays*, Stephen Lowe characterizes the October 1953 Campaign for Nuclear Disarmament march in which he (and thousands of others) participated as "a vast dragon of anger and hope" and "a living example of 'The Theatre of Peace'" (v). At the nucleus of Lowe's selections are plays intervening in the anti-nuclear movements, though his scope is "a greater debate than just saying NO to nuclear weapons" (vi). Nonetheless, CND is a crucial thematic in many of these plays.
7. Carpenter specifically gives priority to the expansion based on "Pilot Lights": *Open Secret* by Ridenour, George Bellak, and Robert Adler. "Pilot Lights" was published in the January 1946 issue of *Fortune*, and *Open Secret* came into being within the year. Carpenter also acknowledges a precursor, *Wings over Europe*, which raises many of the topoi of atomic age plays but anachronistically: Robert Nichols and Maruice Browne's play was first performed in 1929.
8. In an extended study of nuclear spy stories, two German plays would certainly bear substantial analysis: Friedrich Dürrenmatt's 1962 *The Physicists* and Heinar Kipphardt's 1964 *In the Matter of J. Robert Oppenheimer*.
9. As Frederic I. Carpenter has observed, although Wouk wrote *The Traitor* "before the Klaus Fuchs case, it prophesied its actual psychology, and achieved success on the wave of public reaction to this and to the Hiss case" (3).

10. In this didactic effort the nuclear dramas of the Cold War bear strong similarity to the popularizations of physics Elizabeth Leane analyzes in *Reading Popular Physics*.
11. It should be noted, however, that the published ending differs from that originally staged; rather than leaving open the possibility of humanity choosing a safer path for its use of atomic energy, the revised ending focuses on the failures of scientists and politicians. This shift draws *Uranium 235* closer to the typical nuclear drama of the time, in keeping its indictment focused on the scientists and politicians rather than with its earlier efforts to display the wider societal responsibility toward scientific understanding. See Shepherd-Barr's discussion (71–2). For the most part, Cold War science plays allow the audience to safely sit back and watch the drama indict scientists and politicians.
12. In *Thermonuclear Monarchy* Elaine Scarry concentrates her analysis, in contrast, on the totalitarian concentration of nuclear power in the hands of the few while its effects would be distributed across a population.

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CHAPTER 2

Playing Nuclear War: Learning Postmodern War from Modern Physics

Abstract Both Steven Dietz and Tom Stoppard have written plays that enact modern physics to rupture the ordinary logics of spatio-temporal causality within their plots. Viewed together, the two plays suggest a gamification of nuclear warfare and, more generally, international relations. As the stakes had been elaborated throughout the Cold War, both plays turn from those to concerns with the players of these games and the effects not of winning or losing but of the game itself. Ultimately the limitations of knowledge experienced by the characters, limitations created by the disarrayed space-time accepted and created within the plays, work to alter both the decisions the characters can make and the judgments audiences might cast on those characters.

Keywords Gamification • MAD • Wave-particle duality

In this chapter I address two transitional works, produced in the closing years of the Cold War and carrying on many of the obsessions of the nuclear plays of the Cold War but doing so in ways that are—in their enactments of twentieth-century physics—markedly different from the bulk of their predecessors: Steven Dietz’s *Foolin’ Around with Infinity* and Tom Stoppard’s *Hapgood*. Both plays engage the effects of nuclear

weaponry on society, the first through the story of a watch-stander responsible for launching nuclear missiles on command and the second through the intrigues of spies interested in developments in nuclear science. Both plays are embedded in political fields (while showing those fields to be shaped by “ordinary” citizens as much as, or really more than, by the scientists who made the bomb possible) and are engaged in an exploration of those forces through distortions in their representations of spatio-temporality.

In *Foolin’ Around with Infinity* the literary treatment of nuclear weaponry ruptures linear chronology and spatial separation along with point of view. A number of places and times happen all together on the stage, radically disunifying time and place (in the Aristotelian sense) by drawing onto the stage several decades’ worth of time and widely scattered places. The play exemplifies a transition in theater from merely thematic treatments to formal enactments of science, though the play’s formalization of a new space-time is more precisely an enaction of the cultural phenomenon of the fallout shelter than of the science that partially comprises the play’s topic. *Hapgood*, then, represents a fuller enaction of science as such, taking up quantum physics directly and beginning to use it to produce the misbehaviors of time and space that appear to various of the characters’ perceptions; these errancies of space-time would allow Stoppard’s people to violate physical law and be in multiple places at one time or to transport themselves instantaneously from place to place. Both plays mark the closing years of the Cold War with a gesture toward the time that distinguished it, a time that worked differently and called for a different kind of decision.

CAN YOU LIVE WITH NUKES?

An unusual play, *Foolin’ Around with Infinity* was first performed in 1987 and is explicitly embedded in Ronald Reagan’s Cold War. It focuses on the military structures for the political game that was the Cold War, but unusual characterization and nonlinear chronology distribute the responsibility for managing a nuclear arsenal more broadly. Steven Dietz’s play occurs on a stage seemingly cluttered with sets: sharing the stage are a fallout shelter, the command post of a nuclear silo, a part of a sitting room, and a seat for a member of the audience. The action of the play moves between these scenes and through a temporal arc cluttered by diversions. Despite the narrative remark that the action of the play takes place “during

four hours on a winter night,” much of the play wanders so far into the past and future of that night as to make a liar of “YOU,” the character providing substantial explicit exposition (12).¹ YOU are one of the characters of the play, performed by a woman usually seated on the stage in “a chair which is identical to the audience seats” (9). YOU provide a narrative—postmodern and very meta—accompaniment and intervention in the action of the play: at times YOU describe the action, not merely narrating what is going on but calling that action into being; at times YOU interact with the other characters, as part of the action; and at times YOU provide commentary seemingly surplus to the rest of the action on stage.

Foolin’ begins with an usher showing YOU to your seat, onstage. YOU begin to read from the program, extracting from a still lengthier “Note from the Playwright” which is printed in the program. This note describes Dietz’s assembly of a file, a dossier of his expanding knowledge about “these guys. The keepers of the keys. [...] the commander and his deputy in the [nuclear missile] silo who turn the keys” to launch America’s weapons (10).² For his file on fallout shelters Dietz also took a tour of the shelter attached to the Minneapolis Office of Civil Defense. Asking whether the shelters were safe and well stocked, he received this reply: “These [two boxes] belong down here. The others are for the rest of the city. [...]. They’ve been here since ’71. We just never got ’em distributed” (113–114).³ Dietz’s note describes an increasing feeling of being hemmed in by not only the possibility of nuclear warfare but more precisely the ubiquity of the technology for such warfare in conjunction with a striking failure to follow through on defense and survival preparations. The “pilot lights” for nuclear war and defense may be lit, but Civil Defense is “fooling around” as if they have all the time in the world.

The “keepers of the keys” with whom *Foolin’* concerns itself are Arthur “Mac” McCormick and his deputy, Jesse Randall. They play Monopoly off and on throughout their watch. Mac’s estranged daughter and the irritatingly persistent Mr. Anderson round out the cast. Holding together the fragments that make up this play is Mac. Long before the four hour night watch attempting to frame the play, Mac had been an enlisted man assigned to project “Plumbbob,” a test explosion to measure the effects of radiation:

The radiation was given a code name as well. This name was “Wilson.” [...]. [Mac] viewed the blast from trenches at a distance of 500 feet. [...]. At 4:45 a.m. the bomb exploded. A portion of [Mac] exploded along with it. [...].

The light engulfed him. [...]. It was a light that went through his body like a prism, leaving shards of "Wilson" in its wake. [...]. And the shards left in his body haunted him [...] (88, 89)

When we finally hear this story, those shards haunting him explain in part the conversations from the play's future, in which Mac has been institutionalized and his now-yuppie daughter phones to make excuses for her failure to visit him. Within the logic of the play, Mac's irrational behaviors are "the effect of radiation on American servicemen" (88). These "shards of Wilson" also suggest an explanation for the irrational appearances of Mr. Anderson: a hallucination. In various costumes, Mr. Anderson appears in the scenes of the play, often knocking at and entering through a non-existent door to the missile command post, once in the persona of a traveling salesman whose product is "the football"—the briefcase with the launch codes (21–23). Those "shards of Wilson" explain why this technician (and not either his current deputy nor his previous fellow watchstander) is the one to lose his marbles and first murder one (disclosed in reminiscences throughout the play) and then attempt to murder the other. It also, indirectly and in conjunction with the societal paranoia generating and generated by the proliferation of bomb shelters, produces his daughter's different eccentric behaviors.

Luke (the daughter) is a twenty-something woman who lives in an unused fallout shelter and wears many neckties all at once, she says, "out of choice, not fashion. Nuclear Emergency Crisis Kit to Insure Eternity. NECKTIE. It's an acronym. I wear ties to save the world" (14). As a young radical, Luke carries on the eccentricity which had marked her childhood move from her own bedroom to the basement of the family home (18). What seems at first a delusional decision to opt out quickly invokes the lawlessness of many fallout shelter plays of the Cold War: NECKTIE "is taking matters into your own hands" (14). (Her independence in this regard is all the more marked in that, organizationally, NECKTIE doesn't exist beyond her; the play gives us no suggestion of other members.⁴) We are invited to see this not as radicalism or eccentricity but as self-preservation and self-centeredness attempting to be masked in self-sacrifice when we subsequently see her decide on the sustained medication and institutionalization of her father in his later years. Moreover, Luke's NECKTIE project twists in the stark seizure of authority made in Luke's possession of the shelter's "Card Number One" which both authorizes her presence in the shelter and announces she is "the

SHELTER LEADER” as the first to arrive in the shelter (66). As Mr. Anderson emphasizes, in giving her this card, “a lovely little totalitarian society will begin to blossom inside. A common citizen may be elevated, by pure happenstance, to *Dictator*” (67). The girl who embraced jointure with NECKTIE, who seemed to consider absurdity an appropriate and safeguarding response to the Cold War, becomes instead a woman reliant on seizing whatever authority comes her way.

Although Luke says she didn’t choose NECKTIE, her enthusiasm for it clearly marks an acceptance of it. The need for NECKTIE arises because “the time has come to wonder about the people around you”; it is a time in which Luke fears the society has fallen into the lawlessness invoked in *Licence to Murder* or the unreasoning escalation from throwing vegetables to launching nukes in “Pilot Lights of the Apocalypse” (14).⁵ Luke indicates the clock is being run down by “devious thugs with murderous intentions” (15). Instead, both she and her father are in a world largely of their own making. Embracing NECKTIE, an absurd personal practice, Luke’s own separation from social norms suggests she is far from a reasonable guide in the lawless society she perceives. Let’s call this a decision, then; a decision to opt out. She may be making an “attempt at tomorrow,” but it comes at the cost of eccentricity and along with an abnegatory abandonment of normal social relations (moving into the basement just as her father’s work takes him deep underground into his absurd space as one of the “keepers of the keys”) (14–15). Read in connection with her later bourgeois embrace of a comfortable lifestyle and complicity in her father’s confinement, one wonders for whom other than herself she is attempting to preserve tomorrow. And the world she produces in operating “by *instinct*” is not one from which she or her father can exclude unpleasant realities (14, original emphasis). Mr. Anderson will walk through walls to get to them and bother them, breaking Newtonian physical laws as if he were a subatomic particle.

Like Luke, Mac responds to the increasing unreason of his surroundings by seizing what authority he can. On a night watch much like the present night’s, Mac had been playing Monopoly, but Mac got bored by it all, and to alleviate that boredom he began fiddling with the launch keys. Brady, then Mac’s partner, could not stop him any other way and drew his gun on Mac, to which Mac responded by shooting Brady, or so Luke tells us she has discerned (71, 72). The official response to this was to replace Brady. On the night of the play’s framing watch, Mac drives Brady’s successor into a similar standoff, both with their launch keys set and ready to

turn but both also pointing their guns at one another. The play fails to make clear whether there is any time at all after this moment, as Luke, Mr. Anderson, and YOU chaotically interpenetrate the scene.

Playing games to pass the time may seem innocuous. Monopoly, however, is not a neutral choice in relation to the military war gaming on which the very form of nuclear watch-standing is predicated. The tremendous shift in strategic exploration through war gaming after the Second World War can readily be attributed to the persistent reluctance of human players to deploy nuclear weapons and the advancement of computer technology to produce nonhuman war gamers (De Landa 2).⁶ These computer generals—SAM and IVAN—operate on a model of nuclear war as a zero-sum variation on the Prisoner's Dilemma.⁷ In their reasonings, they have as much of a bias in favor of nuclear annihilation being just another possible tactic as human players had a bias against the large-scale destruction implicit in the use of nuclear weapons.

What makes Monopoly a pointed choice is its central goal of concentrating all power in the hands of a single player. Rather than the cooperative simultaneous key turning that is supposed to share responsibility for obediently launching missiles, Monopolists compete for scarce resources and pursue the elimination of other players. Monopoly teaches non-cooperation. The amassing of capital in Monopoly is similar to the nuclear stockpiling of Mutual Assured Destruction.⁸ But unlike the missile silo Mac stands in, the power of possession in Monopoly is limited and temporary: one can win only a game for meaningless paper counters. What Mac seizes are the keys to, as Elaine Scarry would have it, the kingdom of a *Thermonuclear Monarchy*.⁹

Mac's was supposed to be an isolated command post with watch-standers always present and always alone. Though *Foolin's* staging never empties the post, the watch-standers find their conversation diverted and repurposed by the remarks directed at them by the other characters, who cannot be kept out. Luke clamors to be given money to purchase a treat from the popsicle man (Mr. Anderson); she also recites the service member's oath of which her father wants to remind Jesse. YOU take control of the fallout shelter and of a box of Quaker Oats. Both appear equally valuable. In the moment before the keys turn to launch the missile, Luke begins a long, rambling free association. Interrupting Luke's discourse, the light on her is abruptly cut off, at the same time as the siren that had been wailing in the background is also silenced, both precipitated by the

sound of a gunshot. YOU then tell us about our past and present, the trivia of ordinary life, until YOU describe the end, which happens.

YOU. As YOU hear nothing, and as YOU do nothing – the light on YOU goes to black. (*IT does.*) (110)

Words about the past and future destroy cause and effect under the terrible power YOU have to narrate and to cause by narration.

YOU have a powerful imagination. Many scenes occur at the instigation of YOUR visualizations. Sometimes these are also enacted, as when YOU describe the Monopoly game Jesse and Mac are playing segueing into an interaction between Luke and her father at their home (17). But other scenes are only narrated: “YOU imagine an intermission. YOU rise from your chair and begin the pleasantries and pirouettes of the social event” (46). This narration of an “intermission” continues for a number of pages. Several scenes are performed on stage following this imagined intermission before YOU usher in the performance’s actual intermission, saying, “As before, YOU imagine an intermission. This time, however, YOU are on your own” (61). YOU, as a proxy for the audience, are the one to make things happen in this play. Words and hypotheses—the suppositions driving the stockpiling of supplies for fallout shelters and the fears of how Cold War doctrines will be put into effect—are realized in this play, suggesting that rather than the slide from scientific creation of the bomb to political use of the bomb being inevitable, what will happen is a gathering momentum from an imagined use of the bomb to an actual one. YOU shatter linear time; presenting two intermissions is just one example from the play. YOU also bring memories of the past and snippets of the future into the four hour watch of *Foolin’*. YOUR exposition calls fragments of time into juxtaposition, invoking a narrative of causality that seems to explain how Mr. Anderson can knock on and enter through a nonexistent door to a missile silo’s command post “a quarter mile under Utah” and offer Dietz’s own experiences learning about Civil Defense (non-)preparation as an explanation for what had happened to Mac’s former partner Brady (21, 46).

YOU regularly undermine linear temporality by realizing unusual linkages between one moment and another that should not be next. Doing so expands the time of the play, making meaningful not only the disparate times in consideration but also the time of recollection or realization that follows on from the connection. YOUR juxtapositions are productive of an overdetermined causality in which A leads both to B and to R. YOUR

temporal work highlights the chaotic nature of Mac's system, with waves of effect sweeping far from the little cause of "shards of Wilson." This junction of many times includes the audience's time as well, assigning causal potential far and wide. It also shows how much is not determined by the distant cause of nuclear radiation but more widely from the proliferating power of nuclear culture.

As well as muddling proximate and chaotically distant causality, YOU provoke an alienation effect. Seated in "a chair which is identical to the audience seats, YOU nonetheless mirror Luke, who is often seated in her armchair on the opposite side of the stage" (9). As audience and performer, YOU work with Luke to piece together the story of Mac's life and its relevance to the "if-it-happens-it-happens-80s" (113). The frantic efforts to produce narrative sense underscore the irrationality at work in Mutual Assured Destruction. The fatalistic assurance takes the foreground as the foolishness of *Foolin' Around with Infinity*; grounded in a feeling that the world's political situation is moving inevitably toward annihilation on multiple scales, what the play calls for is a breaking away from the Doomsday clock's inexorable countdown towards the final midnight—the final curtain.

Late in the play Luke takes YOUR chair, announcing "The time now is eleven fifty-five" while YOU continue to read from the Playwright's note, joined by Mac and Jesse (98). This reading is in response to confusion, because, as YOU say, "YOU don't know what she wants" (97). Retreating into a script, YOU attempt to avoid confronting the possibility of annihilation, yet this reading is at the same time an appellation. YOU hail us and draw our attention to a world in which the American President can joke, "My fellow Americans, I'm pleased to tell you today that I've signed legislation that will outlaw Russia forever. We begin bombing in five minutes" while the Vice President remarks in all seriousness that "Some people believe there can be no such thing as a winner in a nuclear war. But I don't believe that" (98).¹⁰ YOU want to let things be, to let them develop on their own, but even as the nuclear forces of America have been taken over by elected officials eager to launch the end of the world, the "keepers of the keys" on stage are a couple of men who have likewise retreated into the script, having joined YOU in reading from the note and being about to march through the launch sequence almost like the clockwork by which YOU tell us how few minutes are left until midnight.

Are we as insane as these often apparently irrational characters? While *Foolin'* shares with Cold War plays a fixation on bomb shelters, it takes this

fixation to a new place with YOU and with its splintered temporality. In effect, *Foolin'* appears to conclude that the Cold War will never end, save by actual annihilation: its effects are too pervasive and too controlled by systems devised by the imaginations all too subject to it. Even the chronological leaps the play takes—to when Luke was nine years old and when she will be middle aged, to when Mac was twenty-three, to last year when Mac killed his fellow watch-stander, and elsewhere—are imagined and insubstantial. Past is no more real than future in this play; all of time, infinity itself, is at stake in this play, yet YOU make it all imaginary. YOU view the world as irrational (YOU, being a product of Dietz's nearly obsessive assemblage of files on the processes and philosophies of nuclear warfare, may have no choice but to do so). The time to divert these doomed words from coming to pass was before they had been imagined into being; the only realities now are destructive.

Meanwhile, as Dietz writes in his note, "My generation [...] had now, as adults, elected a man who named the MX missile the 'Peacekeeper.' The unthinkable had become the commonplace" (116). Despite expressing this shift in passive voice, in Dietz's logic the becoming-commonplace of the previously unthinkable is ultimately a result of his generation's actions (the election of Ronald Reagan). As a result, "We are hounded now by technology that, like Mr. Anderson, will not go away. We attempt futuristic solutions to primitive problems. [...]. We are playing Frisbee in the graveyard. INFINITY is the collision of these images. Humorous and haunting. Tactile and ephemeral. Infinity continues to look to us all" (116). It looks to us for answers, or for actions that will reshape the questions. But the play ends, "as YOU do nothing" (110). Perhaps infinity needs us at least to *attempt*.

WHAT HAPPENS IN *HAPGOOD*?

By contrast, in Tom Stoppard's *Hapgood* the attempt never seems to proceed. Focused on the knowledge-games of international espionage, Stoppard's play explores the possibilities for action in the quantum ambiguity of one knowledge network. Confusion, misdirection, and an application of quantum physics to the practice of spycraft keep the same events and the same conversations running across the stage and through the minds of the characters and their audience. The title character, Elizabeth Hapgood, is a British intelligence officer, overseeing many of the other characters. One exception to this is Ben Wates, a CIA agent on loan to

help resolve a problem with a joint counterespionage operation: they want to know whether the Russian scientist, Joseph Kerner, whom the Russians believe is leaking them scientific secrets, is still their “joe,” still a source loyal to Hapgood (who had turned him to the British side), and thus “leaking” only such “secrets” as are sanctioned by Hapgood.

In the opening scene, Hapgood hides in a shower cubicle while Wates, a Russian whom “*we call [...] Russian One, because he is Russian and because there are going to be two of them,*” and Ernest Ridley, one of Hapgood’s agents, run through a shell game involving changing cubicles, towels slung over doors, suitcases left under doors, and peregrinations weaving in and out of the room’s various doors (491).¹¹ All is ultimately about the movement of the information and disinformation included (and not included) in the suitcases. In the end, Hapgood, Wates, and their team will have been fooled by the Russians, because the Russian agent turned out to be twins. As well, though the dialogue and action give no indication, the stage directions specify that Ridley is also actually twins. Later in the play a diagram of Ridley’s wanderings in and out of the room during this scene will be used to demonstrate that one man could not have walked the route “he” had walked.

Paul Blair, a friend and colleague of Hapgood’s, apparently her superior in rank, debriefs the pool exercise with Joseph Kerner in the next scene. As Kerner observes, comparing his situation to the two-slits experiment that is foundational to quantum physics’ understanding of the nature of light,

You get what you interrogate for. And you want to know if I’m a wave or a particle. Every month at the pool, I and my friend Georgi exchange material. When the experiment is over, you have a result. I am your joe. But they also have a result: [...] to keep me credible as a British joe. Frankly, I can’t remember which side I’m supposed to be working for, and it is not in fact necessary for me to know. (501)

The analogy to quantum physics, woven into the structure of the play and into its plot and action, is heavy-handedly spackled across the dialogue. Stoppard ensures that plenty of doublings drive the characters’ uncertainties and therefore also drive their pursuits of the true source of their current problems, and twins crop up unbelievably frequently, though the Russians, the Ridleys, and the Hapgoods are each played by (for the most part) a single actor apiece, restaging the identity of quanta of light to one another and also the quantum physical collapse of the wave function

into the single reality of what one looked for. But making this integration comprehensible calls for extended lectures from Kerner that, like explaining a joke, call too much attention to the enactment of physics at work in the play. The excessive reliance on explanations is regularly blamed for the play's commercial failure.

The play's third scene takes us further into confusion. Hapgood, whom we fleetingly heard referred to by the code name of "Mother" in the first scene, now stands at the side of a rugby pitch, cheering on her son and his teammates. She is, in fact, a mother. And, blurring into our identification of Joseph Kerner "as a British joe," Hapgood's son is also named Joe (509). Here Hapgood's colleague Blair debriefs her, in the course of which he passes along to her nearly all the information we have seen him receive. The hunt for a traitor continues, and Hapgood is a top candidate, yet Blair continues to trust her. Hapgood raises the possibility that Ridley is the leak in their organization, rather than herself or Kerner (who would be the most obvious suspect, being already a double agent).

The next scene, in Hapgood's office, begins in her absence. Paul Blair and Ben Wates confusedly hear Hapgood's secretary's side of a conversation on "the red phone"—apparently a direct line to Downing Street. It is young Joe Hapgood calling in to recount his morning to his mother, so that she can help him figure out where the key he misplaced is. Hers will be the theory, like quantum physics, that explains the observed and unobserved features of the world. Like quantum physics, a spy's job is to build a description from incomplete information. Such a misuse of the red phone prompts Wates to query Hapgood's code name as well as the nature of her relationship with Ridley. In evidence in his growing case against Hapgood, Wates recounts a series of minor disasters of espionage, all of which can be traced back to Hapgood and Ridley. When Hapgood finally arrives, her attention is obviously focused in multiple directions and her remarks, not confining themselves to any single conversation, regularly give her listeners pause. And although she temporarily allays Wates' suspicions, her ongoing inability to keep her professional and her personal lives separate unnerves him. As the scene ends, the possibility that Ridley is also a twin is suggested (a truth stated in the stage directions for the first scene but not indicated in the action or dialogue thus far).¹²

In the second act, traps within traps are triggered. To capture Ridley and his twin, Hapgood and Blair behave as if Hapgood has been suspended, and Joseph Kerner reveals that the Russians had also turned him back against the British by threatening his and Hapgood's son, Joe. But

Hapgood continues to present herself as being on Ridley's side, sending him to her "twin sister," Celia. There is no Celia Hapgood; instead, Ridley encounters a foul-mouthed, disorganized slattern played convincingly by Elizabeth Hapgood. Ridley's part is to help Celia impersonate "Betty" (Elizabeth), so that Hapgood can be in two places at the same time. All of this is, apparently, in response to the kidnapping of young Joe Hapgood by the Russians, over Hapgood's interference with the handoff shuffled through in the first scene. But Joe was never kidnapped, and the plot unfolds the whole scheme as Blair's plan to capture the Ridleys. In the closing scene, Kerner reveals that the story he'd made up to support the kidnapping (that the Russians had turned him back) is not made up: they had, and he plans to go back home to Russia. But, in the closing moments of the play, he turns again and, rather like *Endgame's* Clov, does not leave. What captures his attention is that the game—another rugby game in which young Joe Hapgood is playing—has begun.

ESPIONAGE AS THOUGHT EXPERIMENT

Unlike the espionage plot exemplified in *The Traitor*, and despite the essentially linear temporal sequence to *Hapgood's* plot, this play traffics heavily in iterability. The enactment of quantum physics—especially the many strangenesses of duplication and apparent contradiction—changes the play from pure spy story to high stakes experiment. Most obviously, the quantum iterability occurs in the twinnings: two Russians, two Ridleys, and the pseudo-twins of Elizabeth and Celia Hapgood. Ridley and his brother, like the two Russians, seek to impersonate a single person: both are trying to obscure their separate existences. Meanwhile, to catch the Ridleys out, Hapgood is trying to create for herself two separate existences. The twists and turns and tensions produced by this latter twinning are what most obviously resonate with the quantum physical concerns which Stoppard has entwined around his play.

The play's epigraph is drawn from the writings and lectures of Richard P. Feynman. Stoppard quotes his assertion that "the *only* mystery," the one analogous to "Any other situation in quantum mechanics," is the dual nature of light, as demonstrated with "the experiment with the two holes" (qtd. in Stoppard 483).¹³ This is an experiment that struggles with light being a particle but also a wave. Actually, there are two domains in which this experiment holds strangeness: first, light is weird, and second, watching things turns out also to be a weird process. Most things that we think

of are either particle-like or wave-like, grains of sand or flowing waves. Experiments designed to show that light exhibits particle-like behaviors succeed, so do experiments designed to show that light exhibits wave-like behaviors.

To understand the two-slits experiment, begin by imaging what would happen if a bunch of particles were shot at a screen with a single hole in it. The ones that went through the screen would hit the wall behind the screen mostly directly behind the hole, though some would scatter a bit, bouncing off of one another or the edges of the hole. With two holes in the screen, close by each other, roughly the same distribution pattern would appear, because each hole would contribute hits scattered toward the center. If you change from flinging particles to flinging waves at the screen, it is different. Waves can cancel one another out, when one's peak meets another's trough. Of course, this cancellation happens when there are multiple waves—at least two—in the picture to interfere with one another. Now we revise the experiment one time more, firing single photons (particles of light) at the screen with two holes in it. Firing the photons one at a time would seem to be something that would resemble a particle experiment. But what shows up on the wall beyond the screen is the same interference pattern as when waves are fired. The photons (particles!) are behaving as waves, but more so. These individual photons, sent one at a time, act like multiple waves which interfere with themselves. Furthermore, if you try to figure out which slit the particle-like photon actually went through—if you install a detector—the pattern that appears on the wall behind the screen becomes a thoroughly particle-like pattern: there's no wave interference.¹⁴

This is weird. Even Feynman's explanation of *what* happens concedes that it is a "mystery." Interestingly, in *The Character of Physical Law*, Feynman goes on to explain that the challenge of discussing the wave-particle duality is a "difficulty [that] really is psychological and exists in the perpetual torment that results from your saying to yourself, 'But how can it be like that?' which is a reflection of [an] uncontrolled but utterly vain desire to see it in terms of something familiar" (129). Quantum physics is mainly hard because we refuse to admit the new ideas as fundamentally new: different and unfamiliar. Like Feynman's take on wave-particle duality, in *Hapgood* the chief interest in the play is neither the techniques of espionage nor the explanatory analogy to quantum physics; it is the psychology: the relationships between the characters as they play the espionage game.

The centrality of these relationships may well be why relabeling the play as a “melodrama” helped Stoppard in its production; he says, “The way you label something [...] gets you out of the corner. [...] Hapgood] is melodramatic. It’s not satiric about the spy business. It operates on a heightened, slightly implausible level of life” (Gussow 106, qtd. in Hodgson 140). Now labeled “melodrama,” *Hapgood* can sit down and tell us how its ideal spy story will undermine the conventions of the genre (and thus how it will, itself, undertake this contravention). Kerner, having pointed out some of the formulae of spy stories, goes on to announce:

KERNER. Safe house, sleeper, cover, joe... I love it. When I have learned the language I will write my own book. The traitor will be the one you don’t like very much, it will be a scandal. Also I will reveal him at the beginning. I don’t understand this mania for surprises. If the author knows, it’s rude not to tell. In science this is understood: what is interesting is to know what is happening. When I write an experiment I do not wish you to be *surprised*, it is not a *joke*. (543)

A “polite” spy story that doesn’t withhold information would be “scandalous,” because it would fail to surprise. Joseph Kerner suggests that his book would be predictable, and he has already named the two conventions it would violate: the likeable characters will be virtuous and the obnoxious ones treacherous (543). *Hapgood* becomes Kerner’s spy story as Kerner became Hapgood’s “joe”: Ridley, whom we “don’t like very much,” does turn out to be the traitor, and Blair, whom we are supposed to like—for his friendliness to Wates and to Hapgood herself—is largely vindicated (543).

Hapgood, then, is an experiment rather than a spy story. Things here are as one would, on the face of it, expect them to be. And this explains how the audience is trapped: we expect, after being informed by Kerner, that spy stories are counterintuitive (that the suspicious jerk is a good guy after all), but Kerner also tells us that his spy story will be a very different thing. So, how should we expect *Hapgood* to turn out? Should we look for it to unfold like a spy story or like an experiment? Which game is in play?

What the play tries to do is to be both—it’s a spy story and an experiment. Like light, we have too many ways to read it. So, though we are told, politely, from nearly the beginning that Ridley is a traitor and that Hapgood regularly diverts company assets to her personal ends (having

her son telephone on the red line, playing chess through the international dispatches, having a child with her “joe”), the politeness about Ridley obscures the riddles which spring up around Hapgood. To Ridley, this is not polite at all: he is told there are two Hapgoods, and he is told this lie to send him into a trap. The characters of *Hapgood* entangle themselves and the audience by playing different games. Although Kerner and Ridley are both playing to win, Ridley wants to win a spy game, while Kerner wants to win a family experiment.

In a play about ambiguity, deceit, and knowledge in a pre-quantum sense, we are told too much to be confident of knowing what the truth is. The knowledges and uncertainties at play in *Hapgood* are not connected to ontologically unknowable things (such as quantum states), though Kerner suggests things are not as straightforward as he himself might hope both in his repeated assertions that he does not himself know “which side [he is] supposed to be working for” and in the closing moments of the play in which he, having determined to go and said his farewells, remains on the rugby field’s sidelines (501, 593). What sends these inherently knowable and determinable states—Kerner’s loyalty and the allegiances of any of the other characters in the play—spinning toward the photons to which they are analogized is the play’s espionage context: because deceit is so central to the environment, the characters fool not only the audience but also themselves. This whole play happens because people are pre-prepared to look for there to be twins. As Terry Hodgson notes, “When the mole is identified early, the technical problem resides in finding another form of suspense—the kind that invites a spectator or reader to see or read a play a second time for its human intellectual interest and for its dramatic skill” (140–141). Hodgson appears to conclude—referencing Stoppard’s assertion that “The ideal is to make the groundwork so deep and solid that the actors are continually discovering new possibilities under the surface”—that the play is successful because the audience will need to see it twice to follow the complexities of quantum mechanics (Guppy 179, qtd. in Hodgson 141). What one knows, throughout *Hapgood*, is that there is more going on than one can see. This game is deep.

DECIDING BOTH WAYS

The central game *Hapgood* plays with quantum physics is the title character’s decision to double herself. Her strategic choice, literalizing the duplicity of quantum particles, elevates her demonstrable control of the

multiple games she plays while it also reminds that she is playing them without recognizing boundaries between them. Like the intricate juxtapositions of space and time in *Foolin' Around with Infinity*, the complex network of games and duplicative players in *Hapgood* reassigns agency for its characters. Amid Stoppard's foolishness about double agents and the doubling of "Joes" (as a nickname for covert sources in general) with Joe himself, the duplication of Hapgood is not a matter of mere wordplay nor an enactment of a long-running joke of spycraft (the twins): Hapgood splits herself. She is not only the hyperorganized spymaster whose many roles overlap but also the blowzy rouée who seduces Ridley, reminding the audience of Hapgood's unprofessional relationship with Kerner. Hapgood herself becomes particle-like, insofar as (as Kerner meditates):

The particle world is the dream world of the intelligence officer. An electron can be here or there at the same moment. [...]. It defeats surveillance because when you know what it's doing you can't be certain where it is [...]; and this is not because you're not looking carefully enough, it is because there is *no such thing* as an electron with a definite position and a definite momentum; [...]. (544)

This is to say that Hapgood, manifesting the Celia persona as a separate person, critiques herself for not having Celia's traits while exhibiting that she does have them after all, however alien they seem to the mealy-mouthed propriety she often exhibits (Blair teases her, asking, "What do you say when you burn your hand on a saucepan? 'Oh, sugar?'" [515]). Elizabeth Hapgood is both "Betty" and "Celia," to anyone who can observe them both at once. But Stoppard's protagonist "defeats surveillance" in terms both of fooling Ridley (he doesn't know what he's looking for) and also of confounding her colleagues (who wonder where she is, even as she is acting according to their planned duplicity). She plays the espionage game so successfully as to appear not to be playing the same game at all.

The confusions on which *Hapgood* relies confound the "beauty" Kerner had ascribed to science (543). That is, for Kerner "a science paper is a beautiful thing" because it is readily understood (543). Rather than saving up the answers as a surprise, it iterates itself, pairing puzzles and answers as versions of one another. Or, as Derrida asserts (though this is not his main point) in "Signature Event Context," all writing is iterable and therefore decodable" (315). And indeed, in unfolding some of the senses and interests of the duplicity of *Hapgood*, it becomes clear that the play's

repetitions are decipherable. More: all of Hapgood's secrets are revealed, in one way or another, in the course of the play. She is "Mother," the spy-master; and while travelling on assignment she breaks her cover to send her son a postcard, because she is also a mother. She is primly proper, and she's been carrying on an affair with Kerner for the past dozen years, a social as well as a professional impropriety. She embodies "not only...but also" like a Schrödinger's cat (itself one more effort to understand a problem just like "the case of the experiment with two holes" [Feynman, qtd. in Stoppard 483]).

Hapgood can do all of this, and can be condemned for much of it, because of the power differentials in which she is embedded. She supervises her agents and at least one double agent; she is a mother; she exhibits a concern for propriety at least on the level of language. She breaks the rules apparently thoughtlessly, to support her unconventional family. She is uniquely situated to see how her social and professional roles can be complementary, rendering her individual actions incommensurable with the several roles they purportedly follow from. Her personal agency not only ties together her disparate objectives but also renders her pursuit of them harder to follow.

The several iterations of Elizabeth Hapgood markedly follow from the play's affiliation with quantum physics, whereas the construction and destruction of infinity in *Foolin' Around with Infinity* are socially constructed. That play takes as one of its starting places

The chain of command – from my President giving the order to deploy the nuclear arsenal, to the commander and his deputy in the silo who turns [sic] the keys – was so wonderfully cryptic and Byzantine to me. It had the secret code and handshake feeling of a child's game. It was men playing at war. (111)

In the transition from dramatic efforts to come to terms with the reality of the bomb, to re-presentations and articulations of reality in response to the possible use of the bomb, to alterations in that reality in conformity to the physics which made it possible, the game of War (a card game nearly identical to the British game, Snap, played in *Hapgood*) plays out on a stage increasingly reworked not only by language but by science. Games work because they are bound by rules that cover and determine every aspect of their play while allowing for a range of actions. They also work on a sharing of control. Children grow out of War because the game is

entirely mechanical—no decisions are made. Watch-standers and spymasters grow into it in accumulation of apparent options: to launch missiles or find misplaced keys; to believe neckties can delay nuclear annihilation or doubt one's own allegiances in a plot of deception; or to engage YOURSELF in the contentious action or do one's best on a rugby pitch. All these roles belong to very different games, many of which have rules that are informed not only by the disproportionate power of nuclear war but also by the differential power of understanding the conditions in which the rules are formed.

NOTES

1. Throughout the play, Dietz's script treats YOU grammatically as the second person pronoun rather than as her personal name, and I follow Dietz's convention.
2. See page 111 of the script for similar text in the author's note to be included with the programs for performances of this play. With minor differences, the language YOU are scripted to read aloud on stage matches what is to be printed in the program.
3. This portion is also read onstage, with minor variations, late in Act I.
4. Another character, Jesse, briefly appears to have been acknowledged by Luke as a part of NECKTIE, but this is ambiguous and, even if it is the case, does little to suggest that others beyond Luke's acquaintance have assumed "ties to save the world."
5. "Pilot Lights," somewhat absurdly, has its initial counterattack directed at Denmark because its citizens had reportedly been throwing produce at a statue given by the USA (219).
6. Manuel De Landa's *War in the Age of Intelligent Machines* usefully considers the Cold War era efforts to short circuit the decision. Drawing on the distinction between the "advisory" role of weapons that suggest targets to their remote human operators and the "executive" capacity to act on that information, De Landa considers that the war games drawing on artificial intelligence "blur the distinction" between advice and execution (2). Where computers once merely assessed the effectiveness of the players' strategic decisions within a game, nuclear war has given such games greater prominence and has led to changes in them. They substitute for "a real war" in attempting to give commanders "battle experience" (2).

Viewed along a continuum of "intelligent" or "agential" machines, the computer war gamers appear to be designed toward crossing the threshold, too, in bringing decision-making contexts down to determinations. That is, in making nuclear weaponry just another element in the arsenal, and in the effort to give the machines "some 'common sense' in order to

- eliminate irrelevant details from consideration,” war games straddle the divide between “games” and calculations (2).
7. As De Landa explains, the war game the computers play have been programmed to treat war analogously to two prisoners, separately offered the same scenario: a standard sentence for both if each informs on the other; a reduced sentence for one and an extended sentence for the other if one informs on the other without this being reciprocated; or minimum sentences for both if neither informs (84).
 8. The nuclear deterrence policy known as MAD is sometimes expanded as Mutually Assured Destruction. This elides the intended deterrent effect of the policy. The point of MAD was not that together (mutually) the Soviets and Americans could destroy the planet but rather that both nations could be assured that both were in a position to respond in sufficient force to destroy Earth.
 9. Though Scarry focuses on the disproportion between the leader and the residents of a nuclear-armed nation, her larger point about the abuse inherent in such a disproportion is applicable in a limited way to Mac as a person with the power to deploy the weapons in ‘his’ silo.
 10. These are President Ronald Reagan and Vice President George H.W. Bush. Dietz accurately quotes Reagan’s joke of August 11, 1984, offered up as a microphone test phrase prior to his weekly radio address. The remark he attributes to then-candidate Bush is a paraphrase.
 11. This passing allusion to Oscar Wilde’s *The Importance of Being Earnest* suggests that play’s confusions in its two Ernests; *Hapgood*’s doublings are considerably more prolific and tangled. See Toby Silverman Zinman’s treatment of twinings in “Blizintsy/Dvojniki Tiwns/Doubles Hapgood/Hapgood” and especially his treatment of Wilde’s play (316).
 12. Such omissions from the dialogue, and the often extensive information provided in the stage directions, make the play easier to read than to watch. Yet even in the directions the ideas are densely written and not always clear.
 13. The first half of the play’s epigraph comes from the final volume *The Feynman Lectures on Physics*, a three-volume publication of Feynman’s lectures for the introductory physics course. The second half comes from *The Character of Physical Law*, a series of lectures for a popular audience.
 14. Popular science writers have related this experiment and its quantum weirdness on many occasions. Kenneth W. Ford’s treatment, in *The Quantum World: Quantum Physics for Everyone*, and Brian Greene’s, in *The Fabric of the Cosmos*, are among the more accessible. Although *The Feynman Lectures* are rather difficult, his more popular lectures in *The Character of Physical Law* are fairly clear and engaging. J.C. Polkinghorne’s *The Quantum World* and Roger Penrose’s *The Road to Reality* each rely heavily on mathematics for their presentations, both of which are nonetheless intended for a lay audience.

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Relativistic Intertextuality: Einstein as a Figure

Abstract Albert Einstein is highlighted as an individual engaged in decision making about both his science and his friendships in Paul D’Andrea and Jon Klein’s *The Einstein Project*. The play moves variously from one scene to another, using memory, news reporting, and relativistic physics to produce a spatio-temporal field in which Einstein’s various decisions are interrogated together. The play’s judgment of Einstein proceeds on the basis of whether he has had time to understand how his science and his choices will affect those whom he loves. Ultimately, following the causal sequence of the play’s plot rather than reorganizing events into their historical order pulls apart cause and effect to undermine efforts to assign blame in the absence of adequate understanding.

Keywords Manhattan project • Albert Einstein • Relativity

Iconic scientists—famous, caricatured, misunderstood—play a significant role in science drama. A wide spectrum of uses is made of historical scientific figures (frequently Albert Einstein), ranging from those that seem scarcely fictional, drawing as closely as they do upon historical documents, to those which seem frankly silly.¹ I find *The Einstein Project* in between these two extremes, which moderation allows the play to do more work to

make history, biography, physics, and drama come together. This play demonstrates a temporality generated by the tension between Einstein's historical, biographical time and the time-structure the Einstein character experiences in the play. A representation both of the flow of Einstein's memory and of the relativistic importance of point of view, the nonlinear temporality of the play produces a field in which Einstein's decisions—scientific, personal, and political—can be interrogated together. As playwrights Paul D'Andrea and Jon Klein note:

Albert Einstein was not a comfortable cliché. His stereotyped image is a barrier to understanding the man. The actual Einstein was vital, restless and complex—tall and handsome in his youth, idealistic, relentless, passionate, logical, imaginative, flinty, sensitive, tough, caring, independent, self-confident in the extreme and obsessed with God's thoughts. (5)

The defamiliarization of Einstein effected in this play allows (this fictional version of) the man to appear afresh, alienated from and exceeding the popular images associated with him.

Briefly setting aside the structural peculiarities of the play which are most of interest to me, I need first to recount the stories told by *The Einstein Project*. The play covers episodes from Einstein's life across nearly forty years, from 1907 to 1945. Just as Einstein did a lot of moving around during this time, so does the play, with scenes set in Switzerland, Germany, England, and America. The main set of events comes from Einstein's life. These include his meeting with Max von Laue (not long after "On the Electrodynamics of Moving Bodies" was published), heralding Einstein's ascent into and through the community of European physicists. We are also shown various other encounters with the physicists who were his friends. We see Einstein taking the oath of American citizenship and a near-riot the character incited by a lecture on Germany's denial of scientists' necessary intellectual freedom. Many of these scenes resemble, with varying accuracy, historical events from Einstein's life. Another set of scenes concerns the group of physicists held at "Farm Hall" in England. In *The Einstein Project* these are Max von Laue, Otto Hahn, Werner Heisenberg, and Walther Gerlach.² These scenes provide the reflections and analysis of four of the leading physicists Einstein had left behind when he emigrated, chiefly provoked by news that the Americans had bombed Hiroshima; they wonder whether Germany could have achieved a similar accomplishment and also who in America, which among their former

colleagues, had had a hand in the bomb project. These scenes and others are stitched together with news reports in the style of British Pathe's newsreels.³ Many of the play's newsreels are labeled as coming from "Pathé News," though some are attributed to other (often national) news sources.

Also included in the play is Einstein's writing of a letter expressing the decision for which he is nearly as famous as for his scientific theories: the letter of August 2, 1939, encouraging President Franklin D. Roosevelt to undertake what would become known as the Manhattan Project.⁴ Arguing "for watchfulness and [...] quick action," the historical Einstein writes that physicists are on the verge of being able "to set up a nuclear chain reaction in a large mass of uranium" and that doing so presages "the construction of bombs" (qtd. in Isaacson 474).⁵ Toward the conclusion of the letter, Einstein describes possible duties for a point person for an American project, including the responsibility "to speed up the experimental work" (2). The closing paragraph underscores Einstein's sense of urgency in suggesting the likelihood that Germany already has such a point person in place (2).⁶ Terms as innocuous as "recent," "new," and "immediate" in the opening paragraph introduce the hurry racing through the letter, leading to the threatening characterization of all this newness: it "seems to call for watchfulness" if not for "quick action" (1,2). If American scientists might develop energy from uranium, bombs can also be made; by implication this is a near future which should be pursued by the marshalling of resources enacted by a point person for the Manhattan Project.

Einstein, having thrown his lot in with the Americans, joined with his fellow expatriate European physicists to warn Roosevelt against Germany. Although Einstein ceded a good deal of this decision making to Leó Szilárd, Einstein nonetheless did decide to lend his imprimatur both to the project of persuading the President and to the Manhattan project which would arise from Roosevelt's positive response to the letter. As Einstein would later, frequently, warn, the possibility of such weapons and the fear of such weapons would lead—he thought inevitably—to the use of these weapons in war. Whether he thought in these terms at the time, or not, Einstein's subsequent arguments in favor of various schemes to keep control of atomic weapons away from national governments (by instituting a world government or under the auspices of the International Atomic Energy Commission) are couched in terms casting judgment upon his original decision to sway Roosevelt toward the cultivation of nuclear power and weaponry. As he would write to Niels Bohr in December, 1944, "when the war is over, then there will be in all countries a pursuit of

secret war preparations with technological means which will lead inevitably to preventive wars and to destruction even more terrible than the present destruction of life,” and therefore scientists such as themselves should use their influence to “bring combined pressure on the political leaders in their countries in order to bring about an internationalization of military power” (qtd. in Rowe and Schulmann 364). Already in writing this letter he anticipates Bohr’s resistance to this idea as impracticable. And throughout the Cold War Einstein’s efforts to take back the effects of the decision he had made would be regularly condemned as, at best, naïve. Quixotic though these efforts might have been, they appear to mark a sense of responsibility for setting work on the bomb in motion and even an awareness that, while he had been in a position to make a decision when he signed the letter in 1939, the fact of the bomb’s existence—and especially its destructive capability—drove decision making out of existence as the Cold War ground on.

ALBERT EINSTEIN AND HIS SON

Just as D’Andrea and Klein have been at pains to flesh their Einstein out as a living, contradictory character, they have written nuanced parts for the other scientists who hold significant roles in the play. The final character, Edward Einstein, is complex, too. The historical Eduard Einstein was the scientist’s younger son, raised largely by his mother (Einstein and his first wife divorced in 1918, when Eduard was eight, but Einstein had separated from his wife in mid-1914).⁷ Eduard was a sickly child, spending a year in a sanatorium in 1917–1918 (Isaacson 234). Later, as a student at Zurich University, Eduard would attempt suicide and would again be institutionalized, with a diagnosis of schizophrenia (367–368).

In the play we see Edward as an adolescent, a bit anachronistically (e.g., in a scene set in 1913 he is treated as roughly the same age as Werner Heisenberg, though the latter was historically nearly a decade older). The competition the play stages between Edward and Heisenberg is certainly heightened by this shift: the play’s Edward is able to impress Heisenberg into joining him in a variation on chess (26).⁸ This amiable game degenerates as soon as Einstein crosses over to them, denigrating the game as “a little silly” and challenging his son to come up to Heisenberg’s level, saying “Figure it out. You know it can be done. I’ll bet Werner can do it” (26).

As well as being a foil for Heisenberg, Edward is a foil for his father, an argument for a different accommodation between the social and the scien-

tific—or perhaps an argument for making *any* accommodation to societal norms. There are four key moments in which Edward appears in the play. The opening and closing scenes, which I will discuss at length later, show Edward and his father sailing together. Another scene establishes the competition between Edward and Heisenberg (in connection with their game of chess). The remaining scene has Edward interrupting his father’s attempt in a lecture to speak out against fear and against war. Edward’s mental illness is rendered as childishness as he insists his father sing a nursery rhyme for him (“Timpe Te!” he exclaims, repeatedly [33]). After Edward is carried off, the crowd also turns on Einstein, underscoring his failure both with his son and with his nation. This is the scene that dramatically incites Einstein’s departure from Germany, drawing the play’s first act to a close. The second act will begin with Einstein’s oath of American citizenship, marking Einstein’s departure from Europe, his fellow physicists, and his son as irrevocable, even as the fury of the mob provokes a haste that suggests, despite Einstein’s words to the contrary, that his renunciation of Germany was not meant to be as widely encompassing as it became. As with Einstein’s regrets over encouraging the development of the bomb, what may at the time have seemed reasonable to him—cutting ties with a Germany he found too restrictive of free scientific inquiry—wound up alienating him from far more than a political association.

The play is at work from the beginning to reframe its audience’s understanding of Einstein as a person.⁹ The opening scene is set on a sailboat, manned by Einstein and Edward. Einstein is apparently trying to make his son into a mathematical prodigy. They’re playing a game of counting off the prime numbers in turn, but Edward keeps making mistakes. Einstein changes their game, seeming at first to do so out of kindness, making the challenge the much easier one of counting fingers. Einstein then denies Edward has ten fingers:

EINSTEIN. [...]. (*Einstein grabs Edward’s hands.*) How many fingers on this hand?

EDWARD. Five.

EINSTEIN. Right. Now let’s count the other hand. Ten, nine, eight, seven, six. Six and five make eleven. See? You have eleven fingers.

EDWARD. I do not.

EINSTEIN. Can you prove it?

EDWARD. No.

EINSTEIN. You must show me why you think I'm wrong, Edward. Until you do, you have eleven fingers. (15–16)

Einstein's shift quickly reveals itself to be another frustration for Edward. An interesting point about counting is being set up, but Einstein does not follow through to make the point; he wants Edward to work it out for himself. The demonstration for which Einstein is calling hinges on the difference between ordinal numbers (descriptive of sequences, e.g. first, second, third) and cardinal numbers (generally denoting quantity, e.g. one, two, three). Edward's "other hand" with "Ten, nine, eight, seven, six" fingers should be described instead as having the tenth, ninth, eighth, fingers; Einstein was not counting those fingers but rather naming them.¹⁰

The mismatch on which Einstein's riddle is based has something in common with the mismatch of separated clocks invoked by Einstein in his paper on special relativity. What Einstein argues for in his initial statement of the theory of special relativity (published in 1905, not many years before this scene is set) is a reconceptualization of, among other things, the idea of simultaneity. If two events occur, but not in the same place, how could one know whether they happened at the same time? Under relativity, time and space become space-time in large part because measurements of time are spatially constrained: any clock ticks off local seconds and minutes, not universal ones. Similarly, in treating Edward's two hands separately, Einstein marks the boy's fingers as separated systems, one local set of named fingers and another local set of enumerated fingers. Edward's failure to recognize that Einstein is using different "clocks" as he ticks off his fingers contrasts with the recognition, under special relativity, both that separated clocks need to be reconciled with one another and of the way to accomplish such a reconciliation. The reconciliation of systems which at first glance seem not to need to be reconciled—the flow of time in two different places and the fingers on Edward's two hands—is a problem Einstein recognized in his science. His son fails to understand the problem, and the play will re-present the problem in terms of Einstein's failure to understand the choices made by the physicists who remained behind in Germany.

PROJECTING TIME

Both relativity and Einstein's trick in "counting" Edward's fingers call relationships into question (relationships between space and time or between naming and counting), and similarly the structure of *The Einstein Project* calls the flow of time into question. Throughout the play, scenes shift abruptly across time and out of the usual temporal sequence. The opening scene on a boat, presumably in the years before the First World War, is followed immediately by four German scientists facing an American firing squad in May, 1945 (17). The next scene is in August, but it is followed by 1907:

[In August, 1945] *Heisenberg and von Laue look at Gerlach. He is silent. 1907. Von Laue crosses to a patent office in Berne, Switzerland. Einstein is sitting at his desk in the patent office.* (21)

Although play's stage directions usually indicate the time in which each scene is set, similar indications rarely appear in the play's dialogue. Instead, memory directs the flow of events (as when von Laue, thinking of Einstein, crosses the stage into his memory of meeting the man nearly forty years earlier). Another major, though often misleading, signal of the play's events' temporal locus is in the included newsreel sections. The first of these reports that an eclipse provided evidence for relativity, reports that Einstein played croquet with the Queen Mother of Belgium, and shows Einstein "entertaining fellow physicists by taking his vest off without removing his coat" (23). The newsreel representation of the trick "*shifts into reality*" and "*Einstein finishes the trick*" before his fellows in 1913, years before the eclipse that was reported at the start of the newsreel (23). By drawing on the bi-weekly newsreels of British Pathe, *The Einstein Project* suggests that the events of each of its newsreels are reasonably contemporary with one another. And by seamlessly transitioning from the report on Einstein's vest trick to his performance of that trick in a scene set in 1913, *The Einstein Project* places the 1919 eclipse before 1913.¹¹ Even as the newsreels give historical context, they distort the historical sequence. By serving as transitions, the representations given in the newsreels appear to be caused by the scenes preceding them, as well as seemingly causing the events that follow them.

This disruption of causal sequence provokes the chagrin inherent in proclaiming that hindsight is 20/20. All of these newsreels reflect on the

past from a vantage at least a bit in the future, and the play itself is set before an audience whose point of view includes a knowledge of, at least, the implication of physicists (if not an awareness of Einstein's personal involvement) in the Manhattan project, as well as some sense of the import of Einstein's work in revolutionizing modern physics. This retrospective view encourages the question, How did we get here from there? But the play's fragmenting of its Einstein's relationships with his son and colleagues undermines Einstein's authority as a byword for scientific genius. The relocation of the stakes from global politics and nuclear war to personal and familial relationships, in conjunction with the denial of a conventional causal sequence for analysis, denies this Einstein and his audience a sufficiently clear frame of reference by which either to make or to evaluate his choices. He decides, not as the popular image of the great man but rather as a character subject to considerable limitations on his time and knowledge.

Furthermore, as early as the first Pathé newsreel, the play uses the sections to underscore the entertainment use being made of the scientific history. Not only does the newsreel literally suggest Einstein's potential in vaudeville, it also—by fading from that suggestion into the next scene—reminds us that this Einstein is a character in at least two senses of the word: he's playing a role and he's a bit of a clown. This "Einstein" is not a figure in a documentary film clip, however much the play wants to recall such clips. He is a written version of a historical person. And that person was liable to ham it up for the cameras.¹² Several plays, in addition to *The Einstein Project*, are at work on the usefulness of Einstein's public persona and the fame that accrued to him. Each such instance that I am aware of traces back to the idea that Einstein's fame was such that a letter from him to President Roosevelt would be attended to: Leó Szilárd's reason for seeking Einstein out and encouraging him to sign.¹³

Both the humor of comic relief—relating anecdotes and light moments—and the humor of inadvertent (or ostensibly inadvertent) juxtapositions are at work to reduce Einstein. In making him a character, a vaudevillian, he becomes at once more and less approachable: more approachable, because the distancing of his fame is lessened along with this shift in view, but less, because the character to whom one might make this approach is an Einstein who is less than himself, who is an entertainer who is *not* being a famous physicist. This anecdotal Einstein couldn't possibly decide to help the Americans develop and drop a nuclear weapon; he's too busy playing croquet and doing tricks with his vest.

Yet when the play looks away from Einstein it sees the destructive applications of scientific discovery quite clearly. And it is often able to stage these for our entertainment. Early in Act I is a scene set at Farm Hall, the British estate where captured German scientists were held.¹⁴ Werner Heisenberg (of the Heisenberg uncertainty principle), Otto Hahn (who received a Nobel for the discovery of nuclear fission), Max von Laue (an elder statesman of German physics), and Walter Gerlach (the scientist with overall responsibility for much of the Nazi nuclear program) are attempting to come to terms with having been told that the bomb has been dropped. After they have begun to explore the possibility that this is a lie:

HEISENBERG. They know who we are. They want to test our reactions.
 GERLACH. Be quiet, Heisenberg.
 HEISENBERG. Quiet? If I'm quiet, how will they hear me? (*Heisenberg shuts off the radio. Heisenberg turns to the audience.*) That's what this is all about, you know. Entertainment. Some kind of psychological experiment. And we're the mice. (19)

Evocative not only of the Nazi "medical" experiments and of the behaviorists' psychological studies but also of the experimental practices that were part and parcel of the development both of atomic weaponry and of the understanding of theoretical physics, Heisenberg's characterization of himself and his fellow physicists as mice is at work to shift away the possibility of responsibility devolving upon them. A mouse, after all, has little clear effect on the world stage. Furthermore, Heisenberg's association of experiment with "entertainment" undermines any authoritative claim to be made on behalf of the physicists whose laboratory and thought experiments gave rise to the bomb. Just as mice are not agents, so are experiments not substantive: they're all entertainment, just as is the practice of espionage. The whole conversation, Heisenberg indicates, is "all about" the entertainment of their captors.

As entertainment, Heisenberg's response also implicates his audience. The stage direction ("*Heisenberg turns to the audience*") merely underscores the criticism already present in Heisenberg's reference to "entertainment." If the scientists have been put there to entertain their captors, how much more so are they there for the theater audience? This meta-theatrical moment, at work to make this scene into a play within a play, reflects a common, though minority, effort of mid- to late-Cold War

nuclear dramas. Against the prevailing efforts of many Cold War-era nuclear dramas to portray ordinary citizens in a struggle to protect themselves from a nuclear nightmare made possible by physicists, a smaller body of plays were at work to implicate society, articulating the scientists at work in producing the bomb within the workings of mass culture and presenting them being just as subject to those workings as any other person. Similarly, in Heisenberg's direct address to the audience in *The Einstein Project*, the audience members are forcibly associated with the Allied intelligence officers presumed to be toying with these scientists. The fault accruing is for playing games when nuclear weaponry has become a reality, not as much for the German physicists as for their erstwhile colleagues who have produced it.

Heisenberg and his fellow German physicists held in England, less than ten minutes into the play, provide a backwards-looking perspective that connects the war and the bomb with the decisions Einstein makes throughout the play, decisions that are more about people and nations than about scientific inquiry into physical principles. Einstein's decisions are often abrupt, instants of choice forced upon him, as when the audience at his lecture on the tension between fear and intellectual freedom becomes a mob which he allows to drive him out of Germany (though his pause to discuss this departure with his colleagues marks his departure as a genuine decision rather than purely a flight from the mob), but his decisions are also personal rather than scientific. That is, although Einstein tries to present rational explanations that hold the aura of scientific methodology, his process is flawed by his efforts to ascribe objectivity or rationality or even his own standards of judgment to the people around him. He, like Edward, fails to recognize that an incommensurability is at hand. The very transition made by the most effective of contemporary science plays—an enaction of the science in the form of the play—the thing that makes them so *entertaining*, this is a shift that cannot be maintained by the characters within this play. The audience's frame of reference is not available to the characters.¹⁵ Thus the conventions of watching a play accomplish the relationship between frames of reference: what the audience can see and what each character can see are recognizable on the same bases as those by which dramatic irony can be established. And the audience's frame of reference also includes knowledge of the historical Einstein invoked by the presence of his onstage version. But that stage character is left not only to find his own way through the war but also to find or fail to find his own

relativistic understanding of the distance between his point of view and that of his fellow characters.

“GERMANY CAN GO TO HELL!”

Earlier in chronology, but much later in the play, Einstein and Heisenberg struggle to reconcile their responsibilities in the face of war and quantum physics. Their argument begins to be about the new physics on which Heisenberg is working, but the conversational ground quickly shifts under their feet. Einstein’s insistence on order, on calculability and determinism rather than uncertainty and a statistical understanding of the fundamental nature of things, provokes the shift. In stating this position, Einstein insists that “God is tricky, but he’s not mean. He doesn’t play dice with the universe” (32). This God of Einstein is in control of the universe, and his control is the source of order; that being the case, Einstein is reassured that order is out there to be found, which is good for Einstein, as he insists to Heisenberg that one “can’t live without” a source for order (32). Heisenberg has a response. He doesn’t need God or nature to provide order because he has:

HEISENBERG. My friends. My nation. My work.

EINSTEIN. Stick to your friends and your work. They’re excellent friends and it’s good work, even though it’s doomed to end in certain failure. But don’t let that deter you. But the nation. The nation. Leave that alone. All nations are good for is war.

HEISENBERG. I remember the war. I lost friends and relatives.

EINSTEIN. What happens between human beings is actually of very little consequence. (32)

In one brief conversation, Einstein indicts nations for causing wars and yet fails to express a sense of what is wrong with war. For Heisenberg, war is bad because it kills people. Put in Einstein’s terms, war removes one of Heisenberg’s sources for order. Yet for Einstein people are “of very little consequence.” Why, then, does he so detest war?

Apparently, it is because the organizing principle of wars is fear. Immediately following the adversarial conclusion of this conversation with Heisenberg, Einstein attempts to give a lecture on fear, “a topic that may determine the future of modern science” (34). He tries to explain that fear

led “primitive man” to imagine a God “who protects, disposes, rewards, and punishes,” while a scientist’s God would be very different, as freedom itself is what drives and encourages a scientist’s work (34). His argument, insofar as it is clear, associates all nationalism with fear. And he very specifically indicts Germany for its preference of fear over freedom, concluding, “I’m ashamed to be a German! Germany can go to hell!” (34) His inability to convince his German audience to join him in despising Germany leads directly to his decision to leave. Dramatically stopping only to get into a fight with his friends before the curtain falls on Act I and on his life in Germany, Einstein appears to go directly to American citizenship as the second act begins with his oath.

Where Heisenberg has his friends, nation, and work, Einstein had disavowed nations and his friends, the first in his conversation with Heisenberg and the latter in his acrimonious parting. Calling his friends out for their work with the German government, he suggests they agree with Nazi politics. In response, Otto Hahn urgently cautions Einstein that he is “on the edge of the unforgivable” (36). Einstein ignores his friends’ warning and compounds his insults by delivering a Nazi salute (36). Although he is so clearly presented with options for maintaining relationships, Einstein appears determined to destroy them thoroughly. All he wants, it seems, is his work. And just as he will not let his son’s importunate arrival divert him from his efforts to bend the German people to renounce “Prussian discipline” (which renunciation would gain Einstein the semblance of a freedom within which he could pursue his work), so he will not let his friends’ request that he stay and help them to maintain and restore scientific practice in Germany in the face of the hostility of the Reich detain him (34). They even ask him with whom he will be able to talk in America, as nobody there really speaks physics at their level.¹⁶ He quite calmly replies that he will talk to himself, then (35). These men who are Heisenberg’s “excellent friends” are rejected by Einstein.

When Einstein makes this decision, he sets himself up to assume responsibility for the American bomb project. The pacifist, who would rather “take no action. Absolutely no action,” will have one more conversation with Heisenberg, in which he attempts to discover whether Heisenberg and the Germans are working on their own bomb (36, 46–48). Heisenberg repeatedly attempts to reassure Einstein that all of the work in Germany that is remotely related to nuclear fission is directed toward nuclear power rather than nuclear weaponry.¹⁷ But Einstein cannot believe him, remembering how Heisenberg had found order in his nation. Heisenberg’s

stability now rests solely on his friends and his work, as far as Einstein is concerned, and the friendship is no longer sufficient to support trust when it comes to Heisenberg's statements about his work, which, he says, is "Energy producing fission. I would never build a bomb" (48). When Heisenberg affirms that their friendship should be a basis for trust, Einstein retorts, "That's crazy" (48). Having alienated himself from his own friends, Einstein cannot trust Heisenberg, despite his ongoing commitment to just what Einstein had told him to hold onto: his friends and his work. Einstein's determined anti-nationalism—especially his antagonism toward Germany—places him at a distance from his colleagues. He becomes an isolated system which is incommensurable with theirs. And, not being as adept in understanding "the human factor" as he is in understanding physics, Einstein is left with a decision: to believe Heisenberg, or not to.

Einstein chooses to believe that Heisenberg is too human not to be working on the bomb. Out of his own fear that the Nazis have found a way to pressure Heisenberg into lying to him, and immediately following their conversation, Einstein writes to Roosevelt, a letter even briefer and more urgent than either historical version of the letter. He closes, "Can't you see what's all around you? Quickly! Build the bomb! Before they do. Yes! Build it. (*Pause.*) Yours truly, Albert Einstein" (49). This Einstein acts just as his historical counterpart feared: the knowledge of the possibility of nuclear weapons becomes an urgent race toward having them for oneself. And the quick succession of images flickering through the few remaining scenes in the play shows the second half of that too-hasty sequence, from having the bomb to dropping it. Einstein's advice that the USA undertake the bomb project (like a computerized player of war games) becomes, nearly immediately in the play, the military execution of dropping it.

WHAT MAN CAN DESTROY

Where Einstein signed a letter precipitating the Manhattan Project, his longtime friend Fritz Haber was able to turn his Nobel-prizewinning work on plant fertilizers to war work: poison gas.¹⁸ *The Einstein Project's* consideration of its protagonist's moral state proceeds in large part through a comparison with Haber. Halfway through the first act, the action abruptly shifts to the home of Haber and his wife, Clara Immerwahr, also a chemist. Haber is excited that the success of his gas experiment has gained him his commission as a captain. Shortly thereafter, following a typically abrupt

shift into and out of a Pathé News section, they resume their conversation, now at a club. Einstein joins them.

- EINSTEIN. I have a theory. A man can destroy what he understands. Now, Fritz understands the lungs. So he can destroy the lungs.
- HABER. Oh. And what do you understand, Albert?
- EINSTEIN. The universe.
[...].
- CLARA. Work this into your theory, Albert. You can also destroy what you don't understand. (29)

Einstein is quite straightforward about the destructive capacity of scientific discovery, and he holds himself responsible for the material universe, but Clara's parting remark indicts him for his relational failures. Again and again, Einstein fails to understand his friends, his work, and the countries in which he resides.

Clara considers gas a barbarous weapon, and indicts Haber, saying, "when a scientist becomes a barbarian, and puts his knowledge into the hands of murderers, he no longer belongs in the civilized world. You will be a war criminal" (28). She expels him from citizenship just as firmly as he ensconces himself in it:

- HABER. [...]. In peacetime, a scientist belongs to the world. In war, he belongs to his country.
- EINSTEIN. A scientist belongs to no one.
- HABER. You're so smug, Albert. You think that you're morally superior to me, because I create weapons while you think about gravity and the stars. If my invention gives us a decisive military advantage, the lives of thousands of German soldiers will be saved. Your pacifist position is the immoral one. Where is your love for Germany?
- EINSTEIN. There is no Germany! There are no countries! There is only the one world and the God who made it! The rest are details. (29)

Details, indeed. The interpersonal drama potentiated by so many German and Jewish physicists who had worked so closely together when Europe was not at war has repeatedly captured the attention of science

playwrights. D'Andrea and Klein's Einstein excuses himself in advance for his work against Germany: "There is only one world," he says. Yet the pacifism to which Haber points in contrast to Haber's own patriotism is not the clearest opposition. While this conversation shows Einstein's pacifism as the opposition to Haber's war work, the larger picture—the picture in which *The Einstein Project* frames this conversation—is an opposition between the scientific community and the nation. What will ultimately break Haber in this play—we see him, near death, in a wheelchair—is that he chose the wrong community: Germany would ultimately disown him while his fellow scientists stand around him.

Another iteration of this opposition between the nation and the community of scientists appears inside Farm Hall. Here von Laue and Heisenberg argue with Gerlach about Otto Hahn's response to the dropping of the bomb.¹⁹ *The Einstein Project* represents Gerlach as considerably more callous than is historically necessary, as we shall see *Copenhagen* to do as well.²⁰ Yet, as the titular director of the German fission project, Gerlach becomes the antagonist to those who regret their contribution to the project (such as Hahn) and those who would claim to have subverted it (a central claim of Heisenberg as represented in *Copenhagen*). Here Gerlach clearly affiliates himself with the Nazis, in contrast to the ambiguity the historical person achieved in his political expression.

- GERLACH. [...] I have no sympathy for Professor Hahn. He split the atom and now he enjoys the luxury of feeling guilty. What would the Nazis call that? Decadence.
- HEISENBERG. And what would *you* call it? (*Pause.*)
- GERLACH. Decadence.
- GERLACH. [...].
- GERLACH. When Otto split the atom, at that moment we were ahead. We could have built a bomb. If we had, we wouldn't be in this room now. *You*...are the one who stopped us. You don't fool me for a minute, Heisenberg, with your sanctimonious poses and your lies about technology. You were a coward. You still are. (37)

Hearing the indictment come from Gerlach, we take Heisenberg's actions as bravery rather than cowardice and Hahn's feelings of guilt for making and publishing a seminal discovery on the way to the atom bomb as neither luxury nor decadence. Yet Gerlach's response is only a patriotic

variation on Einstein, who, in his departure, had already condemned Hahn as a weakling and Heisenberg as a poseur.

SAILING INTO THE STORM

Throughout *The Einstein Project*, Einstein sometimes tries and usually fails to connect to the people around him. This flawed human being—a father who abandoned his son, a scientist who no longer trusted his colleagues, and a man with uneasy relationships to the nations in which he sometimes was at home—appears in the play as flawed especially in his attempts to treat people as calculable. He treats his situation as if a determination of the right choice could be made. But he is in the midst of a decision, of a series of decisions, and he has neither enough information nor enough time to understand his lack of information. The speed with which events are enjambed in the closing sequence of the play reflects the hastiness Einstein displayed in his interactions throughout the play, and such speed is taken up in the sailboat to which Einstein returns in the final scene. The action of the play, framed by the two scenes of Edward and Einstein on the sailboat, and informed by the retrospective considerations of the German physicists held at Farm Hall, is arranged as a procession toward the bombings of Hiroshima and Nagasaki, presenting each of Einstein's decisions as another step toward precisely the sort of nationalistic violence against which he had warned Fritz Haber.

In the end, Einstein's "project" will appear to have been his "sons": Edward and Heisenberg. He often worked against them, much as he destroyed everything else, but he had supported each of them enough that they can support him in the end. Shortly before the play's last scene, Einstein holds forth on his philosophy of science, that it is the scientist's job to try to see the universe "from God's point of view," which means the experimental practices of science would simply provide support for theories (51). When relativity was confirmed by eclipse observations, "we could see that my theory was right! [...]. But it wasn't *my* theory. It's a law that belongs ... to nature. It just is. [...]. What happened that day is that theory turned into fact. (*Pause.*) It did. So help me God" (51). Yet even as Einstein disavows any personal responsibility for effecting the state of things, the bomb falls on Hiroshima: "*The first atomic bomb detonates. This is not a single event. It is a sequence of three parts. The first two parts take place in silence*" (51). The bomb's explosion begins as an eclipse; it begins as confirmation of Einstein's theory of relativity, or, rather, as human

observation working on Einstein's theory to make it into fact. Einstein's consideration that relativity wasn't even "*his* theory," though it is an effort at humility, reinscribes the credit it works to shift, suggesting that the universe accommodated itself to his theory. And the play's representation of the atomic bomb begins in that moment of Einstein's power, even as the Manhattan project began in Einstein's brief urging to Roosevelt, "Quickly! Build the bomb! Before they do. Yes! Build it" (49).

The explosion continues, and, "*In the second part, a Japanese woman appears*" and serves Einstein in a traditional tea ceremony (51). Again, though Einstein tries to dissociate himself from the rapid sequence of events, effacing his role in the production of the bomb, the play brings him right back into it. As the Japanese woman reveals herself as Clara Immerwahr, who earlier had recognized poison gas as a weapon beyond the pale of civilization, the final part of the explosion begins. No sooner does Einstein recognize Clara and tell her, "I understand," than she is swept away by the blast (51).

[...]. *The third part is the blast itself. The sound is sudden, multilayered, ongoing and frightening. The entire cast is buffeted around the stage by the shock wave. Visually, chaos reigns. As the blast recedes, the stage empties, except for the scientists, who gather around the radio.* (51)

The scientists are again in Farm Hall, listening to the report of the bombing. This is what they have been discussing nearly from the beginning of the play. The scarcely-imaginable (that Einstein would contribute to such nationalized destruction) is confirmed for them, and as they listen Einstein reckons himself in need of forgiveness, which he receives from his former colleagues.

Then, in the final scene, he is back on the boat with Edward, reprising the opening scene. In that earlier scene, the speed to which the boat is taken by the wind was analogized to the speed with which he and Edward were able to think. Edward was able, in surrendering to the storm, to figure out the sequence of prime numbers which had stumped him moments before. He was, as Einstein suggests "one with the elements" (17). This unity came about in speed: the very thing which had struck Edward as dangerous (the power of the storm, its speed) is what holds him up as he leans out into the wind. This speed both gave Edward the clarity of mind to keep up with his father in their mathematical game and established for Einstein his relationship to the world: "We're so small. So insignificant.

The thought makes me happy,” he had told Edward (17). And when Einstein is small and insignificant, when he was in touch with the natural world, he was able to be in concordance with his son.

This moment returns in the play’s closing scene. Again, a storm closes in on the two sailors. But the sailboat, which the audience also knows now as Einstein’s laboratory, where he has told von Laue he conducts his thought experiments, leads Einstein and his son toward a very different insignificance (22). This time the storm into which they are sailing is the firestorm after the bomb has detonated. And Edward is straitjacketed. Einstein cries out to Edward for help and confesses, “I have neglected you. You are my true son. [...]. I’m afraid, Edward” (52). But Edward has learned his lessons well. He has exceeded his father’s vest trick, having learned to escape his straightjacket, and he is confident that “We can trust the storm,” just as Einstein had been confident that the ordinary storm into which they sailed as the play opened was trustworthy (52).

Meanwhile Heisenberg, who had supplanted Edward, looks on. The play having shown Heisenberg’s worst fears to have been correct—he had refused to work on the bomb, citing his knowledge that “Human skin burns when you heat it to ten thousand degrees” (48)—now gives him the prophetic voice of a pessimistic chorus, pronouncing it “too late” to stop the storm (52). Einstein is out of time, and his advice to the president and to the Manhattan project has been taken up and taken out of his control. Where Heisenberg had seen that research into the bomb would lead fairly directly toward an unconscionable use of the bomb, Einstein had dissociated himself and his science too often from consequences to calculate those consequences. The science had been in his control—he was the only one he could talk to—but he had given it to a nation.

Not knowing whom to trust, not knowing how to consider people other than as children, like the son he tried to shape into a mathematical prodigy, or as geopolitical pawns, like Heisenberg, whom Einstein understands as a possible Nazi lever to control himself, like Haber, who had turned his biochemistry toward war work, or like any of his friends who remained behind in Germany when he left (“Once I’m gone, you can all practice pure, Aryan physics” [36]), Einstein has all along been attempting to calculate the incalculable. Making decisions right and left, Einstein abruptly plowed through the events represented in the play as if he could do nothing else. The clarity with which his decision to distrust Heisenberg contributes to his encouragement of the Manhattan project merely presents the automated way in which Einstein saw the world. Just as he showed

Edward that the answers to the sequence of prime numbers would come more clearly if he stopped thinking about it, so the tide of wartime development brought the weaponry without much thought by Einstein beyond his initial decision. Yet the play as a whole, mixing together so many moments and decisions from Einstein's life like the mixtures created in the Pathé newsreels, breaks down the parts and pieces of Einstein's decision to advocate the bomb even more than it partitions the moment of the bomb's explosion into several stages. Stretching a moment of explosion and the interruption of a calculation into a sequence of events and a set of experiences, the fragmentation and assemblage of these parts in *The Einstein Project* undoes its title character's understanding of the universe in favor of its demonstration that "You can also destroy what you don't understand" (29).

NOTES

1. Heinar Kipphardt's *In the Matter of J. Robert Oppenheimer* is of particular note as a nearly factual play, while numerous examples of silliness exist, including Terry Johnson's *Insignificance*, in which "The Actress" (Marilyn Monroe) meets up with "The Professor" (Einstein) the evening before he fails to appear before the House Committee for Un-American Activities, and Steve Martin's *Picasso at the Lapin Agile*, in which Einstein and Picasso compete for a place in history—and to impress the women they encounter.
2. Historically, there were in addition several other German physicists detained along with these four.
3. British Pathe (named for the founder, Charles Pathe) "were established in London in 1902, and by 1910 were producing their famous bi-weekly newsreel the Pathe Gazette" (British Pathe).
4. In *The Einstein Project*, contrary to historical fact, Einstein writes the letter himself, not just signing off on Szilárd's prose.
5. It should be noted that this letter, as well as a shorter version also signed by Einstein, was actually written by Leó Szilárd. See Isaacson 473–474. Subsequent quotations from Einstein's letter to Roosevelt come from the copy of the (longer) letter posted on Argonne National Laboratory's website.
6. Einstein mentions, specifically, that Carl Friedrich von Weizsäcker's father is the German Under-Secretary of State, implying the sort of access and prioritization Einstein was expecting his proposed American point person to accomplish.

7. D'Andrea and Klein name their character "Edward," but Einstein's actual son was "Eduard," called Tete by his parents. I will use "Eduard" when referring to the historical individual and "Edward" in reference to the character.

The terms of Einstein's separation from Mileva Marić, including financial provisions for Marić and their two sons, were formalized by a legal contract. Yet Einstein's relationship with his sons was sincere, though by turns a fraught or absentminded love (Isaacson 185–187 and *passim*).

8. Similarly, in the play Edward's "madness" requires constant supervision by 1922 (31). This, again, suggests that the character Edward is closer to Heisenberg's age than to Eduard's actual age.
9. Although the play underscores the connections between its character and the historical figure (indeed, between all of its characters and their historical counterparts), treating the play's characters *as characters* is also essential; thus, throughout the remainder of this chapter, unless otherwise noted, my references are to the character in the play rather than to the historical person.
10. That Einstein's naming of the fingers on Edward's 'other hand' begins with 'ten' is another point of access to solving the problem Einstein sets up. The problem with which he is presenting Edward is not insoluble. Yet the boy's ongoing frustration with this problem, and the additional energy generated by the suggestion that his own hands are wrong, presents Einstein's lack of understanding of his son with much more clarity than his desire to connect with the boy.
11. Furthermore, the historical Einstein's friendship with the royal family of Belgium began in the late 1920s (see Isaacson 414–417).
12. This was historically the case as well. As Isaacson notes, "Einstein performed. He gave interviews readily, peppered them with delightful aphorisms, and knew exactly what made for a good story" (269).
13. Even Friedrich Dürrenmatt's *The Physicists* has its Einstein—a German physicist undercover in an asylum, pretending to believe himself Einstein—reflecting on his power to influence military research.
14. Jeremy Bernstein, in the preface to his presentation of the declassified transcripts of conversations held at Farm Hall, remarks that "it became clear to me that they constitute a dramatic encounter analogous to a stage play" (ix). The object of his annotations is to make the drama and the history accessible to an audience not well versed in physics. This is not unlike the efforts to which many science dramatists go, to explain the science so necessary to their plays.
15. See Chap. 1 for further discussion of Kirsten Shepherd-Barr's categorizing concept of "enaction" of science in drama.

16. This is the judgment implied by their conversation. Later in the play, when the responsibility for the American bomb project lands squarely on Einstein, the absence of other physicists of note in America—in this play—will reinforce Einstein's responsibility.
17. See Chap. 5 for an analysis of this position in terms of Michael Frayn's *Copenhagen*. D'Andrea and Klein's presentation consistently treats Heisenberg's denial as truthful.
18. The Haber process was initially directed toward agricultural ends: developing ammonia from nitrogen and thus increasing the availability of nitrates for fertilizers. It was for this application that the Nobel prize committee would grant him the 1918 chemistry prize (Feldman 209). However, the production of various poison gases during the First World War followed similar processes, under Haber's enthusiastic direction (Feldman 228–231).
19. Historically, Samuel Goudsmit reportedly included both von Laue and Hahn in the group to be detained for reasons having more to do with politics than science. That is, he wanted these two to be at the forefront of reestablishing scientific practice in Germany after the war. Both were respected senior physicists and von Laue had been vocal in his opposition to Naziism (Cassidy, "Introduction" xvii). Yet the chief determinant of which physicists were to be detained was ostensibly to cut off German research into fission, making the detention of von Laue (who had had no participation in research during the war) and Hahn (whose role during the war was minor, despite his participation in the discovery of fission) inexplicable to the detainees at the time (see Cassidy, "Introduction" xvi–xviii).
20. Many of Gerlach's fellow German physicists believed him to be more invested in the survival of German physics than in the success of the Nazi's undertakings. One colleague recorded Gerlach having expressed his intention not "to make any war physics nor to help the Nazis in all their war efforts. I just want to help physics and our physicists. We must keep whatever we have, let all our good physicists continue their work [...] and save whatever you can, both men and material, into the time after the defeat. This will be my task, my work and my duty and nothing else" (Rosbaud, qtd. in Powers 325).

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What You Don't Know Is Going to Hurt Like Hell: Knowledge, Power, and the Faustian Bargain

Abstract This chapter analyzes two small academic communities represented in Penny Penniston's *Now Then Again* (a few physicists at Fermilab) and in Tom Stoppard's *Arcadia* (literary, cultural, and mathematical scholars at Sidley House in England). I find in these plays the argument that responsibility especially obtains in the face of the possibility of total knowledge, that although partial ignorance is a constituent element of the decision this is not a mandate to preserve ignorance at all costs, and thus that frame of reference (as a limit on what knowledge one can access) makes possible the sort of limited-knowledge human action that can sometimes be described as just.

Keywords Epistemology • Responsibility • Romance

In this chapter I turn to an exploration of the dynamics of knowledge and power for private, rather than governmental, agents. Many of the characters of Tom Stoppard's *Arcadia* and Penny Penniston's *Now Then Again* are scholars evocative of the scholarly Faust and his deal with the devil. These plays' characters pursue knowledge in contexts in which their efforts alter the conditions producing the possibility of their knowing anything. More complex, the plays enact temporal structures undermining our

typical induction from cause and effect. The sciences primarily at hand in these plays are thermodynamics and chaos (in *Arcadia*) and quantum physics (in *Now Then Again*). As well as enacting ideas from these sciences in their structures, both plays make thematic use of the sciences with which they deal. *Now Then Again* takes up a physical interpretation of quantum mechanics and represents that interpretation's suggestion of elements that move forward and backward through time by presenting scenes sequenced first forward (beginning with a scene set "NOW" and leading toward a scene set "NOW + 13 WEEKS") and then backward (through the same thirteen weeks' worth of scenes concluding with "NOW"). In *Arcadia* two separate (and forward moving) temporal lines intermingle, with small causes producing significant effects, mixing together the forward temporal impetus built into thermodynamics and the disproportion of cause-and-effect analyzed by chaos. Both these alternate temporal structures and the romance plots permeating the plays interrupt and distort the characters' access to and interpretation of the "facts" they encounter. Both plays' engagements with science are queries about causality and, in particular, the effects of knowledge (or presumed knowledge) on events and decisions; alterations in the represented geometry of space-time affect both the range of possible decisions by the characters and the assessment of those decisions and their effects within the context of these plays.

Both plays frustrate the naïve assumption that knowledge is "out there" to be found, if only one is clever or skilled or lucky enough; few of these characters regularly appear to be on track toward understanding what is happening (or what has happened). Nonetheless, both *Arcadia* and *Now Then Again* hold their characters responsible for the decisions they make in these states of incomplete knowledge as well as for the research practices they employ to obtain their "facts." In both plays characters regularly misinterpret facts they do possess and even take as factual things which are not. These pseudo-facts stand in the place of knowledge and interrupt the field of knowledge itself. When the plays' characters use what they believe to be true as a basis for their calculations, they can appear to have a complete basis for determining exactly what should be done. Looking only at their conclusions, their decisions can take on the appearance of determinations. The practices that lead these characters to assume the truth of their pseudo-facts are then the source of the decisions for which they are most responsible: lacking complete knowledge with which to discover which of their assumptions are true and which are not, the characters decide to embark on calculations. The distorted field of knowledge presumed by the

characters of *Arcadia* and *Now Then Again* entangles with the structural disruptions of space-time in each play to affect both the situations with which the characters are faced and the decisions they make in response. In their apparent respect for the obligation to understand the elements relevant to their decisions, the “wrong knowledge” held or obtained by many of the characters in these plays undermines the decision-making processes they undertake, comparable to the interruption “between one’s knowledge and the decision” that Derrida invokes as a condition for making an ethical decision (“Ethics” 298). This is not to say that “wrong knowledge” is readily identifiable with such an interruption; as Derrida insists, the gap that produces undecidability is not a lack of knowledge. Obviously, knowing something that is not factual bears more than a little similarity with not knowing at all. What I am interested in, however, is the dissimilarity between wrong knowledge and no knowledge: the former can effectively bring calculation to an end before a determination has been achieved.

ARCADIA AS REHEATED CUP OF COFFEE

A sustained riff on time’s peculiar monodirectionality, Tom Stoppard’s 1993 *Arcadia* opens on a room Stoppard’s stage directions minutely describe. The room is in Sidley Park, the Coverly family home, and the time is 1809 (1). This setting, used for scenes 1, 3, and 6, is transformed very little to serve for the scenes occurring in the same room in the present time (scenes 2, 4, and 5), and is also the setting for the final scene: an amalgamation of 1812 and the present. As the second scene’s initial stage directions emphasize:

The lights come up on the same room, on the same sort of morning, in the present day, as is instantly clear from the appearance of HANNAH JARVIS; and from nothing else.

Something needs to be said about this. (15)

What Stoppard goes on to say is perplexing. While “*The general appearance of the room should offend neither period,*” Stoppard indicates that “*there is no absolute need to remove the evidence of one period to make way for the other*” and “*books, etc., used in both periods should exist in both old and new versions*” (15, original *emphasis*). To resolve the obvious problem—for example, that a landscape sketch book appearing in the first scene (as a new book) manifests in the second scene (as itself nearly two hundred years older) and is

by direction on stage in both versions from at least the second scene onwards—Stoppard finally directs that anachronistic objects be “*simply deemed to have become invisible*” (15). The unruly passages of time in the play not only need “something said” about them but also need a bit of heterodox problem solving.

The objects “deemed invisible” are just part of what the characters on the stage cannot know, producing a somewhat peculiar frame of reference for each character in order to limit the anachronisms presented to each character. At the same time, eliminating the modern characters’ anachronistic access to the objects of the past materializes the inaccessibility of the past. The very material past—the objects of 1809—is literally present but nonetheless unavailable because it must be “deemed invisible.” This presents a particular difficulty for the modern characters, three of whom are academics whose research hinges upon their presumed access to the past. All three characters tend to operate as though they have simply to theorize vigorously enough or to work exhaustively enough to arrive at an accurate interpretation of the past.¹ But just as there is more on the stage than they are allowed to know, there is more in their areas of study than they are allowed to know.

I read *Arcadia* as demonstrating that responsibility obtains even in the face of the wrongly perceived possibility of total knowledge. The characters of *Arcadia* are not exonerated either because they believe they can know or because they are wrong in that belief. The play’s reversion from past to present not only mocks the modern characters’ attempts to discover the past but also holds them responsible for their failure by structurally enacting aspects of thermodynamics and chaos. The basis for the wrong knowledge they cling to—the frame of reference within which they are confined—also establishes a context for the interruption of determination within which a decision can be made. *Arcadia*’s deployment of these notoriously difficult sciences—thermodynamics and chaos—makes possible the sort of limited-knowledge human action that can sometimes be described as just.

As I have begun to explain, the temporal difficulties of the play appear in its staging but also in its incorporation of two areas of physics: thermodynamics and mathematical chaos are the principle models for the play’s engagement with its time frames. Thermodynamics, the study of heat, came into its own in the nineteenth century.² One of the principle laws associated with the field is that entropy—disorder—increases. In *Arcadia* this tendency toward disorder is discursively represented most prominently

in two figures: a bowl of pudding and a cup of tea. At several moments in the play the characters invoke the image of a spoonful of jam being stirred into a bowl of pudding, observing that stirring will never make the jam and pudding less mixed together:

THOMASINA. [...] You cannot stir things apart.
 SEPTIMUS. No more you can, time must needs run backward, and since it will not, we must stir our way onward, mixing as we go. (5)

The general orderliness of the spoonful of jam, discrete from the bowlful of pudding, is replaced by a messy mix which will not be restored to order. To “unmix” the jam from the pudding would require time to “run backward.” As Thomasina’s breakfast will become a homogeneous mixture of pudding-and-jam, so will a cup of hot tea become cool, Valentine tells Hannah: “Your tea gets cold by itself, it doesn’t get hot by itself. [...] Heat goes to cold. It’s a one-way street” (78). Both illustrations of entropy are overtly deployed in the play to underscore “time’s arrow”: the time “line” is not a line one can move back and forth on; it is an arrow along which events can move in only one direction. It is the arrow along which events usually flow in a play, as in life.

But *Arcadia*’s treatment of thermodynamics is complicated by the play’s use of a newer field: chaos. At terrible risk of over-simplifying: chaos is the study of complicated results arising from simple causes. One common example—the butterfly effect—has the flapping of a butterfly’s wings producing a storm halfway around the world at a later time. Chaos imagines motion. Graphical representations loom large in chaos science, assisting the exploration of the field across wide disciplinary ranges (including weather, information science, and economics); many of the graphs are pretty, aside from their representative signification. For a simple example, consider Cantor’s dust (Fig. 4.1):

You start with a line, and chop out the middle third. This leaves two lines. Taking the end result of the function (in this case, the result of



Fig. 4.1 Cantor’s dust

erasing the middle), start the function again: chop out the middle third of each remaining line. Reiterate the process interminably.³ For a chaotic system, the more iterations one undertakes, the more intricate the pattern will be. *Arcadia*'s operations on time's arrow themselves proceed as chaotic iterations, producing large effects from small variations.

In *Arcadia*'s contemporary plot, Hannah Jarvis, author of a new biography of Byron's lover, Caroline Lamb, visits Sidley Park in the present day. She comes to research "the Sidley hermit" for her next book, and she discovers a notebook written by Thomasina Coverley, in which Thomasina had calculated and graphed an iterated algorithm (25, 43). As Valentine Coverly observes, the technique Thomasina is using is the same one Valentine is using in his efforts to produce a model for the population of grouse in the environs of Sidley Park. But, Valentine says, the technique "hasn't been around for much longer than, well, call it twenty years" (44). This may seem at first a striking anachronism, but Valentine's extended elaboration, serving as the play's chief explanation of chaos theory, makes clear that there is some significant difference between their processes.

Thomasina "started with an equation and turned it into a graph" while Valentine has "a graph – real data – and [is] trying to find the equation which would give you the graph if you used it the way she's used hers" (45). Valentine considers it the difference between a mathematics exercise, tedious in the days before computers, and a real-world application. But he has mistaken Thomasina's intention. She was responding to her mathematics lessons in which the exercises she was set describe, as she puts it, "only the shapes of manufacture" and not those of nature (37). Thomasina considers equations as if they could be formulae for the production of nature ("Armed [with only classical mathematics] God could only make a cabinet" but could not make flowers [37]), and she wants, like Valentine, a different problem set; she wants to start from nature and find the formula that would describe it. As Valentine rhapsodizes, "The unpredictable and the predetermined unfold together to make everything the way it is. It's how nature creates itself, on every scale, the snowflake and the snowstorm. [...]. Each drip sets up the conditions for the next, the smallest variation blows prediction apart [...]. The future is disorder" (47, 48). For Valentine, chaos is new, powerful, and amazing. The minute unpredictability of chaotic systems, the endurance of that unpredictability, and the utility of chaos in describing natural phenomena are what make the present "the best possible time to be alive" (48).

Valentine's description also speaks to the chief difficulty Stoppard has given Valentine and his colleagues: "the unpredictable and the predetermined unfold *together*" (*emphasis added*). To Hannah Jarvis and Bernard Nightingale, pursuing research in connection with the early-nineteenth-century history of the house, their subject is utterly predetermined: the past would seem to have already happened. But the play shows that past unfolding together in syncopation with their researches, making the past appear mutable. One example is the apparently solid data Valentine is using for his grouse calculations: the house's game books. After we see Valentine's celebration of centuries of hard data, a nineteenth century scene reveals Thomasina's brother's protestation that Byron had stolen the credit for shooting a hare, showing that at least in some regards, the game books are not factual (79). This error in the game books also renders Hannah's and Bernard's reasonings suspect, as Byron's presence at Sidley becomes a matter of fact for them based largely on the evidence of his appearances in the game books. The erroneous basis for deciding that Byron was at Sidley Park suggests the possibility of other, greater, errors. And *Arcadia*'s audience is left juggling several incompatible stories of 1809.

The details of the Regency story that seem reasonably undisputed are that Septimus Hodge, employed as Thomasina Coverly's tutor, has invited his friend Lord Byron to stay, has been involved in an affair with Lady Croom, has been seduced by Mrs. Chater, and is contemplating writing another unfavorable review of Mr. Chater's poetry. At the same time, Lady Croom's brother is also carrying on an affair with Mrs. Chater, and a landscape architect is proposing a large-scale renovation of the grounds. These plans include a hermitage, and Thomasina, for the amusement of herself and Septimus, adds a drawing of a hermit to Noakes' landscape sketch book.

In the present day, Hannah will mistake that drawing as "The only known likeness of the Sidley hermit. [...]. Drawn in by a later hand, of course" (25). Her errors about the hermit seem pale in comparison with the sweeping, self-aggrandizing, mistaken deductions Bernard Nightingale draws in his pursuit of a connection between Ezra Chater and Byron. In both cases, a relatively small initial error is compounded both through the modern characters' developing work and through further revelations in the scenes set in 1809. From the play's second scene (the beginning of the contemporary story), the audience sees the modern characters drawing conclusions contrary to the past already revealed in the first scene. But the

differences between the past itself and the present perception of that past are more than simple contradictions. There are also replications, as *Arcadia* works its way through so many iterations of Septimus' role in Sidley Park: complicating each apparent fact or motive with elaborations as well as inaccurate presumptions, replicating elements of his 1809 situation both in 1812 and in the modern characters' situation.⁴ In these reworkings, the play calls knowledge itself into question.

"KNOWING" THE "FACTS"

The play opens on a question from Thomasina to her tutor: "Septimus, what is carnal embrace?" (1) Thus *Arcadia* flirts with a romantic comedy's form in that Thomasina's query provides an opening for an inappropriate romance to develop between the 13-year-old and her 22-year-old tutor. Septimus replies that the phrase means "the practice of throwing one's arms around a side of beef" (1). Captain Bryce will later assert that a tutor's "duty [is] to keep [the pupil] in ignorance," and Septimus' misinformation campaign will quickly be entangled with a more accurate definition of the phrase (11). And Septimus will face some unpleasant consequences both for providing Thomasina with this inaccurate definition and for failing to provide her with an accurate one. Their discussion of the definition(s) of "carnal embrace" is based both on Thomasina's ignorance and on Septimus' reliance on simple incompleteness of knowledge. That is, Septimus provides a comically incomplete (as well as absurdly inaccurate) definition of "carnal embrace." When Thomasina discovers this definition's inability to cover a later (more accurate) use of the phrase, Septimus protests, "I never said my definition was complete" (3). But, throughout the play, especially in the scenes set in the twentieth century, Stoppard reveals the extent to which the questions we ask and the answers we look for determine what sorts of answers we will find.

Various characters consider facts as socially constructed in the play. As Lady Croom insists, "Mr Chater, you are a welcome guest at Sidley Park but while you are one, *The Castle of Otranto* was written by whomsoever I say it was, otherwise what is the point of being a guest or having one?" (13) Dialogue itself, then, is for creating or enforcing "facts" rather than for conveying them. Thomasina, at the scene's closing, reports that Mrs. Chater asked her to deliver to Septimus a note "with the utmost safety, urgency and discretion" because it was "of scant importance" (14). Although Thomasina queries the soundness of this conclusion, in this play

the relation of care and importance nonetheless takes on precisely the inversion Mrs. Chater accidentally suggests: it is the trivial which should be attended with care (14).

These trivia dominate and obsess the three modern scholars: Bernard has made his way to Sidley Park to investigate Ezra Chater's connection to the place; Hannah is using the Sidley hermit as her "peg for the nervous breakdown of the Romantic Imagination" (25); and Valentine is taking advantage of "The game books. [His] true inheritance. Two hundred years of real data on a plate" to generate a formula for grouse, because that's what the books give him data for (46).⁵ But Valentine, the mathematician, wants to ensure trivia are kept in their proper place.

VALENTINE. (*Casually*) Well, it's all trivial anyway.

BERNARD. What is?

VALENTINE. Who wrote what when ...

[...].

VALENTINE. The questions you're asking don't matter, you see. It's like arguing who got there first with the calculus. The English say Newton, the Germans say Leibnitz. But it doesn't *matter*. Personalities. What matters is the calculus. Scientific progress. Knowledge. (60–61)

Underlying Valentine's interventions is inter-disciplinary combat: Bernard's argument depends in large part on "Who wrote what when" and has as its primary object (aside from self-aggrandizement on Bernard's part) an elaboration of Byron's personality. These are claims, as Hannah will later emphasize, which "can't prove to be true [but] can only not prove to be false yet" (74).

The everyday sense of the word "trivia," insignificant, is at odds with a technical sense, one which also, in a way, adds up to insignificance. A mathematically trivial problem is one which neither requires special innovation to solve nor produces results which themselves would contribute to solving a non-trivial problem. As Valentine's example makes clear, knowing calculus is enormously useful to a mathematician, but knowing whether Newton or Leibnitz was the first to develop it makes no difference to a person's ability to use calculus. Thus, Valentine dismisses everything to do with "personalities" as, by definition, trivial. In the course of the quoted dialogue, Valentine introduces his rude contempt for Bernard's work behind the screen of technical jargon, but this excuse fails, given the

emotion Valentine brings to the argument. He wasn't simply diagnosing the type of question Bernard was asking, but rather he is insulting from the beginning, not only belittling Bernard's work but also damning him to the pursuit of a trivial question which would not earn Bernard the headlines he seeks. The tensions of the interdisciplinary conflict between mathematics and literature echo those often arising in a science play: the presumption that the areas are as incompatible as Bernard and Valentine find one another.

In scene five, at the top of the second act, Bernard rehearses his paper on the duel he supposes happened between Byron and Chater. He regularly receives responses he doesn't want—to questions he intends as rhetorical—from his unruly audience:

BERNARD. [...] But, as we know now, the drama of life and death at Sidley Park was not about pigeons but about sex and literature.

VALENTINE. Unless you were the pigeon. (54–5)

BERNARD. [...] Is it conceivable that the letters were already in the book when Byron borrowed it?

VALENTINE. Yes. (56)

BERNARD. [...] Who but Byron could have written the four lines penciled into Lady Croom's copy of *English Bards and Scotch Reviewers* –

HANNAH. Almost anybody. (57)

Valentine's unhelpful interjections point to his frustrations with the maths for his grouse as much as his accurate criticism that Bernard has theorized beyond his data. More importantly the ongoing battle between Bernard and Valentine—sometimes exacerbated, sometimes mediated, by Hannah—stages their methods and their objects as opposed to one another; *Arcadia* works by several means to frustrate the simple opposition through which they battle.

Just as Bernard becomes more invested in fame than in facts, so Septimus' odd pedagogy suggests that the pursuit of knowledge, the pursuit of the unknown, is for the distraction of his pupil rather than for the addition to knowledge. He says to Thomasina, "If I knew how [to prove

Fermat's last theorem], there would be no need to ask *you*. Fermat's last theorem has kept people busy for a hundred and fifty years, and I hoped it would keep *you* busy long enough for me to read Mr Chater's poem" (2).⁶ Here Septimus not only gives his 13-year-old pupil a task well beyond her presumed abilities (she being 13 years old and the theorem having remained unproven for nearly 200 years beyond the time in which this scene is set) but does so not primarily in hopes that she would accomplish it or even that she would learn something in the attempt. He suggests the possibility that she might solve it, implies that she might be more successful a mathematician than he is, and buries both of these implications beneath the overt claim that he had "hoped it would keep [her] busy." On the surface, at least, *Arcadia* subordinates intellectual labor to sexual entanglements: Septimus' affair with Mrs. Chater is more important to him (and to the play's nineteenth-century plot) than is Thomasina's mathematics lesson.

In the present-day plot, however, Valentine emphasizes the creation of knowledge: "In an ocean of ashes, islands of order. Patterns making themselves out of nothing" (76). He has taken up the equations Thomasina left behind, iterated them by computer, and considers the result "publishable" (76). But he is puzzled: Thomasina's work, he thinks, should have made her famous. But, as Hannah points out to him, making his reference to the "ocean of ashes" a bit disturbing, Thomasina had died in a fire. For Hannah, this is support for her theory that Septimus was the Sidley hermit. Hannah's leap, however, is not the sort of creation of knowledge Valentine can embrace, "[b]ecause there's an order things can't happen in," as he complains (79). Neither Septimus nor Thomasina can have understood what they were doing, according to Valentine, and so, for all that he feels obliged to credit Thomasina for the equations he had iterated, he believes he is himself the first person to see the application these equations describe. His inheritance is "ashes" and he will provide the order.

COMMUNAL RESPONSIBILITY

Irene Martyniuk, in comparing *Arcadia* with A. S. Byatt's novel *Possession*, emphasizes two facets of the flow of knowledge within *Arcadia* that function to fuse together not only the two sets of characters but also the audience of the play into a single community. The first of these is a limitation:

the audience is not allowed to know more than is known by the characters of the play.⁷ The second is an opening: the flow between the two time periods, enacted in the joint presence and discursive overlapping of the two sets of characters on stage in the seventh scene, wherein “all the knowledge is shared” (Martyniuk 284). The jointure of the two temporal contexts achieves, among other effects, a side-by-side comparison of the unknowable futures before them. As Hannah decries, “Comparing what we’re looking for misses the point. It’s wanting to know that makes us matter. Otherwise we’re going out the way we came in. That’s why you can’t believe in the afterlife, [...]. If the answers are in the back of the book I can wait, but what a drag. Better to struggle on knowing that failure is final” (Stoppard 75–76). The pseudo-certainty the play produces—that the Sidney hermit was Septimus, living in the hermitage and attempting to prove Thomasina’s theorem after she is killed in a fire—is just as subject to undermining as is Bernard’s thesis (which we see undermined on stage) that in a duel at Sidney House Byron killed Mr. Chater.

It is this tension between certainty and uncertainty, between the knowable and the unknowable, or even between the believable and the demonstrable, that Michael Vanden Heuvel identifies as “a compromise formation with postmodernism” (227). He writes that on the one hand, Stoppard “maintain[s] faith in the postmodern slippages and flux of language, signs, history, identities, and interpretations,” but, on the other hand, “Stoppard nevertheless insists that when structure and stability emerge, attention must be paid” (227). One of Stoppard’s regular practices is to turn history (including literary history) on its head. *Rosencrantz & Guildenstern Are Dead* famously reinterprets *Hamlet* through such a “postmodern slip-page.” Throughout Stoppard’s career, the use to which he has put the variability of language and identity speaks to the “maintenance of faith” Vanden Heuvel invokes. Yet this turmoil is not for Stoppard productive solely in its own right: even amid chaos, there is structure.⁸ Such an inclusion and exclusion—disorderly order and orderly disorder—like Hannah’s insistence that unknowability validates the struggle to know, ties together the most classical elements of thermodynamics and chaos and subordinates them to a broader context of practical uncertainty. While it would be erroneous to suggest that the difficulty in calculating future states of chaotic systems is productive of an uncertainty that is, like the uncertainty addressed in Heisenberg’s principle, inherent in the nature of things rather than in limitations on calculation, *Arcadia*’s focus on the access its

characters have to facts reframes knowability as most importantly a measure of what those characters could discern.⁹

Septimus overtly links free will with the arrow of time and the inevitable maximization of entropy. In response to Thomasina's question about the impossibility of mixing the jam back out of her pudding, he says, "since [time] will not [run backwards], we must stir our way onward mixing as we go, disorder out of disorder into disorder until pink is complete, unchanging and unchangeable, and we are done with it for ever. This is known as free will or self-determination" (5). The stage directions then indicate that Septimus "*picks up the tortoise and moves it a few inches as though it had strayed*" (5). Following the apparent nihilism of Septimus' take on the subordination of free will to the demands of entropy, using a tortoise for a paperweight appears surprisingly optimistic. He moves Plautus the tortoise as if he believes it is possible to impose order, but this movement was unnecessary, as Plautus had not, in fact, "strayed." In this brief moment, Septimus' apparent effort to increase the orderliness of his work table is as best neutral to that effort: Plautus was already just where he belonged. Exerting his own free will against Plautus' over the course of only "a few inches," Septimus might like to be "done with it," but he seems rather to prefer to continue to exert himself on the world. For all that he pronounces inevitable disorder, he chooses not to embrace it.

In a later scene Thomasina grieves over the loss of the library at Alexandria, exclaiming, "How can we sleep for grief?" Septimus responds in a circular figure: "By counting our stock. [...]. We shed as we pick up, like travelers who must carry everything in their arms, and what we let fall will be picked up by those behind. The procession is very long and life is very short. We die on the march. But there is nothing outside the march so nothing can be lost to it" (38). Septimus' response presumes that time doesn't matter. That is, the temporary loss of anything along the march is irrelevant because the lost thing will come back around at some point. This suggests that the immediate temporal context (within which any thing might be lost) is trivial, a point not entirely reinforced by the importance of *Arcadia's* own temporal structure. Septimus also indicates that we can "count" everything as within "our stock," again, a position refuted by clearly irretrievable losses of knowledge to the characters within the bounds of the play. Like Septimus' relocation of Plautus, his philosophical assertion that a closed universe ("there is nothing outside the march") means everything will be retained somehow wars against the entropy he proclaims. Although Septimus clearly states the increase of disorder and

the loss of knowledge, he wants to think that human action matters, and has positive effects. Thus, he recasts the losses as necessary to new acquisitions (“we shed as we pick up”) and suggests we get our rest not by counting sheep but “by counting our stock.” What we have is both a solace against what we have lost and a triviality useful merely as a dull aid for sleep.

Septimus’ brief efforts to reconstrue the inevitably increasing disorder decreed by the second law of thermodynamics are aided in the play by the entropy-countering effects of the scholars’ efforts to sort out the history of the house. These efforts are not successful, apparently because they substitute leaping to conclusions and one-upmanship for academic rigor. But their lack of success, in the context of the play’s figural reliance on thermodynamics, would seem to be inevitable. That is, one could analogize not knowing what had happened to an entropic disorder. Making such an analogy would suggest that had the modern scholars discerned what had happened in 1809 they would have increased the orderliness of the house. I argue rather that making poor scholarly practice the reason they fail to learn what went on is one way in which the play avoids allowing thermodynamics the final say: they don’t fail to learn because disorder must increase; instead, they fail to learn because they are caught up in the romantic and professional possibilities of their encounters at Sidley Park. Thus entropy is obeyed, in that the proliferation of wrong ideas about what had gone on is an increase in disorder. But entropy does not have the ultimate responsibility: the modern characters went wrong because they leapt so ardently to conclusions. Their decisions, however flawed, invite affirmation for siding with optimism rather than despair. In the closing moments of the play Septimus waltzes with Thomasina and Hannah dances with Gus, who has just given her Thomasina’s drawing of Septimus with the tortoise. This is a hopeful moment, when two young people enjoy the attention of the objects of their affections and before Thomasina has died in the fire which will begin later that night. Though Thomasina is about to become “ashes,” she has already been picked up again by Hannah, who believes Thomasina is the author of the equation Valentine has pushed through the computer into a publishable form.

In weaving a romance plot into *Arcadia*, Stoppard invites an evaluation of the characters’ decisions not only based on their scholarship but also based on their behaviors toward one another, yet the responsibility held by the tenuous community of characters is to the pursuit of knowledge. Though they cannot obtain certainty—Thomasina lacks a computer to

elaborate her calculations and the modern scholars lack sufficient access to the past to draw accurate conclusions—they can try. Bernard, as irresponsible in his romances as in his scholarship, flees the premises. Valentine rushes off to console his sister. Hannah alone, still searching for the proof which would confirm her guess that Septimus had been the hermit, is left to accept Gus' invitation to waltz, in awkward emulation of Thomasina's waltz with Septimus.

BACKWARDS PROPAGATION: *NOW THEN AGAIN'S* HANDSHAKE WITH TIME

John G. Cramer observes in his introduction to Penny Penniston's *Now Then Again*, that whereas many theories of physics arise as attempts to write mathematical descriptions of observed events, quantum physics leapt forward in mathematics, producing descriptions in math far beyond what had ever been observed in experiment. The equations were tremendously useful but also produced fraught disagreements over the physical significance of these formalisms, and these competing effects were pervasive in shaping the metaphysical considerations of twentieth-century physicists. As Mara Beller has related, in Heisenberg's development of matrix mechanics he "intended to eliminate not only the orbits of bound electrons but even the experimentally observable paths of free electrons" (Heisenberg qtd. in Beller 20). "This approach," Beller continues, "was tantamount to giving up all hope of devising a visualizable physical interpretation for the new matrix mechanics" (21). As the mathematics determines future approaches to quantum physics, it also creates statements about reality that require explanation. One of these is Cramer's "transactional interpretation" of quantum mechanics, which addresses the appearance of waves moving backwards in time in the mathematical formulations of quantum theory.¹⁰ Cramer writes that his theory "depicts quantum events as a handshake between the future and the past through the medium of quantum waves that travel in both time directions" and affirms Penniston's play as "a nice map for thinking about the probings and development of a transaction that ultimately becomes an element of reality." Cramer's theory takes seriously the advanced waves arising in John Wheeler's and Richard Feynman's work in electrodynamics. (An "advanced wave" is a wave which, among other things, travels backward in time. Advanced waves should be considered in tandem with "retarded waves,"

which move forwards in time. As Cramer notes, Wheeler's and Feynman's work was not ultimately a satisfactory solution for the problem they were addressing [659].) In brief, electrons will from time to time put out advanced and retarded waves which balance each other out by having equal and opposite energies. These waves will encounter other particles and these encounters will produce further pairs of waves, ultimately canceling out one another's effects outside the origin points for the waves.¹¹

This temporal transaction—which Cramer figures as a handshake between an advanced and a retarded wave—is the controlling structural and thematic metaphor of the play. The chronological early point is in the time of the play's first scene (set “now”). Between this point and the chronologically latest point in the play (thirteen weeks later), the waves shake hands, overlapping and contradicting one another, so as to produce a clean time line leading into and out of this three-month period. As such, the play's structure (act one covering three months in forward temporality and act two revisiting and revising the same scenes in reversed temporal order) allows past and future experience to influence the central characters' decisions. This formalism challenges the generic inevitability of the play's comedic romance plot.

Read as a comedy, *Now Then Again* tells the story of a frustrated romance between Ginny, an undergraduate working at Fermilab, and Henry, a young research fellow. The play opens with Henry literally hiding under a desk (which happens to be Ginny's), totally absorbed in calculations about weakly interacting massive particles (WIMPs).¹² His supervisor, Dr. Trouvant, finds him and informs him that two dozen members of the department have been waiting for him to present on mesons and their decay properties (something overtly unrelated to WIMPs). Meanwhile Ginny, who is an undergraduate summer intern at Fermilab, plans to complete her internship, marry her high school sweetheart, and become a conventional Southern lawyer's wife and a high school mathematics teacher. But Ginny has developed her summer research, and her leisure readings in theoretical physics, into a paper, on WIMPs, which she would like to see presented for the (fictional) Haven Prize.¹³ With vehemence equal to that with which Trouvant pursues Henry's requisite departmental presentation, Trouvant rejects Ginny's proposal. Ginny's efforts to persuade Trouvant are cut short by Chris's arrival, with a minister, and Trouvant storms off in search, again, of Henry. Chris has “hijacked” a minister to marry them three months early, avoiding both the delay and the hassles of actually planning their wedding (10). Meanwhile, Felix, the janitor, is

convinced that Henry is due to meet his true love that evening. Throughout the first act of the play, Felix is aware of events other than those the audience has seen unfold: he sees what is caused by the waves reaching backwards from “NOW + 13 WEEKS.” He convinces Henry to crouch in a corridor with him, insisting:

FELIX. I'm not crazy. I know. This is where you meet her. You see her for the first time right here. Between eight and nine o'clock.

HENRY. Eight and nine o'clock according to who?

FELIX. No, no, no—I am trying to set you up—don't talk to me about physics.

HENRY. I'm just saying—Einstein. Relativity. It's always eight according to someone. We could sit here forever.

FELIX. I talk about love and you talk about Einstein. You think this is good for your sex life?

HENRY. Not everybody gets a sex life. Some of us just get cool computers. (12–13)

This opening scene, set “NOW,” establishes the basic elements of the romantic comedy: a socially insecure man who is a theoretical physics postdoc at the lab and a tremendously confident woman who is merely an experimental physics undergraduate intern. Felix believes they are destined for one another. And Felix's collapse, from the brain tumor which will kill him before the end of the act, facilitates Ginny's and Henry's meeting, not during the 8 o'clock hour in act one's “NOW” scene but the following morning during the “NOW + 1 DAY” scene. The play unfolds through the first act with the two of them finding in one another a professional complement: Ginny helps Henry to be less terrified of public speech, and by working with her Henry gives Ginny's work sufficient authority for Trouvant to be willing to see their paper submitted for the prize. Along the way, Henry falls in love with Ginny and also tries to convince her to make a career in physics; Chris gets quite jealous of all the time Ginny spends with Henry; Felix discovers in Ginny's trash can an engagement ring exactly like Ginny's own; and Felix's deathbed conversations with both Henry and Ginny are efforts to push the two of them into a destiny with one another. However, throughout this three-month relationship, Ginny's fidelity to Chris frustrates the possibility of a romance between Henry and Ginny.

So far, so cheesy. But act two stages the scenes from act one in reversed temporal sequence, starting with “NOW + 13 WEEKS” and ending with ‘NOW.’ This reversal shows both the audience and the other characters of the play the scenes of a developing romance which Felix has been seeing all along. Throughout act one, Felix acts on the knowledge of interactions between Henry and Ginny which do not occur in that act. His knowledge relies on the transactional interpretation of quantum mechanics, which (as explained in the play) takes literally the mathematical indication that quantum physical events include forward and backward moving (advanced and retarded) elements. Explaining to a group of high school science students, Henry and Ginny conclude:

- HENRY. So it’s not just the past that changes the future, it’s the future that change the past.
- GINNY. Like shaking hands, making sure that everything stays together. (36)

These signals accomplish the faster-than-light communication between entangled particles which so bothered Einstein about quantum physics. (This is not, however, to say that Einstein would have found the philosophical underpinnings of the transactional interpretation unproblematic.) The signals also cancel one another out, conveniently erasing contradictions on the macro-scale.

Thus, in the transactional interpretation of quantum mechanics Felix’s insistence that Ginny and Henry will meet between eight and nine o’clock in “NOW” is only one example of Felix’s non-classical knowledge.¹⁴ In the play’s opening scene, Felix knows ahead of the interaction that Ginny and Henry will meet. Henry’s invocation of Einstein and the idea that it is always eight o’clock somewhere is a problem, not only because it signals Henry’s relatively greater interest in science than in love but also because the source of Felix’s knowledge is a metaphorical “advanced wave”—a feature of Feynman and Wheeler’s mathematical formalisms involved in quantum physics and not a feature associated with Einstein’s work on relativity. Not only are Henry and Felix opposed in focusing on science or love, but they are also working from very different scientific frameworks. That the janitor’s quantum love has support is shown when, in “NOW + 1 DAY,” Felix greets Ginny by name, despite their not yet having met.

The thing that is interesting here is that in act one’s “NOW + 13 WEEKS,” Henry’s actions are based not only on the experiences the

audience has seen but also on events and interactions that only Felix has seen. Whereas before Felix's death, only Felix was aware of things via this transactional interpretation, after Felix's death Henry becomes clearly subject to the same transactions: Felix's gnomic pronouncements no longer mask Henry's knowledge. At the end of the first act, Henry finally takes the action that sets up the "advanced wave" (a wave moving backwards in time) which act two shows ramifying backwards through the same temporal loci to rewrite the entire course of his relationship with Ginny. As the first act ends, Ginny and Chris are waiting to board the plane to return home, and Henry catches Ginny at the airport:

- HENRY. I have been looking for you, Ginny. That's what we do, isn't it? We look. There are millions of collisions a second, billions a day, and we look [...].
- GINNY. I can't just change things, Henry. [...].
- [...].
- HENRY. It's all right, Ginny. We have a whole future together. You just don't remember it yet. (52)

It seems that Henry does not, himself, remember the relationship either and that he is simply acting on faith that Felix's reports are true. Henry's earlier aborted attempt to tell Ginny he loves her—"I promised Felix I'd do something—say something to you" (49)—lends some support to such an argument in its reliance on only Felix's word and Henry's emotions for Henry's motivation. However, in their exchange at the airport, Henry's confidence—"We have a whole future together"—is sharply distinguished from Ginny's lack of memory of the events leading up to it, suggesting that Henry does, in fact, remember. As Felix's last words before the funeral scene express, Felix feels the knowledge should be latent in Henry: "You did do it. Somewhere, some part of you did. I know. I remember" (48). Between the deathbed scene, during which Henry does not yet remember what Felix has known, and the exchange in the airport, Henry's knowledge has changed and the only clear cause of such a change is his search for Ginny. Looking for knowledge, the basic task of a scientist, here changes reality.

This knowledge which seems to have sprung into full form for Henry not only arrives from Felix but also appears in glimpses around the edges of the action: there are multiple media supplying the information. For example, while Ginny and Chris are getting married, she says that she sees

“a man teaching a woman how to roller skate. She looks like me. Don’t you think she looks like me?” (14). Throughout act one, Henry will periodically encourage Ginny to take up roller skating. These “waves” also take material form: at “NOW + 2 WEEKS” in act one Felix discovers Ginny’s engagement ring in her trash basket, but she is at the same time still wearing it. In the comparable scene in act two, Ginny loses the ring. It is this lost ring that shows up, carried on a wave proceeding backward in time from “NOW + 13 WEEKS,” in the trash in act one: the audience just doesn’t realize it until near the end of the play.

It is important that these visions of a different past are not only Felix’s: he is dying of a brain tumor and we could rationalize the possibility that this has distorted his perceptions. Within the universe of this play, the time between “NOW” and “NOW + 13 WEEKS” is subject to doublings and alterations effected by a quantum handshake, but these perturbations do not continue before or after those bounds.¹⁵ The instability the characters experience regarding what events happened and what they can know does not affect events before the beginning/ending of the play (before “NOW”) or after the play’s chronologically latest point (“NOW + 13 WEEKS”). The story the play tells is the story of the waves that overlapped in the temporal region in which they were cancelling themselves out.

Now Then Again’s enactment of the transactional interpretation of quantum physics takes the form of a struggle between two possible futures. This struggle influences several of the characters’ decisions. Ginny must negotiate the differences between, on the one hand, her engagement and the life she had always anticipated having, and, on the other hand, her enjoyment of experimental physics and the possibility of a romantic and professional partnership with Henry. Likewise, Henry is caught between his belief that the past is as he has remembered it (and as the audience has seen it: meeting Ginny at “NOW + 1 DAY” rather than “NOW”) and Felix’s compelling narrative of Henry meeting his “destiny” (5). Both characters’ struggles reflect the operations of the power-knowledge system, as Michel Foucault describes it. He writes:

the subject who knows, the objects to be known and the modalities of knowledge must be regarded as so many effects of these fundamental implications of power-knowledge and their historical transformations. In short, it is not the activity of the subject of knowledge that produces a corpus of knowledge, useful or resistant to power, but power-knowledge, the processes and

struggles that traverse it and of which it is made up, that determines the forms and possible domains of knowledge. (27–28)

Reading Jeremy Bentham's *Panopticon*, Foucault underscores the lines of sight and obscurity in the structure: the supervisor sees all, but each object of that supervision becomes "the object of information, never a subject in communication" because the prisoners are invisible to one another (200). He writes, "Visibility is a trap" (200). Although Chris's and Felix's surveillances of Henry and Ginny (not to mention the audience's view of the entire system) are suspicious precisely because Henry and Ginny are in communication with one another, which does make them 'subjects in communication,' Foucault's general power-knowledge relations are a broader structure within which *Now Then Again* is readily interpretable.

In *Now Then Again* several 'processes and struggles' are at play. As Henry puts it, "Not everybody gets a sex life. Some of us just get cool computers" (13). Or in Ginny's terms "I'm happily married [to Chris]. [...] I love a lost cause [Henry]" (25). In Henry's struggle with the destiny Felix describes to him (one in which he gets both the computers and a sex life) and Ginny's with the radical departure a life with Henry would be from the marriage with Chris to which she has been on track since at least age six, both characters find themselves caught between the social conventions they have accepted—geeky scientist and Southern bride—and the romance plot of the play, and *Now Then Again* exceeds the trite conclusion of a clichéd romantic comedy by the knowledge effects produced as Ginny's decision to leave Chris for Henry travels backwards through act two to effect Ginny and Henry's meeting in the play's last scene. Ginny's decision produces this revision of the past.

FIDELITY TO THE PHYSICS: COMPARING *NOW THEN AGAIN* AND *BETRAYAL*

Of course, I am not arguing that only by literalizing physics can a play engage in an alternative temporal structure. In terms of the structure of the second act of *Now Then Again*, Harold Pinter's *Betrayal* provides an obvious counter-example. In fact, the similarities between *Betrayal* and act two of *Now Then Again* are telling. Silvio Gaggi has asserted that *Betrayal*'s chief structural device—the presentation of the affair beginning with an

encounter 2 years after its conclusion and ending with Jerry's initial advance to Emma—is not “a gimmick but [...] actually fundamental to the content of the play” (504).¹⁶ He claims that the disruption of sequence directs the audience's attention away from the sexual betrayal of a man having an affair with his best friend's wife and onto the rhetorical power struggle between the three characters:

the play becomes a continuous process of discovery, partly by the characters themselves but also on the part of the audience. For the audience the ambiguities are not ambiguities of fact (since we are told the end of the action at the beginning of the play there is no question about the outcome) but ambiguities regarding the relative knowledge and understanding of the three characters. (505)

In *Betrayal*, the reversal of chronology does, in fact, suggest that the drive to fill in back story (to amplify the narrative of “how did we get here?”) mirrors the temporal forward drive of cause and effect. As Claudia Barnett suggests, *Betrayal's* process generally backwards through time provides the audience with the actual past unfolding rather than “merely [being] told by potentially unreliable characters about past events” (70). The play then works against this apparent reportorial drive, calling into question the motivations for and truthfulness of everything the characters say to one another: although the audience sees what was said in the exchanges the play provides, there is no ultimate guarantee that these characters are truthful with one another in the moment nor that they understand one another. As Barnett argues, “They change their lives, but not in the manner Emma once implied; they change their lives because they change themselves, realizing the roles they thought they once ‘played’ have become (or perhaps always have been) real” (72).

Contrariwise, in *Now Then Again*, the backward drive of the second act not only supplies a different starting point in the airport departures lounge, one from which Ginny and Henry's romance can carry forward, but also explains inexplicable elements of the first act, for example, finding Ginny's engagement ring when she is also already wearing it. The doubled ring is one that was lost (or thrown away) in act two. It's the same ring. The same cannot be said of the characters: they can remember (in one temporal direction, at least), and thus they are not the same as their doubled selves. Ginny, not driven forward and backwards in time, did not in fact meet Henry and go roller-skating with him. Instead she married Chris.

Memory, of course, is a form of knowledge, or, as Ginny puts it:

GINNY. Data. I have been collecting data. Twenty-two years plus three months and six days worth of data. That's how long we've known each other. [...]. I'm just saying that I have a lot of experimental evidence to suggest that you are absolutely positively the man I am supposed to be with for the rest of my life. [...]. I'm scientifically validated. (50)

Here Ginny tries to use the force of this accumulated data to keep herself on the path toward the life she had been planning for those twenty-two years. When Henry arrives with another set of memories—what Felix has remembered over the course of the past thirteen weeks—the struggle is not a struggle to reconcile two faulty memories. Henry and Ginny are in this instance comparing both a lifetime of memories versus a few months of memories and also two competing sets of events occurring over those past few months. In this case, Penniston has achieved via physics what Pinter's reversed temporality accomplishes for *Betrayal*: the reversal works to “eliminat[e] the memory-related discrepancies which abound in other plays concerned with memory” (Scolnicov 83). In *Betrayal*, memory cannot err because in lieu of remembered scenes the audience is presented with the action of the scene itself. In *Now Then Again*, the discrepancies of memories are not questionable falsities; the discrepancies are instead fugitives carried on a wave, propelled quantum mechanically by a different set of decisions.

Is this, then, a straightforward problem of teleology? Can we read the narrative drives of both *Betrayal* and *Now Then Again* as suggesting that beginnings inexorably lead to endings, that cause and effect work their ways out no matter where one begins? In the case of *Betrayal*, perhaps. But the knowledge-power structure of *Now Then Again* is more complicated, because the two sets of events (Ginny marrying and ultimately leaving with Chris or Ginny meeting Henry instead of marrying Chris and going on to do graduate work in physics) are given equal reality in *Now Then Again*. It is clear that Ginny's moment of decision—at the airport during “NOW + 13 WEEKS”—will be the determinant of whether the past that shapes her future is the one in which she married Chris or the one in which she decided not to. And the play's sequence—first the act in which Ginny stays with Chris and then the act in which Ginny chooses physics and Henry—suggests that Ginny really chose the latter.

FAUST OR DON JUAN IN FERMILAB

The affirmation offered by *Now Then Again's* enactment of the handshake model foregrounds possibility, the openness in "The really big decisions in life [...] the ones that [...] change the past" (Penniston 47).

In encouraging Henry to tell Ginny that he loves her, Felix insists:

FELIX. The important thing is that it would change you. Tell her how you danced with her under the stars and how you kissed her while the clarinet music was playing.

HENRY. I never did that. I don't do that. I'm a scientist—a geek since I was four years old. I don't blossom. I don't explode into passion. I get nauseous and sweaty and I mutter. (47).

And Henry is not exaggerating. Already in presenting to a group of high school students—presenting science not love—Henry's sweaty muttering ineptitude (about the science which is after all his passion) was what led Ginny to step in to save his presentation. She turns Henry into a walking example of an electron waiting for the handshake signal from the future:

GINNY. Electrons are weird. Like maybe my friend Henry, here. [...]. The point is, you never know which way it's going to go. Neither does he. Yet. [...]. "What am I? What am I?" he says. [...]. But these waves travel out around him, until somewhere out here [...] in the future, it meets another electron. This electron hears the question [...]. So, the electron takes a look [...] and says, "Well, you're standing here aren't you? I think there's hope for you yet." (34–35).

Ginny continues her campaign to make Henry a successful public speaker (both for his own benefit and so that she will be free to stay home with her husband when the time comes to present the paper she and Henry have written together). She reassures him and also saves his presentation to the students (thus saving face for Henry with his supervisor).

But in act two, the tables are turned and Henry has been changed. In the congruent scene from the second act when Ginny "*steps in to rescue the nervous HENRY*," she rescues him more quickly than any of us might imagine, and he conquers his issues with presentation by turning the illustration around:

GINNY. Electrons are weird. Like a teacher.

HENRY. Like a teacher...or maybe a very smart college student. (62).

Henry takes charge of the presentation; rather than elaborating on the example Ginny had previously offered him of a teacher who seemed to be able to be anywhere, he uses Ginny herself and the decision she faces (between “a brilliant career” and a life in “the backwoods of South Carolina” [62]) as his example for the students. In doing so, Penniston’s stage directions indicate that “*he transforms from a nervous, shy neurotic guy into a strong, passionate, articulate speaker*” (62). Henry’s transformations occur as he increasingly acts to persuade Ginny to stay with physics and to stay with him. But the play works hard to keep the decision one that will be made equally and independently by both Henry and Ginny. In the final scene Chris, in arriving with a minister to marry Ginny, tells her “Whatever it is [in the display of a lepton collision], if it’s better than me sweeping you off your feet, I’ll go home” (78). When we see Ginny choosing, the decision is clearly between continuing her career and marrying Chris; Henry does not enter into her calculations; she has not yet, after all, actually met Henry.

Ginny’s choice, then, is between being Faust and being Don Juan. Comparing the developments and iterations of the stories of Faust and of Don Juan, E. M. Butler surmises that although both Don Juan and Faust act from “tremendously powerful emotions,” the two types have been judged very differently, elevating the lover to heights the learner is barred from: “the conception of Don Juan, the ruthless, irresistible, conquering male, took Europe by storm; whilst the equally ruthless, titanicly aspiring Faust remained caviare to the non-German general public” (xiv). In act one, Ginny chooses Don Juan’s route: she even articulates her work on WIMPs in terms more appropriate to a hobbyist than those of a dedicated scholar. And the driving generic force of the comedic romance underscores this play’s affiliation with the Don Juan trajectory. Ginny is “ruthless [and] irresistible” in her plans, focused on and productive of romance. She marries Chris on the condition that she will continue her internship at Fermilab, producing a demonstration of his devotion in his agreement. She works to remake Henry as a more successful public speaker and in so doing leads him to fall in love with her. Her paper on WIMPs (and its success in the competition for the Haven Prize) are tools in that pursuit: she uses the fact that in living her chosen life she “won’t have this” to pressure Henry into agreeing to practice his presentation skills by giving the talk to the high school stu-

dents so that he will be able to present their work in Switzerland (33). Her drive makes Henry fall in love with her even as she “works on” him to further her plan to get out of physics and into a conventional married life.

But in act two Ginny’s choices are on “equally ruthless, titanicly aspiring” terms, in pursuit of a career in physics. Where act one stages Ginny’s continuing work at Fermilab as a simple and relatively unimportant delay before her return to South Carolina, and thus articulates Henry’s interest in her as both futile and unsolicited, in act two the urgency concerning Ginny’s forfeiture of a future in science comes from Ginny herself rather than from Henry. Thus, act two includes a more assertive Henry, different because of Ginny’s influence and able to make his case for her remaining in physics, and a more conflicted Ginny who sees clearly the draw of a relentless pursuit of knowledge. As Chris observes, “She never got like this before—always working. It’s not like her” (66).

DECIDING FIDELITY

In *Now Then Again* Ginny and Henry proceed through the first act believing that they know the constraints upon their partnership: Henry is awkward and Ginny is married. In the play’s transformed temporality, consequences of a different past are let loose between Chris’ arrival with the minster and his departure thirteen weeks later. In trying to convince Ginny to marry him early, Chris argues that he is more significant to her than her research. In act one, Chris asks Ginny to compare the significance of her own research with the possibility of marrying him, and she admits there are “Millions of collisions every second, most of them—boring. About one time in a billion you get something worth looking at” (11). But in act two, when Chris asks her to compare the “lepton picture” with “me sweeping you off your feet,” a very different image appears:

(GINNY stares at the graph. The colors explode out from the center like fireworks.)

GINNY. This could be something. [...]. Do you know what the odds are against seeing something like this? [...].

CHRIS. In three months, [...] none of this will make any difference.

(GINNY looks at him in a sudden moment of complete clarity.)

GINNY. I can’t marry you. (77, 78–79)

The consequences of Ginny seeing experimental results she just might be able to interpret appear in traces throughout the play, though neither the audience nor Ginny sees these results until the final scene. For example, the engagement ring she threw away in act two was found in act one and, looking off stage at the play's beginning, Ginny sees the roller-skating lesson Henry gives her at the end of the play. Because the play enacts the transactional interpretation of quantum physics, Ginny is allowed to decide not to have married Chris. Her decision, at the airport in the middle of the play, after Felix's funeral, sets up the random retrieval of a significant picture in the play's last scene. And her not-fully-understood knowledge—those glimpses of the results of calling off the wedding—contributes to the decision which produced this knowledge. This kind of mutually-constituting system is furthermore mirrored in the ways in which Henry and Ginny complement one another, making each other more successful. Ginny doesn't know what may come of her decision, despite the glimpses she has had of how it has come about, but the play's romance plot affirms her decision, as does the science *Now Then Again* enacts. Because Ginny chooses physics (and Henry), physics, as dramatized in the play's use of the transactional model of quantum mechanics, provides a justification for her choice: what Henry called "a glimpse into the nature of the universe" (52).

Likewise, in *Arcadia*, knowledge flows between past and present under the audience's watchful eyes. The chaotic succession of facts and errors builds to suggest the possibility of an informed decision—the possibility of a responsible publication by Hannah or Valentine, the possibility of Thomasina receiving the credit due to her work, or the possibility of some contravention of thermodynamics' law of entropy. Septimus' onstage burning of Byron's letter to himself, unread (to demonstrate his fidelity to Lady Croom), underscores the impossibility of learning everything, but the romantic closing of the play in a multi-temporal dance suggests Hannah might have been correct in her identification of Septimus as the Sidney hermit (71, 95–97). With Bernard's example before her—a caution and an encouragement—Hannah seems to hesitate to take Gus's offering of Thomasina's drawing of Septimus and Plautus as sufficient proof for publication. As an audience, we know that Bernard's ideas have been fairly comprehensively wrong, mostly hinged on the idea that the duels to which Chater challenged Septimus were actually a single duel fought by Byron. And the masses of burned papers—reportedly full of "cabalistic proofs that the world was coming to an end" (27)—are, like the burned letter

from Byron, more ashes of what has been irretrievably lost: despite Septimus' optimistic paean to a phoenix-like cycle of knowledge, thermodynamics does win in the end and the audience of *Arcadia* knows that all decisions are ultimately made in an "ocean of ashes" of incomplete knowledge.

NOTES

1. Valentine, the mathematician whose work on the history of the local grouse population depends on developments in chaos theory, could be considered an exception, in that chaos itself includes some defiance of such expectations. But he, too, talks about his work as if he will achieve a formula. As he says to Hannah, "you can't keep tabs on everything, [...]. But it isn't necessary to know the details. When they are all put together, it turns out the population is obeying a mathematical rule" (45). Valentine acknowledges a limit to what can be known and dismisses the limitation in the next breath.
2. Bruce Clarke's *Energy Forms* is particularly useful for its treatment of appearances of thermodynamics in novels from the inception of thermodynamics as a field (in the 1840s and 1850s).
3. James Gleick's *Chaos*, which Stoppard read while preparing *Arcadia*, provides an accessible introduction to the early history (see Jernagan 20). The book's color plates illustrate a nice range of the graphics, though a web search for "Mandelbrot set" will turn up one of the most famous. See Gleick 92–95 for his discussion of the Cantor set. Intriguingly, Gleick attributes Mitchell Feigenbaum's extended attention to the anomalies which gave rise to his foundational contributions to chaos theory to "immersion" in Goethe's work, both Goethe's theory of color and his literary work, especially *Faust* (163–166).
4. Christopher Innes has detailed the manner in which characters in each period are "mirrored" in the other (100).
5. The Chater connection Bernard has found is the inscription from Chater to Septimus, which the audience have seen Chater write, a dramatic irony first in Chater's punning misconstruction of Septimus' carnal embrace of Mrs. Chater (he writes that Septimus "stood up and gave his best") and then in Bernard's tendency to accept Chater's misunderstanding of Septimus' intentions (21, 9).

Hannah's reference to "The only known likeness of the Sidley hermit" is similarly already undermined: we have seen Thomasina graffiti it onto Noakes' sketch book well before the hermitage itself had been built (25). Likewise, the accuracy of the game books Valentine uses will be called into question in the play's last scene.

6. Fermat's last theorem was that "when x , y and z are whole numbers each raised to power of n , the sum of the first two can never equal the third when n is greater than 2" (Stoppard 3). For example, while $3^2 + 4^2 = 5^2$, when the power is greater than two (e.g. $3^3 + 4^3 = z^3$), the bases (here 3, 4, and z) don't exist to make the equation work out, at least for whole numbers (the cube root of 91 is in between 4 and 5). Fermat proposed the theorem, but didn't prove it. (Andrew Wiles proved it in 1995, after Stoppard had written *Arcadia*.)
7. Martyniuk compares this with the rare but significant intrusions of an omniscient narrator in *Possession*. There most markedly effective in the postscript, just after the reader is led to believe that Byatt's modern characters had figured everything important out about the historical characters, the narrator reveals details to which the modern characters have no access. See especially Martyniuk 273–278. Note that this is not meant to suggest all the characters have as much knowledge as the audience; in fact, none of the play's characters has all the facts.
8. Chaos itself, as a scientific area, works precisely on the tension between apparent disorder and actual structure.
9. As Jernigan observes, "the extent to which *Arcadia* is postmodern is dependent on how it emphasizes the theory's assertion of practical impossibility to anti-epistemological effect" (18). Jernigan notes Lyotard's recognition of "both quantum mechanics and especially chaos theory as the postmodern theories par excellence, given their radical incredulity over the possibility of achieving a grand metanarrative description of the universe" (Jernigan 4). It should be noted that, despite Jernigan's acceptance of a kinship between the ontological uncertainty of quantum physics and the 'anti-epistemological effect' of the practical difficulties of determination in chaotic systems, Jernigan also critiques Lyotard's assessment (see Jernigan 27–28).
10. See Cramer, "The transactional interpretation of quantum mechanics." He writes that "The mathematical *formalism* of quantum mechanics, although refined and generalized in the intervening decades, has never been seriously challenged either theoretically or experimentally and remains as firmly established today as it was in the 1930s" (647). Since its codification, the mathematics by which physicists describe the quantum world has been maintained; the math has, for a long time, seemed to work; what it means has by no means been equally settled. One cannot even uncontestedly state that these so-effective formalisms describe reality at the quantum level.
11. As Cramer emphasizes, the transactional interpretation jettisons locality but retains causality (648–649).
12. Despite the silly-sounding name, WIMPs are a genuine topic of particle physics; many names of particles and properties are quite whimsical, includ-

- ing the quark, a word drawn by Murray GellMann from James Joyce's *Finnegans Wake* (Zukav 244).
13. The disciplinary boundaries separating experimentalists and theorists are at least as much a barrier to acceptance of Ginny's proposed work as is her status as an undergraduate.
 14. "Classical" physics is also described as "Newtonian" physics: physics operating under the rules as understood before relativity and quantum theory.
 15. For a technical discussion regarding the Dirac-Wheeler-Feynman work on quantum waves, emitters, absorbers, and the time boundaries imposed on effects (whether or not time-symmetry is assumed), see Cramer "Transactional" 659–661. As Cramer is careful to acknowledge, the transactional interpretation of quantum mechanics should not be considered as allowing "backward-in-time signaling" or other time-travel-like effects, despite the model's ready adaptation to such uses in art (661).
 16. Gaggi compares the language games between the characters of *Betrayal* to Tom Stoppard's game of questions between the title characters of *Rosencrantz and Guildenstern are Dead*.

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Torn Palimpsest and Recycled Time: Copenhagen and Conclusion

Abstract In Michael Frayn's 1998 play, *Copenhagen*, complementarity works not only as an extended metaphor but also as a topic of discussion for the characters. These fictional versions of Niels and Margrethe Bohr and Werner Heisenberg work through unsatisfactory explanations for their motivations, increasing uncertainty about the reason for and content of their meeting during the Second World War. Rather than fulfilling the hope shared by these characters, the play shows that their effort—the building up of an incomplete picture from multiple frames of reference—and the preservation of uncertainty are what allow the play to end with a more complicated definition of justice than that with which it began and with the suggestion that this more-complicated justice has been obtained.

Keywords Complementarity • Uncertainty • Niels Bohr • Werner Heisenberg

In the world-made-manifest by the observations of theoretical physicists, the decision to practice science is itself a decision which opens onto the ethical domain. By observing the world, physicists not only describe its attributes but ascribe these attributes to the subjects of their observations. And the dilemma of these new Faustus is not whether they could find themselves bored some day or so sated with knowledge that they are content to

rest upon their laurels; instead they are challenged by the opening of ontology to epistemology: what worlds will they bring into being through their searching for further knowledge? In this confrontation, bred in relativity's discovery that the observer's spatio-temporal relationship to what is being observed matters, and born in the quantum weirdness by which the observer's decision what to look for produces the actual qualities sought, science drama plays through the ethical effects of the decision to enter into decision.

After the Cold War, as science drama returns to the fundamentals of twentieth-century physics, scientists reintegrate into society carrying the baggage of physicists' war work. Their implication in the development of nuclear weaponry is, however, necessarily subordinate to the interpersonal relationships at play. Yet chance and personalities have such wide sway that the incalculability of the full chain of effects from their actions becomes in itself a reiterated call to responsibility. The crux of the matter is the determination that the future is indeterminate. Michael Frayn's *Copenhagen* has intervened in this context, particularly through its emphasis on the fracturing of the relationship of two physicists, an emphasis nuanced but by no means challenged by the play's concern with these two scientists' involvements in the development of nuclear weaponry. The chief distinguishing feature on which Charles A. Carpenter has remarked in noting that *Copenhagen* is the only nuclear drama to have been published since 1989 is its relative inattention to the Bomb (3).¹ As Carpenter writes, "Symptomatically, [*Copenhagen*] does not deal with nuclear terror or the possible effects of nuclear war, but rather with the personalities and activities of physicists whose discoveries underlie the creation of the atomic bomb" (3). The play participates in the shift from Cold War dramatic tendencies of instruction and terror to enactments of physics that exculpate scientists from sole responsibility for the destructive potentials and realities of their research.

Copenhagen is more like its fellow physics plays written after the Cold War than like the nuclear dramas which preceded it.² The play is something of an apotheosis of the tradition in science plays of integrating form and theme. Kirsten Shepherd-Barr has emphasized that performance is "precisely the point [of *Copenhagen*]: to show the interdependence of form and content," and "what has distinguished plays like *Copenhagen* and *Arcadia* from more routine works that employ science [is that they] use the theater on at least two levels: as a place for engaging science for the exploration of philosophical ideas, and as a way of investigating the nature

of performance [...] itself" (103–4, 104). Bringing together thematic interests in physics, metaphysics, and personalities with formal structures emerging from those subjects (and thus also shaping their developments), *Copenhagen* engages in a tough interrogation of its characters' obligations—as scientists, as citizens, as friends—while subjecting them to a spatio-temporal structure manifestly emerging from the science they had, themselves, created.

TIME, HISTORY, AND MEETING THE OTHER

Where *Arcadia* and *Now Then Again* showcase skewing of the usual sequence of cause-and-effect by operating outside regular linear time, *Copenhagen* suggests and ultimately undermines yet another irregular spatio-temporality. The "arrow of time" in *Arcadia* and in *Now Then Again* is a two-headed arrow; both plays enact a temporal flow in which cause and effect are allowed to proceed "forward" and "backward" in time. Instead of such a reversal or a doubling back, in *Copenhagen* time appears to go in circles. Three times the character Werner Heisenberg relates "I crunch over the familiar gravel [to the Bohrs' front door], and tug at the familiar bell-pull," sending the play's three characters again into a re-enactment of the events that followed Heisenberg's arrival (12, 53, 86).

The historical Heisenberg did, in fact, visit his friend and mentor, Niels Bohr, one evening in 1941. The overt reason for Heisenberg's presence in Copenhagen was an astrophysics conference offered there as pro-Germany propaganda, a conference largely boycotted by the Danish physicists then working with Bohr (Cassidy, *Uncertainty* 436; Walker 92). Both Frayn's play *Copenhagen* and the historical Heisenberg's later explanation suggest that there were other, less publishable, reasons for Heisenberg's visit. Yet that Heisenberg visited Niels and Margrethe Bohr in the fall of 1941 was almost the entirety of the agreement between the principals' later reports of the event. Michael Frayn seizes on the historical uncertainty surrounding these details, and the result is *Copenhagen*.

The question to which the play addresses itself—or, rather, one question among the many—is Heisenberg's motivation in making that visit. As the character Heisenberg expresses with some exasperation, "there are only two things the world remembers about me. One is the uncertainty principle, and the other is my mysterious visit to Niels Bohr in Copenhagen in 1941. Everyone understands uncertainty. Or thinks he does. No one understands my trip to Copenhagen. Time and time again I've explained

it" (4). Although *what* was said during that visit has remained without consensus, *why* it was said has remained the larger question, both in history and in Frayn's play. The play is thus as much interested in passing a moral judgment as an historical one, and some reviewers and critics have condemned the play as advocating too strongly on behalf of Heisenberg.

This apparent advocacy exists largely in the play's manner of presenting one explanation the historical Heisenberg provided: that he had gone to speak with Bohr in hopes of convincing him to go along in a conspiracy to make nuclear weaponry seem so impossibly difficult to produce that no party to the war would undertake it. As I will argue, this is but one of the Heisenberg character's strategies for exonerating himself.³ All of the efforts included in the play to excuse or even to explain Heisenberg (and Bohr) arise in relation to the question Heisenberg remembers having posed: "if as a physicist one had the moral right to work on the practical exploitation of atomic energy" (36).

This recollection multiplies narratives for each of its three characters, dividing their memories as each splits off from the scant points of agreement and even leaps to differences about several other incidents in their shared pasts. These divisions occur across a seemingly originary scene of confrontation in which each character is concerned not only with the others' motivations but also with the extent to which these conversations will expose each of them to the surveillance of the Nazis occupying Copenhagen. The confrontations the play stages underscore not only divisions of the present but especially vulnerability of exposure to an *other*. As Martin Hägglund has written, "The relation to the other is thus the nonethical opening of ethics. This opening is violent because it entails that everything is exposed to what may corrupt and extinguish it" (88). In *Copenhagen* everyone has emphatically become other. Frayn's characters grapple to manage their exposure to the Nazi government and to one another. And both the wartime danger attached to Nazi surveillance and also the post-war potentials for further disruptions of reputation and relationship are fraught openings for each of the characters. In each engagement, in each negotiation or approach to any of these others, *Copenhagen's* characters consider themselves as "exposed to what may extinguish" them. Even in trying to remember where and when their conversation took place, this exposure is obvious: Heisenberg exclaims, "We must have been outside! What I was going to say was treasonable. If I'd been overheard I'd have been executed" (36).

Moreover, in the variety of temporal perspectives the play offers on the evening of Heisenberg's meeting with the Bohrs, various intelligence agencies' post-war interests in the conversation between Bohr and Heisenberg admit into the range of "others" the British and American governments as well as all of "the world" which "remembers [... Heisenberg's] mysterious visit to Niels Bohr" (Frayn, *Copenhagen* 4). They are beset by others, not only "anything whatsoever or anyone whosoever," but *everyone* (Hägglund 88). They understand themselves as always opened to the violence of the possibility of (in)justice.

Two specific violences permeate *Copenhagen*: the use of atomic weaponry and "the end of the famous friendship between Niels Bohr and Werner Heisenberg" (Frayn, *Copenhagen* 4). And the comparison between these, though it flirts with trivializing the bombings of Hiroshima and Nagasaki, generally works to raise the stakes on the personal relationship. Yet within and beyond their friendship—and *Copenhagen's* invocation of its characters as ghosts remaining after their deaths calls up a truly wide range of beyonds—Bohr and Heisenberg approach one another from a disjuncture, what Derrida calls the "dis-adjustment of the 'it's going badly'" (*Specters* 22). Heisenberg's visit has been going very badly for the Bohrs for some time, while Heisenberg is so out of adjustment that it takes him several pages even to reach the scene. The question at hand is whether the rough going is a path to justice or just the abrasion of another injustice. As David Barnett carefully distinguishes, the contrast between the ghostly characters and the performances as their formerly living selves calls into question "[t]he status of the sovereign individual," suggesting an abstracted ethical conundrum rather than the concerns of three particular persons (147). The inequities arising from Heisenberg's status as Bohr's former pupil and protégé, not to mention being a scientist working within and for Germany, are many and contradictory, and such differentiation is all the more striking in contrast with the unanimity and affection presented by the play's description of Bohr and Heisenberg's former relationship: doing their "best work together," practically as "Father and son" in "A family business" (5). Yet the play reveals this appearance of unity as a mere cover over differences that had provoked violent rows even when the two were close friends. So, what hope of justice would there be, particularly for the characters of *Copenhagen* who are "all three of us dead and gone"? (3)

In attempting to work this out, *Copenhagen* works not only in the characters' conversations with one another but also in and across a formal

disjunction: time appears to flow in loops. By staging meetings not only between people but also between times, *Copenhagen* has the opportunity to map a way toward personal justice in its route out of the spatio-temporal confines it has drawn. As Frayn's characters discuss their contributions to theoretical physics and iteratively discuss and reenact the events—always changing slightly—of the night of their meeting, these iterations suggest characters trapped in a loop of time. However, the changes in each iteration reveal still more faulty memories. These changes also indicate the characters' vested hopes that attaining complete memory (complete knowledge) can show them a way out of these apparent temporal loops. They want a way to go forward rather than simply to repeat, retract, and reframe their explanations of the past. These unsatisfactory explanations increase rather than reduce uncertainty about the reason for and content of the meeting around which *Copenhagen* circles.

Werner Heisenberg's uncertainty principle focuses on the way that getting knowledge of one property of a particle (such as its position) impedes getting knowledge of another of its properties (such as its momentum). Niels Bohr's theorization of complementarity—much more difficult to conceptualize—emphasizes, rather, that because quantum particles exist in probabilistic states the particles only *have* measurable properties when these properties are being measured (and thus that if you can only measure one property at a time, a particle that has a position does not have a measured momentum). *Copenhagen* takes a complementary view of memory and history and thus, rather than fulfilling the hope shared by these characters, the play presents their effort (of building up an incomplete picture from their multiple frames of reference) in combination with the changes inherent in a complementary view of memory-history as the very combination which allows the play to end with a more complete definition of justice than that with which it began. The play's optimistic, if vague, conclusion further offers the suggestion that this process-oriented justice has been obtained.

WHAT HAPPENED IN *COPENHAGEN*?

The play opens on Margrethe and Bohr continuing—after their deaths—to wonder “Why did he [Heisenberg] come to Copenhagen?” (3) Bohr, remonstrating her curiosity, shortly before being caught up by the same question himself, asks, “Does it matter [...] now we're all three of us dead and gone?” (3) The question about Heisenberg's intent will occupy the

play's three characters throughout the twists and turns of its two acts, and it is Margrethe who begins to exonerate their joint obsession with this question: this is one of those questions which, she says, "remain long after their owners have died. Linger like ghosts" (3). Just as the play offers embodiment to three dead people—Bohr, Margrethe, and Heisenberg—it offers a series of embodiments to these ghostly questions.

These reenactments provide the major structure of *Copenhagen*. Shortly after the three characters have recounted bits of their lives leading up to the evening of the meeting, and before they unambiguously recognize one another's presence on the stage, they enter into an iteration of the meeting itself, starting with Heisenberg's arrival on the Bohrs' doorstep, carrying through a series of sometimes awkward, sometimes friendly reminiscences among the three characters, leading to the departure of Bohr and Heisenberg on a walk (for a conversation away from the surveillance they believe almost certainly installed in the Bohrs' home, a conversation offered to the audience only through Margrethe's imagining in this moment), and concluding with the men's abrupt and unfriendly return.

Following this first reenactment, Bohr indicates that the conversation on the walk broke off because Heisenberg had suggested he was looking into the possibility of fissioning uranium. This leads the Bohrs to a reflection on Heisenberg's later, post-war, visit to Copenhagen, during which he was accompanied by a British intelligence agent; that was their first of many efforts to reconstruct this same conversation (Frays 35). At this point, Heisenberg and Bohr once again hit the wall of incompatible recollections which had stymied them in 1947, but they undertake to work together again to recount their conversation, not for the sake of any government agents this time but for themselves and Margrethe. The care with which they appear to choose their words this time initially obscures how incredibly elliptical Heisenberg and Bohr are in ascribing intentions to themselves or to one another. Their unstated suggestions and their gestural explanations of the relevant nuclear physics lead to a debate over Heisenberg's recollections of the evening at Farm Hall in England when he and the other German nuclear physicists learned that the USA had used a fission bomb on Japan, a conversation for which Bohr was obviously not present. He nonetheless offers insight into how he feels the German scientists' conversation must have gone. This recollection leads to Bohr's vigorous criticism of the dangers inherent in the reactor Heisenberg had been working on before being confined in England with the rest of the German group. Margrethe's sense that Heisenberg is "like a lost child" by the end

of this provokes Bohr's sympathetic request, "Tell us once again [why you came]. Another draft of the paper. And this time we shall get it right. This time we shall understand" (53). The act closes as this second iteration of their 1941 meeting begins.

In the second act, their efforts to remember—or reconstruct—the meeting in question have led them back to the beginnings of Heisenberg's and Bohr's relationship with one another: the act opens on them recalling preparations to go off together on a hike early in Heisenberg's first stay at Bohr's physics institute, in 1924 (Frayn 55). Their line of conversational associations leads them back and forth through several of the major developments in physics before the Second World War and also through some of the personalities connected with those developments, terminating with an argument about Heisenberg's ineptitude and immorality in participating in the German nuclear project. A part of this argument hinges on the calculation of the critical mass of uranium-235 for a bomb: when Heisenberg actually performed the calculation, why he hadn't done it earlier, why he got it so badly wrong when he did do it, how the American team had calculated it, and why Bohr hadn't calculated it considerably earlier when his work (with John Wheeler) had shown that U-235 fissions but U-238 does not.⁴

Threaded throughout the play's major iterations of the 1941 meeting, several anecdotes and motifs also recur, reinforcing the suggestion of a cyclical temporal structure for the play. One wonders whether these three characters will be doomed to repeat their efforts again and again in this regard, whether the question "why did he come?" will still be "lingering" and causing them to spin their wheels. The cycling through memory begins as Heisenberg steps from the play's present to "September, 1941, Copenhagen...[...] at once" (6). Allowing this transition dramatic momentum by using it to launch the first moments of the reenactment, Frayn temporarily elides Margrethe's important qualification of the nature of their reiteration of the past: it "becomes the present inside your head," not objectively (6). Two consequences arise from the limitation of this return. First, to move the past into the present only "inside your head" reminds us, as we will again be reminded when the posthumous characters begin commenting on their remembered and reenacted activities rather than straightforwardly embodying them, that this is an overlapping of the temporal path rather than a genuine return to the past: their metacommentary underscores the differences between 1941 and the present. Second, the past which is becoming present is based in just the sorts of

“curious” and fallible memories that misremembered the month of the meeting as October rather than September (6).

The decision the three characters make to revisit their past enables the play’s near-cyclical temporal structure, while the mix of memory and uncertainty driving their reenactments of that September meeting produces the questions this reenactment tries to answer and also produces limitations on the decisions Heisenberg and the Bohrs make at any time in the play. Knowledge, time, and decisions all appear locked together in a mutually-constitutive system, as these three characters struggle through their reenaction to understand not only what *was* but more painfully who they themselves have been.⁵ As these characters’ knowledge of each other’s beliefs, motivations, and actions changes, their own options for actions and the very motivations they claim for their actions also change, apparently retroactively. Thus, the structure of temporality through which these three characters move during this play is deliberately misrepresented as cyclical. It is an overlapping not with one historical past but with a set of possible tracks of the past.

A DRAMATIC HISTORY OF PHYSICS

The sheer variety in accounts of the meeting—both those given by the principals and those proposed or contextualized by historians—provides one explanation for the range of the historical tracks Frayn’s play proposes.⁶ The historical background against which Frayn’s play unfolds has been repeatedly explored. Matthias Dörries’ *Michael Frayn’s Copenhagen in Debate* assembles a spectrum of responses, largely by historians of science, to the relationship between Frayn’s play and the historical event inspiring it. Each essay in the collection includes its author’s elaborations upon the 2002 release of several relevant documents held at the Niels Bohr Archive.

Historians’ responses to the play, generally, may be roughly sorted into three overlapping groups: those whose emphasis indicates that a play should generally be judged for its ability to entertain rather than its ability to represent history—as Michael Eckert writes, “We do not go to the theater for information about historical circumstances” (24); those who believe historians have something to learn from Frayn’s efforts—Klaus Hentschel considers the play “a successful attempt at shaking off this mindset and leaving room for more than one interpretation” (31); and those who consider the play’s historical inaccuracies a near-fatal flaw—Gerald

Holton writes of the danger of audiences mistaking Frayn's play for history (49). (In choosing Holton as a representative of this third category, I am nonetheless mindful that despite his frequent and sharp criticism of Frayn's infidelity to history Holton is alive to the play as "a hugely successful work of *fiction* for the theater" [55; *emphasis* Holton's].) These historians suggest underlying philosophies of history driving their responses to the play: is there one truth or are there many and when an episode of history is fictionalized how much of a truth-claim can the resulting fiction have? I suggest these questions as more fruitful than a convenient division of the group into two camps: one aligned with Thomas Powers and trenchantly continuing to advocate for a generous reading of Heisenberg's actions and the other grouped with Paul Laurence Rose, whom Frayn considers "the most outspoken critic of both Heisenberg and my play" (Frayn, 'Copenhagen' Revisited 22).

In fact, Matthias Dörries characterizes the historical debates following the first performances of the play as themselves "a drama" and a "public spectacle" (i). Interestingly, Dörries continues: "We see in this debate what we expect to see in the theater: accusations, imputations, justifications, and reflexive monologues" (i). Generically, the historian of science suggests that drama and dramatic conflict have more to do with a courtroom or a trial than with extra-legal drives and desires. Much of the debate surrounding the historical plausibility of the play presumes Frayn intended to set the historical record straight. And in discussing the relationship between history and the play, Frayn offers:

The central event in it is a real one. Heisenberg *did* go to Copenhagen in 1941, and there *was* a meeting with Bohr, in the teeth of all the difficulties encountered by my characters. He almost certainly went to dinner at the Bohrs' house, and the two men almost certainly went for a walk to escape from any possible microphones, though there is some dispute about even these simple matters. The question of what they actually said to each other has been even more disputed, and where there's ambiguity in the play about what happened, it's because there is in the recollection of the participants. (95)

Frayn's frequent appeal to historic fact in support of his play undermines his likewise frequent assertion that a play is not obliged to be factual. This tension would seem to legitimate historians of science's criticisms of the play for its historical inaccuracies. While the historians have launched their

own trial, the resolution *Copenhagen* offers suggests that Frayn has brought the trial to a close, much as Niels Bohr may have thought his formulation of complementarity had the possibility of bringing to a close an ongoing debate in quantum physics: the problem of light seeming to be both a particle and a wave.⁷

Niels Bohr initially presented “complementarity” in a fairly general, and non-mathematical, lecture to a group of physicists at a 1927 congress marking the centennial of Alessandro Volta’s death. Bohr’s emphasis at that time was expressly not the mathematics, which he considered central to the developments of quantum mechanics, but rather the interpretation of those methods in the physical world (see *PWNB* 1: 9). Physics, Bohr reminds us, requires observation (*PWNB* 1: 54).⁸

En route to an explanation of the theory he will propose, complementarity, Bohr references Heisenberg’s then recently devised uncertainty principle. In describing the claims and effects of the uncertainty principle, two sets of concerns addressed by the principle arise: the disturbance produced by measurements and the impossibility of measuring wave-like properties and particle-like properties at the same time. In the domain of classical physics, a good description of the observed universe includes not only the locations of the elements of it with regard to time and place but also the causal effects developing from that situation. This “causal space-time description” works fairly well for the things we can see without instruments, things that are large and slow, at least by comparison with Planck’s constant and the speed of light (Bohr, *PWNB* 1: 55). Similarly, in the classical illustration of a billiards table, the location and the movement of the objects in a big, slow system arise directly from what came before, be it a cue striking a ball or a ball rolling into a pocket. As I have discussed in connection with *The Einstein Project*, Albert Einstein’s relativity theory disturbed the distinction between space and time. Quantum physics disturbed the association between location and causation. At hand in Heisenberg’s uncertainty principle is an experimental difficulty (observing the universe *disturbs* the universe) and an ontological one: the greater the precision with which one property is measured, the lesser the precision to which another can be measured or even said to exist.

Bohr’s complementarity is most relevant to the latter problem. Raising the apparent incompatibility of the treatment of light as particle and as wave, he indicates that “The two views of the nature of light are rather to be considered as different attempts at an interpretation of experimental evidence in which the limitation of the classical concepts is expressed in

complementary ways” (PWNB: 1.56).⁹ As Bohr argued, causality and spatio-temporal location become complementary and exclusive. Bohr elaborates (in this lecture and elsewhere) on the completeness of a quantum-description which is nonetheless bound by the limits articulated in the uncertainty principle. A precise statement of location, for example, would be a complete description, despite the lack of any statement of momentum (thus one might consider Heisenberg’s principle a statement of limitations and Bohr’s a statement that within those limits one can nonetheless encompass a complete system). Bohr’s theory allows one to know that one is done with description.

Early in the second act, while Heisenberg and Bohr are rehearsing the progress of physics between the wars, they attempt to elaborate the interrelation of Heisenberg’s uncertainty principle and Bohr’s complementarity¹⁰:

HEISENBERG. Listen! Copenhagen is an atom. Margrethe is its nucleus. About right, the scale? Ten thousand to one?

BOHR. Yes, yes.

HEISENBERG. Now, Bohr’s an electron. He’s wandering around about the city [...], no one knows where. [...]. I’m a photon. A quantum of light. I’m dispatched into the darkness to find Bohr. And I succeed, because I manage to collide with him.... But [...] he’s been deflected! He’s no longer doing exactly what he was so maddeningly doing when I walked into him!

BOHR. But, Heisenberg, Heisenberg! You also have been deflected! If people can see what’s happened to you, [...] then they can work out what must have happened to me! The trouble is knowing what happened to you! Because to understand how people see you we have to treat you not just as a particle, but as a wave. [...]. Particles are things, complete in themselves. Waves are disturbances in something else.

HEISENBERG. I know. Complementarity. [...].

BOHR. They’re either one thing or the other. They can’t be both. We have to choose one way of seeing them or the other. But as soon as we do we can’t know everything about them. (68–69)¹¹

However Bohr, Heisenberg, and Margrethe approach their reenactment of the 1941 meeting, they foreclose some avenue of possibility. And the question they are trying to answer is *not* where Bohr is: “The trouble is knowing” what Heisenberg was up to, as a physicist, a friend of Bohr, and a German. The complementarity metaphor, which the historical Bohr had hoped would meet the physicists’ needs in part because it bore “a deep-going analogy to the general difficulty in the formulation of human ideas,” maps onto the struggle these characters undertake in articulating their ideas surrounding Heisenberg’s visit as well as the epistemological limits they face (*PWNB* 1: 91).

HEISENBERG ON TRIAL: (NOT) KNOWING WHY

The centrality of epistemological concerns raises several points of connection to two other genres of science drama: the courtroom drama (e.g. *Licence to Murder* and *In the Matter of J. Robert Oppenheimer*) and the espionage drama (e.g. *Hapgood* and *The Traitor*). The judicial-ethical context invoked by legal systems in such plays (explicitly in courtroom drama and implicitly in espionage drama) is also invoked by the characters of *Copenhagen* when Niels and Margrethe Bohr’s opening dialogue offers the premise of the play as questions:

MARGRETHE. But why?

BOHR. You’re still thinking about it?

MARGRETHE. Why did he come to Copenhagen? (3)

These first words of the play are a series of questions; implicit in them are not only the often-debated question of Heisenberg’s motives and their relation to either his loyalty to Germany or his efforts to keep the Second World War a conventional rather than nuclear war, but also the question of Heisenberg’s personal loyalty to the Bohrs and, moreover, what could possibly cause Margrethe still to be bothered by the uncertainty surrounding Heisenberg’s reason for visiting.

As Heisenberg underscores, “explaining and defending myself was how I spent the last thirty years of my life. When I went to America in 1949 a lot of physicists wouldn’t even shake my hand. Hands that actually built the bomb wouldn’t touch mine” (Frayn 47). His suggestion is that the questions he answered about himself were never unproblematic. His answers were not merely facts; they were defenses against charges leveled

against him, and the restagings entered into by *Copenhagen* are a part of that series, despite Heisenberg's initial frustration that "The more I've explained, the deeper the uncertainty has become" (4). So, from the beginning these characters' efforts toward understanding are a product of deep uncertainty and moral accusation; Heisenberg having been already commonly judged guilty of being a Nazi physicist, the play operates on the basis of a slight opening of uncertainty about that judgment; Heisenberg continues to attempt to "explain and defend" himself.¹²

Accusation is, suitably, a covert component of the espionage drama, but the epistemological struggle is yet more complex: not only does one side seek to find who the spy or criminal is but the spy also seeks to obtain some (secret) knowledge. Practicing physicists' subsumption under the military-industrial machines of wartime Germany and America drew a line of secrecy across the friendships clearly developed among working physicists. Frayn's play suggests that by 1941 a combination of military secrecy and surveillance has cut off communication not only between Heisenberg and the non-German physicists but also between Bohr and the physicists working in America. Frayn's Heisenberg repeatedly seems not yet to have grasped this shift. At one point he claims "the choice [whether or not to pursue a fission bomb] is in our hands! In mine – and Oppenheimer's!" (44) His sense of equivalence with Oppenheimer, through which one could read an awareness that Heisenberg and Oppenheimer are opponents in the race toward the bomb, is undermined by Heisenberg's "our": for Heisenberg the struggle between Us and Them is not between the Axis and the Allies; it is between the physicists and everybody else.

At the same time a proliferation of attention both threatens and permits communication in *Copenhagen*. The characters suspect, rightly, active surveillance to broadcast and act upon whatever might be said in the Bohrs' home, and they therefore proffer covering dialogue for its benefit, e.g., "A turn around the garden [as we talk]: Healthier than staying indoors, perhaps" (32). In the presence of surveillance the Bohrs and Heisenberg found themselves conversing elliptically at best (and, historically, the possibility of surveillance is one reason given for the lack of contemporary documentation of the meeting, such that most of the documents available even now were written long afterward). Yet in the afterlife of their dramatic reenactings, they attempt to deceive themselves into an un-observed state: "Let's start all over again from the beginning. No Gestapo in the shadows this time. No British intelligence officer. No one watching us at all," Bohr proposes, only to have Margrethe contradict him: "Only me" (38). To be watched is the precondition for all the conversation in this play.

Margrethe and the spies are not the only watchers. Bohr and Heisenberg are themselves watching one another, even as the play's audience watches everything. As Derrida writes, "Only mortals can watch over them, and can watch, period. Ghosts can do so as well, they are everywhere where there is watching; the dead *cannot do so*—it is impossible and they must not do so" (*Specters* 174–5, *emphasis* Derrida's). Mortals and ghosts—neither the immortal nor the merely dead—can watch, do watch. Watching particularly acts on (and should act to benefit) ghosts: *Copenhagen's* lingering ghostly questions and its almost equally-lingering characters. And the watching is, for Derrida, what can provide a "welcome" to ghosts, which would be done "out of a concern for *justice*" (175, *emphasis* Derrida's). In a concern for justice, Derrida calls down not only watching and welcoming but specifically words, words of memory and welcome.

Whether the welcome is accepted in the terms in which it is offered (and such an insistence on terms would be coercive rather than welcoming), hospitality does not call for a revisitation of the past or a replaying of static recordings. In these terms, Bohr and Heisenberg *must not* enter again into the events of 1941 with the 'Gestapo in the shadows.' Out of a concern for justice, they should offer welcome, reaching from a future toward a past; their obligation toward justice is to "learn [...] how to talk with" the ghost (Derrida, *Specters* 176). And *Copenhagen's* three characters try; the three of them reenact the visit for the first time in the play under the impetus of Margrethe's ongoing questioning of Heisenberg's reason for making the visit. Neither this question, severally iterated, nor its partner, "What did he say?" ultimately receives a settled answer, suggesting that this question is, as Bohr suggests, one with "no answers to find" (32, 3).¹³

Bohr's concern about the possible impossibility of finding answers once again enacts metaphysical considerations associated with the Copenhagen Interpretation of quantum physics. Under the Copenhagen Interpretation (which derives from Bohr's and Heisenberg's combinations of complementarity and uncertainty), some things are inherently, ontologically, unknowable. The limitation is not a limitation of instrumentation, of technology, or even of human perception and cognition. Similarly, the questions with which these ghostly characters engage may have no answers to find.

The men decide to try again for their possibly nonexistent answers, presenting their attempt "in plain language [not mathematics ...] for Margrethe's sake," making her the Derridean "'scholar' of the future" who is listening to the ghosts (Frayn, *Copenhagen* 38; Derrida *Specters* 176). She was also historically Bohr's typist through the drafts of his scientific papers,

so Bohr's implication that Margrethe is the audience for whom the mathematical language would need to be translated is nearly as absurd as his presumption that Heisenberg would find mathematics the most appropriate language for explaining his own intentions. Bohr's conceit enables the theatre audience—possibly less well-versed in quantum physics than Margrethe—to attempt to understand the ghosts which are these three characters.

MEMORY, TIME, AND PURPOSE

Copenhagen begins in a play of verb tense and memory. The opening dialogue between Margrethe and Niels Bohr establishes (within four lines) that Margrethe, Bohr, and Werner Heisenberg are “all three of us dead and gone” and that Heisenberg's visit to the Bohrs is something that Margrethe is “still thinking about” (1). Having clearly established the past tense's appropriateness for use regarding not only that visit but also the entirety of their lives, these “ghosts” quickly rehearse the fraternity of nuclear physicists that had surrounded Niels Bohr before the war.

It is worth noting that the Bohrs do not unambiguously notice Heisenberg's presence until after the three characters have separately worked their ways through the day leading up to Heisenberg's arrival at the Bohr's home. The characters' preoccupation with the same question—what Heisenberg intended in visiting the Bohrs—places in juxtaposition their separate memories of the physically separated events of the day, a juxtaposition underscored by Heisenberg's narrative description of his own approach to the Bohrs' house, which suggests his separation despite his presence on the barren stage with the Bohrs.

To arrive at the reenactment of the evening, Bohr and Margrethe discuss and reenact their concerns. Their conversation shifts from the confusion they still feel to the concerns they felt at the time, disagreeing about their initial responses of attraction toward and repulsion from Heisenberg when they had, early on, welcomed him as one of the family, and concluding that it would be impossible to go to his lecture when it was being sponsored by the Nazis (4, 6–7). Heisenberg, on the other hand, speaks a more linear narrative, not as obviously marked by a post-1941 perspective. He offers reflections that appear directly prompted by Bohr and Margrethe's conversation, in contrast to the internal consistency of Bohr and Margrethe's conversation with one another.

Not yet coordinated in space, though together on the stage, the three remember:

- HEISENBERG. September, 1941. For years I had it down in my memory as October.
 MARGRETHE. September. The end of September.
 BOHR. A curious sort of diary memory is.
 HEISENBERG. You open the pages, and all the neat headings and tidy jottings dissolve around you.
 BOHR. You step through the pages into the months and days themselves.
 MARGRETHE. The past becomes the present inside your head.
 HEISENBERG. September, 1941, Copenhagen ... And at once – here I am, getting off the night train [...]. (6)

Against Heisenberg's admission of the fallibility of his memory, Frayn immediately deploys a textual metaphor for memory and, in the dissolution of the "pages" of memory into "the months and days themselves," re-authorizes memory as a present and reliable text. As well as transforming malleable memory into textual stability, this dialogue further transforms that text into a direct rather than mediated access to the past: memory presents rather than *represents* the past. To make this transformation work, Frayn has also to bring the past into the present, to alter the distance between the scene of the play's present and September 1941, so that Heisenberg also becomes present to himself.¹⁴ These characters do not simply enter into their pasts, nor do they just think about the past. While they move themselves backward into their memories, they also bring the past forward and surround their present selves with that past. Although this has the effect of representing each character as overlapping his or her own earlier self, the frequent asides not only provide the audience with access to the characters' thoughts but also underscore the hidden dissociation between 1941 and the play's posthumous present.

The similarity of Bohr's figuration—"You step through the pages into the months and days themselves"—to a filmic dissolve or flashback, along with Heisenberg's narrative "here I am," helps to lure the audience into accepting the first iteration of the events of that evening as if this presentation were unmediated by time and memory. Heisenberg's presentation, that he is "at once"—immediately, unmediatedly—in 1941 draws time into this loop of some 60 years. The doubling of the moment effected by

the characters' asides reinforces the suggestion that the temporal geometry is a static loop: Margrethe especially provides a running commentary in which the negative opinions she expresses toward Heisenberg at the beginning of the play appear to be a later commentary developed from opinions she held in 1941.

As with the reversed temporal flow (and reversed causality) shaping *Now Then Again*, the application of quantum physical rules to *Copenhagen*'s characters frustrates the audience's expectation of familiarity when another repetition of the "same" scene appears on the stage. And, in fact, as *Copenhagen*'s characters press through their restagings again and again, looking for different bits of the puzzle they are trying to solve, admitting to more and more possibilities in those moments, the historical tracks they attempt to trace begin to mimic quantum dynamical superpositioning. That is to say, quantum elements are associated with a wave function (ψ), the square of which (ψ^2) is regularly called its "probability wave."¹⁵ The wave describes a range of variously probable realities which observation collapses to a specific pinpoint that becomes the only reality. In *Copenhagen* we get to see a set of possible histories and this precisely because we are not observing actual history—to make an observation collapses the wave function to what *is* rather than allowing it to range over what is possible. Such collapse, or the observation provoking it, is comparable to the lesser of two options Derrida indicates for interacting with a ghost. The coercive observation would be to "make conversation" with the ghost rather than engaging, more generously, in "talk" (*Specters* 176). This latter type of interaction is one which is not be imposed on the ghost from the outside but which the ghost is to be allowed to teach, even if such teaching changes the one "with" or "through" or "in" whom the ghost speaks (176).

Far from being a play in which the temporal geometry is a clear repetition or even remembrance of a single set of events, the play builds a temporal collage of quite a number of moments drawn from the characters' lives before and after the 1941 meeting. One moment invoked several times in the play is the death of the Bohrs' oldest son, Christian, who drowned, having fallen off a sailboat.¹⁶ Bohr's regret regularly resurfaces in conjunction with discursive images of *Heisenberg* as a "lost child" (52). Of the six times Christian's death is specifically referenced in the play, four directly follow such images, as if the idea of Heisenberg's lostness, associated with homesickness and with wondering where he can be at home in the world, reminds Bohr of his other lost child. Another of the occasions on which Christian's death is mentioned follows Heisenberg's comparison

between his own isolation and the Bohrs' family, an inversion of the inclusiveness of the "father and son business" to which his collaboration with Bohr had been compared early in the first act (28, 5). The memory of Christian's death—"those same few moments that I see every day," Bohr reflects—seems to function straightforwardly to underscore that in the estrangement between Bohr and Heisenberg after the war, Bohr lost another son (29). However, the fifth invocation of Christian's death reconstellates that loss:

- HEISENBERG. You think I should have joined the plot against Hitler, and got myself hanged like the others.
[...].
- HEISENBERG. [...]. What would it have achieved if you'd dived in after Christian, and drowned as well? [...].
[...].
- HEISENBERG. [...]. Better to remain alive, and throw the lifebuoy. (75, 76)

Here Christian's death happens not only because Bohr had allowed the boy to take the tiller of the boat but also because all that seems to have been done to save him was to throw in a lifebuoy. Did Bohr choose to stay aboard and then, having changed his mind, have to be restrained from leaping in after? Would he, too, have drowned if he had leapt in? Heisenberg's analogy of active plotting against Hitler to diving off of the boat to save Christian works against the repeated associations of Heisenberg with Bohr's children by comparing Heisenberg's failure to act with Bohr's.

In this instance, what Heisenberg has lost is not his home nor his life but the reckless speed with which he had blown past decisions. Throughout the play, skiing appears as a figure for thinking. Early on, Bohr raises it as an indication of Heisenberg's competitive spirit, with Heisenberg's recollection of both his time and Bohr's a clear indication that the race had mattered to him:

- BOHR. I don't recall how long I took.
- HEISENBERG. Forty-five minutes. [...]. Your ski-ing was like your science. What were you waiting for? [...].
- BOHR. At least I knew where I was. At the speed you were going you were up against the uncertainty relationship. [...].
- HEISENBERG. I certainly didn't stop to think about it.

- BOHR. Not to criticize, but that's what might be criticized with some of your science.
[...]
- HEISENBERG. Decisions make themselves when you're coming downhill at seventy kilometres an hour. (24–5)

In competition with the usual response to Heisenberg—that he was working to give Hitler the bomb—or even one of Bohr's responses in the play—that his failure to do so was a result of incompetence, evidenced by the manifest failure to include what are now considered basic safety measures on his nuclear reactor as well as his huge miscalculation of the critical mass (Frayn 51, 82)—Heisenberg races to reach a place beyond the war-time division and to displace decision making itself from himself to the speed. Rather than accusing Heisenberg for working to give Hitler the bomb or, as Bohr does elsewhere in the play, for incompetence in his manifest failure to take adequate safety precautions on his reactor and in his hugely miscalculating the critical mass needed for a chain reaction, Bohr's reflections displace judgment onto Heisenberg's speed, his incalculable momentum.

As well as the sheer speed which would, the play suggests, prevent Heisenberg from thinking about what he is doing, Heisenberg offers up Bohr himself as the responsible party. When the two counterfactually reenact their later meeting—which was in 1947 with Heisenberg's "very conspicuous minder from British intelligence" also present (35)—wherein they first tried to come to agreement on what they had said in 1942, emphasizing that this time they have no audience but themselves and Margrethe, Heisenberg says he had come to Bohr, on behalf of "the whole German nuclear team in Berlin" because they "all see [Bohr] as a kind of spiritual father" and were seeking "absolution" from "the Pope" of quantum physics (38, 39).

But Heisenberg revises his statement of purpose. He disavows absolution and instead proposes that he and Bohr can discourage work on fission by emphasizing its difficulty and expense, as long as Bohr can get Oppenheimer to go along (40–44). Having begun to shift responsibility onto Bohr, as also happens later in the play when Heisenberg suggests his own work on fission is comparable to Bohr's inability to save his son from drowning, Heisenberg jumps forward to the night he learned of the bombing of Hiroshima. He begins by taking advantage of the war-time polarization into Us and Them—along with the English language's ambi-

guity between a singular and a plural “you”—to shift entire responsibility for the bombing onto Bohr’s shoulders, for a moment, as he contrasts the responses of the Germans confined at Farm Hall to the realization that “You’ve done it, though. You’ve built the bomb” (46). Margrethe launches to Bohr’s defense, noting that the Manhattan project was well underway before Bohr arrived. He further demurs:

- BOHR. In any case, my part was very small.
 HEISENBERG. Oppenheimer described you as the team’s father-confessor.
 BOHR. It seems to be my role in life.
 HEISENBERG. He said you made a great contribution. (47)

Because he joined a work in progress, he is able to focus on answering *how* and not *whether* to make use of the Bomb, “work[ing] out how to trigger the Nagasaki bomb,” making it possible to start that explosion now that Einstein, Roosevelt, Oppenheimer, and others started the project (47). As Margrethe observes, Heisenberg’s shift has the effect of putting Bohr on the defensive, in the same rhetorical position Heisenberg was forced into for “the last thirty years of [his] life” (47).¹⁷ Heisenberg—his own “goodness” made perhaps as irrelevant as Bohr’s—says that culpability in either the nuclear holocaust or the Nazi’s Jewish holocaust is enough to produce “shock” and self-abnegation (47, 46). And what he himself takes responsibility for is “the real moment of decision” in which he avoids telling Speer that the nuclear reactor—a power plant—could produce the very plutonium a bomb would need (48, 49). Heisenberg calls this the decision and thus takes credit for killing the German bomb program rather than responsibility for killing people.

To solve the diffusion equation, which informs the critical mass to maintain a chain reaction in nuclear fission, makes the bomb seem possible. Heisenberg uses his overestimate made after the fact (and his failure to make the calculation any earlier) to excuse himself; he proposes these as exonerating details indicating his non-intention to make the bomb. And Bohr sees his options in response as anger (the reaction the first reiteration of the meeting produced, in act one) or “the paternal role” (90). The problem with choosing “the paternal role” is, according to the counterfactual logic Bohr and Heisenberg explore, that this fatherly intellectual guidance would have pursued the ideas with Heisenberg, developing them into a confirmation to Heisenberg that the bomb is possible; this would

have radically altered the nature of the decision Heisenberg has got to make: Heisenberg would have been responsible not for failing to disclose that his reactor would very slowly produce plutonium for the bomb but more actively for either developing or failing to disclose the possibility of developing the bomb itself. The more arguably ambiguous positions Heisenberg historically and fictionally situated himself in would cease to be options, if Bohr had pushed him to make careful calculations and to question his own assumptions.

Farcically, Heisenberg's planned interruption of work on nuclear fission weapons (if we take him at his word that this was his intent) goes awry by another interruption: Bohr put an end to the conversation before Heisenberg was able to fully articulate his plan in 1941. But had Bohr not interrupted (as the characters counterfactually explore in the closing pages of the play), he would have asked the question making Heisenberg's attempt to foreclose the bomb projects treasonous rather than neglectful; Bohr would have asked Heisenberg about the calculations on which he based his assumption of the difficulty of developing the bomb, calculations Heisenberg had not carefully made. As Margrethe describes it to Bohr, "That was the last and greatest demand that Heisenberg made on his friendship with you. To be understood when he couldn't understand himself. And that was the last and greatest act of friendship for Heisenberg that you performed in return. To leave him misunderstood" (89). In the tension between responsibilities—to his friend and mentor, to his country, and to the international community of physicists—Heisenberg could not make a decision in one direction without simultaneously making a betraying decision in another.

As the play's very first restaging of the meeting gets underway, Heisenberg is already alive to the tension of decision. He reflects:

HEISENBERG. So now here I am, walking out through the autumn twilight to the Bohrs' house at Ny-Carlsberg. Followed, presumably, by my invisible shadow. What am I feeling? Fear, certainly – the touch of fear that one always feels for a teacher, for an employer, for a parent. Much worse fear about what I have to say. About how to express it. How to broach it in the first place. Worse fear still about what happens if I fail. (10)

HEISENBERG. I crunch over the familiar gravel to the Bohrs' front door, and tug at the familiar bell-pull. Fear, yes. And another sensation, that's become painfully familiar over the past

year. A mixture of self-importance and sheer helpless absurdity – that of all the 2,000 million people in this world, I'm the one who's been charged with this impossible responsibility. ... The heavy door swings open. (12–13)

Heisenberg begs several questions: by whom or what has Heisenberg “been charged with this impossible responsibility,” for what has he been made responsible, and why is it impossible? His fears—awe of Bohr and fright associated with the conversation he plans to start and with the consequences if he fails (again, fails at what is our question)—coupled with his sense of ‘self-importance’ suggest that his responsibility relates to his position in Germany at the time: the “uranium club’s” theoretician since September 1939 (Cassidy, *Uncertainty* 418). The work of the uranium club was nuclear fission, both for energy production and for use as a weapon. Although the historical Heisenberg (and many of his supporters) have often argued that Heisenberg’s efforts were directed primarily towards the former use—and even argued that his focus on energy production was a deliberate effort to deprive the weapons teams of resources—Heisenberg himself “reportedly recalled: ‘It was from September 1941 [the month of Heisenberg’s meeting with Bohr] that we saw an open road ahead of us, leading to the atomic bomb’” (qtd. in Cassidy, *Uncertainty* 435). Heisenberg’s anxieties, in the context of Frayn’s play, remain equally attributable to two desires: fending off German (and American/Allied) development of the bomb and demonstrating the truth of his theories by producing a fission bomb.

DECIDING RESPONSIBILITY TOWARD THE GHOSTS

As Bohr and Margrethe argue about why Heisenberg might be coming to visit them, Margrethe wonders whether it is because Heisenberg is working on a fission bomb. Bohr counters that “no one is going to develop a weapon based on nuclear fission,” because “one of the implications of [the 1930 paper by Bohr and John Wheeler] is that there’s no way in the foreseeable future in which fission can be used to produce any kind of weapon” (11, 12). Although a great deal has been made, both historically and in this play, of Heisenberg’s failure to calculate the diffusion equation (which answers how large critical mass for a fission weapon would be), Bohr’s oversight in this analysis has been relatively largely overlooked and strangely never directly a point of contention, despite Heisenberg,

Margrethe, and Bohr's continuing explorations of their ignorances and attempts to shift responsibility and blame from Heisenberg to Bohr and back. Instead, in this early moment, Bohr believes his authority and his careful work are sufficient to prevent any physicist from working to develop a fission bomb. The first iteration of Heisenberg's visit ends in Bohr's outrage—such outrage that when Margrethe asks what Heisenberg had said Bohr replies “Nothing. I don't know. I was too angry to take it in” (33)—apparently angry over an inference that Heisenberg was working on a fission bomb.

As long as their questions remain unanswerable ghosts, *Copenhagen* performs interruptions to the efforts its characters make to pin down not only what the past was but how it should have been. The decision, emerging in response to questions without offering an answer, grants responsibility and subjectivity to the one who decides.¹⁸ At one point, Frayn's Heisenberg practically shouts at Bohr that he had come to Copenhagen so that Heisenberg, Bohr, and J. Robert Oppenheimer (who would lead the American bomb project) could among them conspire to make nuclear weapons appear too impossible for any of the parties to World War II to pursue. Bohr's response to this plan:

- BOHR. Not to criticise, Heisenberg, but if this is your plan in coming to Copenhagen, it's ... what can I say? It's most interesting.
- HEISENBERG. It's not a plan. It's a hope. Not even a hope. A microscopically fine thread of possibility. A wild improbability. Worth trying, though, Bohr! (44)

In contrast to the presumption that only high-possibility outcomes are worth pursuing (inherent in the contrast between optimism for the American bomb project and pessimism for the German project, based on the masses of U-235 estimated as necessary), Heisenberg offers that his “microscopically fine thread of possibility” is “worth trying.” And this possibility itself is an interruption of another sort: Heisenberg's plan would be to interrupt nuclear research itself, to delay the undertaking of weapons research (if not permanently then at least until the war had been finished through conventional means).

Whereas Heisenberg and the Bohrs initially found themselves trapped by the persistent ghosts of unanswered questions, that trap takes the shape of Schrödinger's box.¹⁹ The uncertainty relations, by which complemen-

tary properties of experimental objects at the quantum scale are said to be determinate only to a degree inversely proportionate to the extent to which the complement is determined, then, are useful in describing the probability of any particular position, momentum, and so on., of such particles. Schrödinger's cat, locked in its impenetrable box, is said to be a probabilistic mist of living-cat and dead-cat, until one opens the box to discover which of the two equally-probable states obtains. Such discovery, collapsing the wave-function of probability into one determinate state, is what the characters in *Copenhagen* seek: one actual narrative of Heisenberg's reasons for going to see Bohr and of what the conversation actually was. The apparently closed loops of time—like Schrödinger's impenetrable box—are the site of a thought experiment and an epistemological game. Just as Schrödinger's cat is both alive and dead *and* neither alive nor dead, until somebody opens the box to have a look at it, so are these ghostly questions everywhere and being answered in every way—unanswerable because, despite an audience sitting and watching the *play*, the event itself (Bohr and Heisenberg's actual meeting) had no objective observer. The play's questions are almost nonsensical in these terms, as *Copenhagen* seemingly only offers a range of variously probable answers: Heisenberg did and did not understand the reactor on which he was working, he was and was not doing so to divert German resources from their bomb project, and he was and was not attempting to recruit Bohr to keep nuclear weapons out of the war.

Despite Bohr's suspicion that there are 'no answers' to the question, and motivated by a generally scientific desire to know, the three characters launch themselves into the past. As they do so, they are listening to the ghostly questions to which Margrethe attends from the beginning of the play.²⁰ As scientists and scholars, Bohr and Heisenberg follow Margrethe's attention to those questions, those ghosts, now that "no one can be hurt, now no one can be betrayed" (4). In so doing, they engage in a practice Jacques Derrida prescribes at the end of *Specters of Marx*, to "learn [justice ...] from the ghost" because "[t]hey give us to rethink the 'there' as soon as we open our mouths" (176). Justice, here, unfolds in a future which listens to its past. This kind of listening breaks time out of simple linearity and also suggests the relativistic question of frame of reference: from which vantage point, which frame of reference, can we find "the 'there'"? In their repeated efforts to reenact the meeting, the characters of *Copenhagen* implicitly accept the premise that reenacting produces a potential vantage point from which to view that past. Their misgivings

suggest they know better, but that they continue anyway is a reflection of such “rethinking.”

In tracing the shape of space-time, *Copenhagen* is one text which overtly considers “the ‘there’” given by specters. Two sorts of ghosts emerge in *Copenhagen*: the three characters reflecting after their deaths and also the unanswered questions about the specific content of their meeting.²¹ The “ghosts” themselves—in the sense of the spectrally present personae of the Bohrs and Heisenberg—are haunted by interrogative specters of their joint past. We can take this haunting as a complication of the relationship between the “ghosts” with whom Derrida enjoins us to talk and these ghosts of scholars who are themselves talking with ghosts. In the incalculability of the gift of existence granted both to these ghostly questions and to the uncertain events, *Copenhagen* invites a reading of temporal disruption as generative of the complementarity within which one can talk with the ghost.

In *Meeting the Universe Halfway* Karen Barad elegantly elaborates an agential realist account of the philosophy and physics the historical Niels Bohr developed. Though *Copenhagen* is far from the central focus in her argument, her treatment of the play is telling. Reading from the play’s form, Barad articulates what she calls “Frayn’s uncertainty principle—the one that says that ‘we can [in theory], never know everything about human thinking’ (4). The important differences between Frayn’s principle and Heisenberg’s, as Barad carefully delineates, undermine the argumentative power of the analogy Frayn wants to draw between the two principles. Acknowledging that Frayn has made these problems for himself in relying on analogy (and then subverting even the limited power of analogical reasoning by a lack of rigor in the play’s use of uncertainty and complementarity), I nonetheless argue that the play leaves intact just enough of the metaphysics of complementarity to be legible outside the game of blame in which the play leaves many readers ensnared.

Although the ghostly characters of *Copenhagen* believe themselves subject to judgment, or subjected already to condemnation, the plurality of possibilities for their pasts remain un-chosen among: rather than reading the play’s final iteration of the 1941 meeting as the last word on the subject or the determinate observation, it is simply yet another in the range of possibilities. Heisenberg’s closing words connect uncertainty to hope to love ... and ultimately to the friendship of leaving one’s friends misunderstood: “But in the meanwhile, in this most precious meanwhile, there it is. The trees [...]. Our children and our children’s children. Preserved, just

possibly, by that one short moment in Copenhagen. By some event that will never quite be located or defined. By that final core of uncertainty at the heart of things" (94). What is determinate and unalterable here is an environment with trees and children. That there was a future after the meeting, the play settles. The meeting itself, however, is undefined for Heisenberg—he appears to renounce his self-serving explanations.

Frayn's escape for Heisenberg from this dilemma ultimately is not an escape: Bohr becomes responsible in part for the atomic bombs dropped on Hiroshima and Nagasaki, and Heisenberg is once again implicated, for not doing more to prevent Bohr's interruption. But the "one short moment" Heisenberg invokes seems to be a moment in the heart of Bohr who began with curiosity (a sympathetic curiosity, unlike Margrethe's). Heisenberg can name it as "one short moment" but he cannot place the moment in space or time nor can he name what *happened* in that moment. *Something*, he wants to say, preserved the world itself; Heisenberg does not know, and nonetheless proposes that uncertainty itself is that *something*. His argument here rests on the network of decisions made in the face of uncertainty, leading to a world which, however full of objective evidences for Bohr's or Heisenberg's culpability, continues to exist. Justice lives, for Heisenberg, in Frayn's play, in the weaving together of a network of decisions more than in the historical judgment rendered him for the outcomes of his decisions. Likewise, despite the play's repeated efforts to shift blame from Heisenberg to Bohr, Bohr's willingness to enter into reenaction and to bring into being a range of possibilities for the meeting, to embody ghosts, and set them at play within probability waves of temporal loops, equates justice with the decision to enter into decision.

NOTES

1. Carpenter is careful to qualify his statement in relationship to the criteria delimiting his archive of nuclear dramas; he has ascribed dates to plays in accordance with their initial performances, but he includes in his survey only plays which had been published (before his own book's appearance in 2000).
2. This is not at all to say that it doesn't fit Carpenter's criteria; it does, but its main energy drives the play in a very different direction.
3. The historical Heisenberg's approach to this explanation is somewhat elliptical. His emphases in this line tend to dwell more on the general technical difficulties, which were presented as directing his (and Germany's) work

toward the development of a nuclear reactor rather than toward a nuclear bomb. See David C. Cassidy's discussions in *Uncertainty* (Chapter 26, "Reconstructing," 501–522) and in *Beyond Uncertainty* (Chapters 28 and 29, "Explaining the Project: Farm Hall" and "Explaining the Project: The World," 369–389). The latter book, as Cassidy explains, "draws upon, yet in many ways transcends," the former (7). The sheer volume of newly available materials was a significant influence in Cassidy's decision to revisit, revise, and "transcend" his biography of Heisenberg.

4. On this point the play, as it often does, makes reference to an actual publication: Niels Bohr and John Archibald Wheeler. "The Mechanism of Nuclear Fission." *Physical Review* 56.5 (1 September 1939): 426–450.
5. As Robert L. King has argued, *Copenhagen*'s characters are "the heirs of [*Waiting for Godot*]'s Didi and Gogo," and they "play roles [...] as reenactments of actual events [and] the playacting teaches a form of objectivity" (174). As scientists, Bohr and Heisenberg make themselves subjects of their own study, buying for themselves a certain alienation from themselves, a vantage point from which to assess their own behaviors and motivations, King suggests.
6. As Frayn emphasizes in his postscript to the play, "All the alternative and co-existing explications offered in the play, except perhaps the final one, have been aired at various times, in one form or another" (95). Frayn is at no pains to give rhetorical emphasis to the sounder of these expositions; he explicitly claims a dramatist's license even as he has been criticized for relying too closely on Thomas Powers' *Heisenberg's War*. As Karen Barad has noted, though the play does not pretend to resolve the uncertainty surrounding the historical facts, many critics have sought to obtain from Frayn a sense of his responsibility to those facts. She writes, "even with the emergence of new historical evidence that flies in the face of Frayn's reconstruction, he remains resolutely unrepentant. In response to his critics, he insists that he doesn't feel any obligation to hold himself responsible to the historical facts" (9). Frayn's regular comparisons of his work with the work of historians, however, suggest just one source of ongoing animus.
7. Though the wave-particle problem is not chiefly that in which *Copenhagen* addresses either complementarity or uncertainty, Bohr's lecture on "Atomic Theory and Mechanics" (in which he introduces complementarity) makes clear that this is the inciting problem for his theory (see *The Philosophical Writings of Niels Bohr* [hereinafter *PWNB*] 1: 55–56).
8. Later in the lecture Bohr acknowledges the difficulties involved in speaking of "observation" with regard to quantum phenomena (67).
9. In the course of this lecture several complementary pairs are mentioned, including particles and waves, position and momentum (or energy), and spatio-temporal description and causality.

10. Unless otherwise indicated, from this point forward when writing of Heisenberg, Bohr, and Margrethe, I mean Frayn's characters rather than their historical counterparts.
11. The characters' flexibility to stage these thought experiments is facilitated by the play's staging: three chairs and a bare stage, with minimal variations in the lighting effects. The absence of contextual markers aids such quick shifts as when Margrethe is suddenly rhetorically shrunk to a nucleus—something millions of millions of millions of times smaller than she is.
David Barnett and others have remarked on the tension between the set's barren and closed lack of specificity and the converse liveliness and specificity of the play's performers (particularly in the opening production at London's National Theatre) (146). Barnett considers that this dichotomy furthers the "postdramatic" potentials of the play.
12. The staging for the London premier included "seating for part of the audience, who thus suggested a tribunal in some afterlife where the dead may be finally judged" (Bilson 27).
13. "What did he say," in several similar articulations, occurs again on pages 34, 35, 36, and 38.
14. In a late iteration of this meeting, each of the characters experiences himself or herself as a ghostly smile invisible from his or her own point of view (87).
15. For a lengthy and accessible introductory treatment of quantum physics, focusing on the metaphysics which have been associated with the field, see Nick Herbert, *Quantum Reality: Beyond the New Physics*, in which Herbert writes, "Einstein called ψ a *Gespensterfeld* or ghost field. Since it carries no energy, the wave function is also referred to as an empty wave. In France, the ψ wave is called by a beautiful name—*densité de présence*, or 'presence density'" (96).
16. Karen Barad has critiqued Frayn's use of this incident "for the purpose of layering Bohr with every (un)-imaginable kind of life-and-death responsibility" (14). Barad's focus is not only the incompassion inherent in choosing such an event but more broadly Frayn's rhetorical inconsistency in arguing on Heisenberg's behalf for a suspension of judgment (based on the thesis that we cannot have enough knowledge of his motivations to make a fair judgment) while repeatedly offering Bohr up for indictment throughout the play.
17. See Barad 16–17 for a concise and compelling critique of Frayn's use of such rhetorical shifts in this passage and elsewhere.
18. Derrida insists that the gap that prevents decidability is not a lack of knowledge (an uncertainty) but rather an interruption "between one's knowledge and the decision" ("Ethics" 298). The "interruption" bestows ethical urgency, it creates undecidability, and this temporal break in "the chain of

- consequence” gives the ethical or political decision spatiality (“Ethics” 298).
19. August W. Staub has also compared the play’s structure not only to Schrödinger’s thought experiment but also to the multiple frames of reference at work in Einstein’s relativity. His article draws a number of comparisons between the ideas of early twentieth-century physics and the form and content of *Copenhagen*.
 20. Margrethe says, “Some questions remain, long after their owners have died. Lingered like ghosts. Looking for the answers they never found in life” (3).
 21. Margrethe specifically refers to the unanswered questions (about what happened at that meeting, and why the meeting happened at all) as “ghosts” (3).

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