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An Infinity of Questions: Dramatizing Science on Stage

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AN INFINITY OF QUESTIONS

DRAMATIZING SCIENCE ON STAGE

What's past is prologue. –William Shakespeare 'The Tempest' II.1.258

1

In 1610, in Padua, the mathematician Galileo Galilei observed our moon and the moons of Jupiter through a telescope. In the autumn of 1941, Werner Heisenberg paid a visit to fellow physicist Niels Bohr in Copenhagen. The consequences of both these events entered into history. And each of these events has been dramatized in a play. *The Life of Galileo*, by Bertolt Brecht, challenges authority and the status quo. Michael Frayn's *Copenhagen* explores what he calls "the epistemology of intention," our ability to understand why people do what they do.¹ Both plays raise the issue of the scientist's moral obligations and responsibility to society. For ultimately there can be no pure pursuit of knowledge for knowledge's own sake. Both *The Life of Galileo* and *Copenhagen* feature science on stage and exemplify what science and drama do best, especially in conjunction with each other: they describe and explore the world by means of modeling ideas.

I chose to explore these plays because they both contained a moment of revelation for me. I was electrified when I heard Galileo say as his friend looks through the telescope, "What you are seeing has been seen by no other living person but me. You are the second."¹ It was wondrous to imagine what it must have felt like to be the first person to look upon the face of the moon. It was a brilliant moment of scientific discovery, both poetic and brainy. I was thrilled. For the first time in a lifetime of theatergoing I was moved nearly to tears, and by a telescope of all things.

Shortly thereafter, I reread *Copenhagen*. Something Heisenberg said in the play grabbed me: that he wouldn't miss the chance to do his research "if I can possibly help it."² If he and Bohr, like Galileo, felt that joyful electricity when they made breakthroughs in their work, small wonder they pursued it, even at high costs. The way they are compelled to do their science reminded me of doing theater. I am forever being drawn into new productions and projects. For me, doing theater is exhilarating. And like Heisenberg, I can't help myself. I am attracted to the fusion of disciplines and ideas that are brought to life on the stage. Coming from a family of several scientists, the interdisciplinary nature of Brecht and Frayn's projects

¹ Brecht, Bertolt. David Hare, Adapter. *The Life of Galileo*. For the Almeida Theatre 2004, revised for the Royal National Theatre, 2005. 15. Unless stated as coming from the 1966 Charles Laughton translation, all further quotations of the play are taken from this text.

² Frayn, Michael. *Copenhagen*. London: Methuen, 1998. 77. All further quotations of the play are taken from this text.

captivates me. The subject matter of these plays is rich, but both of these dramas also 'stage' the very concepts they contain. The interdisciplinary possibilities of theater that are exemplified by *The Life of Galileo* and *Copenhagen* make an audience both think and feel.

Fusion is everywhere in the contemporary world. Interdisciplinary courses and approaches to education are becoming more and more prevalent. But the project of joining science and drama is not new. Plays dealing with science reach as far back as 1604, with Christopher Marlowe's *Doctor Faustus*. Other plays about science have followed, particularly in the 20th century. In the last decade alone, in addition to *Copenhagen* from the world of physics, there are Tom Stoppard's *Arcadia*, which deals with chaos theory, Timberlake Wertenbaker's *After Darwin*, which examines evolution, chemist Carl Djerassi and Roald Hoffman's *Oxygen*, which concerns the discovery of the element that gives the play its title, and David Auburn's *Proof*, which deals with the world of mathematics.

But *The Life of Galileo* and *Copenhagen* particularly stand out and make a strong pair, even beyond sharing the thematic link of the atomic bomb. Both plays explore the scientist's responsibilities to society and use their characters' science to enact the themes of the drama. The similarities in the way these plays stage their issues is also striking, given the difference in their authors' projects: Brecht's choice of writing about Galileo springs from his reaction to the Nazis and from his own Marxist ideals, and Frayn's choice of writing about Bohr and Heisenberg's 1941 meeting developed out of his interest, as a philosopher, in epistemology. These are excellent plays centered around science both because they do justice to their theatricality, as well as to the science they dramatize. In these plays, the science is not merely a useful device for symbolizing the play's larger issues. For both Brecht and Frayn chose to write plays in order to *embody* the text through performance, similar to the way a model demonstrates a scientific theorem.

Bertolt Brecht wrote the first version of *The Life of Galileo* (hereafter *Galileo*) in 1939, in Denmark, with the Nazi regime's oppressions and persecutions in mind. He created a second, English-language version, in collaboration with a number of people, most notably the English actor Charles Laughton, who played the title role in 1947 in Los Angeles. Brecht was reworking the play again in 1955 for his Berliner Ensemble, but died before its completion. The play chronicles the life of Galileo Galilei, beginning with his 'improving' a Dutch telescope that he passes off as his own invention, turning it to the skies and finding proof for the Copernican theory of heliocentricity. His research brings him into conflict with the Roman

Catholic Church, which viewed Copernican theory as displacing man and God from their positions in creation. Eventually, Galileo goes before the Inquisition and recants his theory in order to save himself from torture. He spends the rest of his life under house arrest, where he secretly finishes his *Discourses* on two new sciences, which are smuggled out to Holland. At the end of the play, Galileo acknowledges himself to be a traitor to science.

Michael Frayn's *Copenhagen* is indebted to Brecht. It is about Niels Bohr and Werner Heisenberg, physicists who are scientific descendents of Galileo. Written in 1998, *Copenhagen* features the specters of Niels and Margrethe Bohr and Werner Heisenberg on a bare stage. They try to work out what happened during a conversation Bohr and Heisenberg began on Heisenberg's visit to Bohr in 1941. Though dead, they still hope to clarify their motivations because their work—even before the war—paved the way for the atomic bomb, the ultimate example of the dangers of science that Brecht's Galileo alludes to in his final speech.

Both these plays humanize the science. In this day and age of complex machinery, nanotechnology, advanced mathematics and highly specialized fields, science can benefit from a certain 'softening.' Writing courses for scientists aimed at helping them to communicate their ideas intelligibly to non-scientists reflects their awareness of this need. And scientific institutions like the Wellcome Trust and the Sloan Foundation give grants specifically for theater projects that break down the barriers between science and art and promote understanding of science.

There has always been a certain general apprehension about science. The roots of that apprehension are old, possibly beginning with Galileo's displacement of man from a central position in the universe. Science has gradually supplanted religion as a source of answers and explanations; even so, *Copenhagen* dramatizes what Brecht's Galileo feared: that the progress of science paves the way for destruction. Yet in both *Galileo* and *Copenhagen*, the scientists' own hope for science is that it may help solve human problems, not cause them.

Theater's approaches to questions about the human condition have helped science in the past century as its power became more deadly. Considering Cold War policies, author Charles Carpenter wrote, "Just as strategists now had to 'think the unthinkable,' writers were now compelled to imagine the unimaginable."² Theater from its Greek origins (*theatron*: the seeing place) has dealt with seeing the 'unseeable' and enduring the unendurable. Author of *The Moral Dilemma of the Scientist in Modern Drama*, Allen Hye notes, "Like the artist, the scientist lives for a new expression of reality...[And] fear of scientific breakthrough is linked

both to the specific products or philosophical implications of a discovery—a new weapon, an unsettling idea—and to the simple fact that the breakthrough requires a fresh encounter with reality.”³ With good plays, we have such encounters with our views of reality in the theater. It is a forum we have created for such explorations and reckonings. Teacher Kirsten Shepherd-Barr writes, “Whatever the particular type or category, most science plays are [investigations of]...human problems by reference to scientific ideas.”⁴ *Galileo* and *Copenhagen* are even more than that; to remove the science is tantamount to erasing the play. Both plays are intriguing precisely because their science is not merely a springboard into philosophical issues. Rather, the content and form of these plays are shaped by their science in order to enact that science and its implications for human life.

Science and theater share formal similarities as well. Science lends itself to drama as a theatrical metaphor. Dramatic structure can mirror the scientific method and a play’s production is akin to a theorem’s model. The scientific method and structure of a scientific paper are similar to the format of a traditional, realist play: hypothesis/exposition (Act One) experiment/complication (Act Two), and conclusion/denouement (Act Three). Science uses models for demonstrations, while theater embodies and performs (‘demonstrating’ through actors and sets and costumes and music, etc). Moreover, there is the tendency of theater theorists and artists to create methodologies and systems based on, and inspired by, scientific concepts. Shepherd-Barr notes that, “Brook, Stanislavsky, Brecht, Meyerhold, Grotowski and Boal...[all] set down and codified their ideas and strategies about performance.”⁵ Some of the impulse for codifying theatrical theories stems from the desire to legitimize the often marginalized and controversial theater by lending its practices the authority of science.

In science then, one devises a theory, seeks out evidence and, if that evidence supports the theory, that theory becomes a law. Translating this model to theater results in something of a looser process, but it is a similar one. Constantin Stanislavsky had an idea about what constituted authentic acting, and so he created exercises to enable actors to give the desired style of performance, which became a brand of naturalism (or ‘The Method,’ in America). Having a systematic approach to theater gives it grounding. Yet the fact is that performances vary; each will be distinctive. A performance is much like a science experiment. There are expectations and predictions about the outcome. Then the ingredients are thrown into the beaker, the actors onto the stage, and what happens happens. The result, however carefully planned and designed the conditions and rehearsals, is a unique and ephemeral creation.

Even more than attempting to justify, or ground, drama, science-like systems and methods give structure to theater arts. Indeed, Polish director Jerzy Grotowski's "Laboratory or 'Methodical Exploration' [was] founded vaguely on the model of the Bohr Institute for physics," with three tenets: to stimulate a process of revelation, to be able to articulate that process and "to eliminate from the creative process the resistance and obstacles caused by one's own organism, both physical and psychic."⁶ In light of Bohr and Heisenberg's discussion of their working and publishing habits, and Galileo's exclamation, "Our aim is not to open the door to wisdom, but to set a limit on stupidity!" Grotowski's rules could apply equally well to science (Brecht, 54). Science is inherently dramatic. Chemist and playwright Carl Djerassi attributes this to the fact that science "deals with the new and unexpected."⁷ Even if plays are concerned with the commonplace, instead of fantastical adventure, something in the drama must encourage the audience to view the subject from a *new* angle. Indeed, much of Brecht's theatrical technique served this purpose: making the familiar somehow foreign in order to cause the audience to think about it.

At heart, both theater artists and scientists are creators. Hye writes, "The ability to create is something uniquely human, and within humankind this ability is highly developed in the artist and scientist. For that reason, they are often seen as outsiders, set apart from the average citizen by their abilities and interests, and frequently in conflict."⁸ And conflict drives drama. People continuing to pursue their own desires in the face of obstacles, or trying to reconcile their wants with the differing wants of others, keeps a play going. Both *Galileo* and *Copenhagen* have very clear and highly charged conflicts: between man and authority, ambition and morality, career and country, friend and friend. While the conflict of a drama can often conclude with resolution, *Galileo* and *Copenhagen* end with no neat sense of closure. This aligns them with science, a discipline that, at least so far, has no ultimate resolution. There is always another experiment to be conducted, competing ideas and theories to explain phenomena.

Science works well on stage because it wants to share its information, discoveries and uses. The theater is a versatile means of communication, teaching and entertainment. With science so specialized nowadays, without devoting a lifetime to it, average people cannot become experts in its various fields. But drama can make complex science accessible. The stage is a place where disciplines can meet. At the very least, the theater is an accepted place for (thinking and feeling) people, audience and actors alike, to 'play' at being well versed in those disciplines for a few hours. Frayn says that as a playwright he cannot know

How much they [the audience] know. Some of them are going to know less than you do yourself and some of them are going to be nuclear physicists and they're going to know a great deal more than you do. So, I think you really just [have] to just tell the story and make the story work. Or try to.⁹

Simply, the audience enters the theater with varied levels of knowledge of physics, history and so on that can be expounded upon as the production progresses. Through the performance (the dialogue, blocking, setting) the actors impart the science involved to their audience.

Plays rivet people's attention because they are like a barometer of the day for the culture, nation or movement from which they emerge. The science of *Galileo* and *Copenhagen* are relevant today, though both deal with specific individuals and events of the past. This is another important characteristic of the dramatic structure: distance. Playwright David Hare observed that we need a "slight touch of distance if we are going to be able to think and feel at the same time."¹⁰ Perhaps we cannot do both at close quarters because of a sort of psychological equivalent of Heisenberg's Uncertainty Principle, but with the aid of distance we can do both because of Bohr's theory of Complementarity. With a degree of detachment the dual activity of thinking and feeling becomes possible. The dramatic form provides that step of removal between the action on the stage and the people in the audience.

In theater the real life rendering of a script is through bodies. In science, the real life rendering of a theory is through models –such as Galileo's Ptolemaic and Copernican models of the solar system. Of course, bodies are messy and not totally controllable, or predictable, in a production. Similarly, there will always be the randomness of human error in a science experiment. Frayn sagely remarks, "I think ideas come and you write them down. If they make people laugh, they laugh; if they don't, they don't."¹¹ A playwright can only presume a joke will provoke laughter; he can't ensure that it will.

A play, then, is a living, breathing creation. It is an enacted text, made up of people on and off stage, as well as those in the audience. Brecht and Frayn chose the dramatic form in order to have it serve the ideas and content. Were it not for the special qualities of the dramatic form (being live, interdisciplinary, communicative, communal etc.), Brecht and Frayn –both accomplished writers of other genres– might simply have written an article or a poem. A playscript is a text intended to be performed. Performances, like science, make the invisible, visible. The abstract becomes –however fleetingly– concrete. As no other medium can, theater offers Brecht and Frayn the immediate connection between stage and audience, the nearly palpable sensation that the play is effective and really succeeding in sharing its ideas. Both

Brecht and Frayn dramatize the science to make it more accessible to more people than physicists and historians. They do this because there is something at stake for the audience, as well as, the characters. The Church still struggles with science, even after 're-opening' Galileo's case in 1992. The atomic bomb remains a very real threat to everyone, despite the sixty years that have passed since the first one was dropped on Hiroshima. The characters and the audience have a vested interest in finding answers to the questions raised by each of these plays.

To me, a play is an interdisciplinary enterprise. The final artwork belongs to several people. Galileo, for example, will be played by Simon Russell Beale as written by Bertolt Brecht, adapted by David Hare and directed by Howard Davies (and costumed by X, lit by Y, set built by Z and so on). Or in the words of Brecht himself, "You may say: this is getting complicated. I must answer, it *is* complicated."¹² Just as theater is a collaboration of action, the visual, tactile and verbal, so the characters are likewise composite creations of many artists working together. The goal is to perform it before an audience. And that audience is key to the dramatic form. Theater critic Eric Bentley defined drama simply as: "A impersonates B while C looks on."¹³ Every play in performance shares at least one thing in common: a relationship between actor and spectator. And it might be said that, in science, the scientist becomes the audience of the phenomenon being explored. The paradox Frayn dramatizes is that "the act of observation itself alters the object being observed."¹⁴ And in *Copenhagen*, both the characters and the audience are observers. But in fact, the act of observation can reveal more about the observer than the observed subject. Galileo's lack of precaution in studying sunspots and his consequent failing eyesight reveal his rashness and passionate compulsion to do research. Still, in theater, the audience has a limited time to observe. Director Sir Peter Hall notes, "There is a limit to what we can untangle in the theatre in the fleeting moment. An audience never has much time. And on stage, the actors know it takes only a few seconds to lose the audience's attention for minutes, if not for good."¹⁵ A live performance occurs in real time. There is no chance to re-read a paragraph as one can with a novel, or immediately to repeat the experiment.

Yet a defining characteristic of modern drama (in contrast to medieval passion plays, for example) is that scripts are published. Plays enjoy a double existence of ephemeral performance and the permanence of publication. The performance of a play is fundamentally

different from the reading of the script because it is a communal act. Frayn comments that its corollary in science is like bringing

two sub critical masses... together which became a critical mass when they met and [start] the chain reaction. I think there's something about the theatre that's like that. You've got half a critical mass on the stage, you've got half a critical mass in the auditorium, and when the two are brought into contact the thing really takes off. ... This is really vital. [The audience] bring something of themselves to it, just as actors bring something of themselves to a text.¹⁶

Even now, “despite the proliferation of book groups and literary blogs, reading is ultimately a private act.”³ Though they are written to be read, dramatic texts are remarkable because they are meant to be read on their feet, so to speak. And it can be said that a production is a kind of ‘reading,’ albeit an elaborate one. For this reason, Brecht holds that “Proper plays can only be understood when performed.”¹⁷ Each interaction with a script, each production of it, is a new reading of it.

‘To read,’ even has a place in theatrical jargon. In rehearsal, a director may affirm the actor’s choices, saying a moment ‘reads’ well. In considering sightlines, design elements and the use of properties, artists must consider what ‘reads’ to the audience. In other words, if something “reads well” on stage, it is succeeding in communicating the vision of that production. What a professor of literature would call a ‘reading,’ a director would call a ‘concept,’ that is a specific angle on the play; a lens by which to examine it, a certain setting and approach that brings out something particular, or sheds new light on it. Brecht claims, “The theatrical occasion was what mattered, the text was only there to make it possible.”¹⁸ In effect, the script, along with the costumes, setting, lights, directions, actor’s choices, are all means of conveying the vision of the production.

Historical people and events inspired Brecht and Frayn’s visions for *Galileo* and *Copenhagen*. But the plays are not histories, nor do the playwrights purport that they are. Bentley observes that although, “playwrights and novelists depart from the *facts* of history, they still present the larger *forces* of history.”¹⁹ Brecht and Frayn use people and moments from history because both playwrights saw in them important themes relevant to their own time and place.

Brecht chose to dramatize the science and issues of Galilei because he saw the man’s life as a means both of confronting the evils of Nazis Germany and promoting his own Marxist

³ Rich, Motoko. “A Good Mystery: Why We Read.” [The New York Times](#). 25 November 2007. 1.

agenda. In the play, Brecht makes sweeping departures from Galileo Galilei's actual history. Were *Galileo* a history lesson, this would be problematic. On the subject of creating his characters Brecht writes, "In the same way characters are not simply portraits of living people, but are rearranged and formed in accordance with ideas."²⁰ *Galileo* is a work of Brecht's epic theater, freeing it from any obligatory verisimilitude.

In comparison, Frayn chose to dramatize the mysterious 1941 visit in Copenhagen to explore how to work out from external behaviors what is going on within. Instead of a political agenda, his play is a philosophical inquiry. Frayn playfully says,

As a writer one doesn't really choose one's stories; stories choose one. The story comes into one's head, and seizes one's imagination, for some reason. [The 1941 meeting of Bohr and Heisenberg] crystallized a lot of the epistemological difficulties I'd been thinking about as a philosopher for many years. So that's why I did it about real people.²¹

Indeed, Frayn's entire play is not so much a departure from historical fact as it is a supposition, simply because the facts are an enigma, even to the two men involved. Historians and scientists alike have responded with vehemence to *Copenhagen* and its relation to its historical underpinnings, some with anxiety, some with approval. The release of Bohr's private papers in 2002 has only added to the complexity of the play. Bohr wrote several drafts of letters to Heisenberg after the war touching on their 1941 encounter. In a 1957 draft, Bohr writes, "I am greatly amazed to see how much your memory has deceived you in your letter to the author of the book," referring to Robert Jungk and his book, *Brighter than a Thousands Suns*, which published parts of a letter from Heisenberg regarding Copenhagen.²² Though Bohr never sent any of the drafts, throughout the letters and notes is the wish to speak with Heisenberg what happened. In a 1961 draft, Bohr wrote, "I also hope that we shall have the opportunity to talk to each other in greater detail about what happened during the war, about which I have been asked by so many interested parties/circles, among which such great historical interest in precisely those eventful times is now arising."²³ In the play, Frayn gave his characters of the two men the opportunity to talk to each other that the historical men never managed. In an interview, Frayn commented, "There is no possibility that the real characters can have happened to be like your fiction. But...you just have to trust them and go with...the characters that are emerging."²⁴ The Bohrs and Heisenberg of *Copenhagen* are artistic creations. And Frayn writes about the importance of imagination in the work of a playwright in his postscript to *Copenhagen*

The great challenge facing the storyteller and the historian alike is to get inside people's heads... to make some informed estimate of their motives and intentions – and this is precisely where recorded and recordable history cannot reach. Even when all the external evidence has been mastered, the only way into the protagonists' heads is through the imagination.²⁵

Imagination is precisely the realm of a play and a fundamental element of science.

2

Galileo is a play about intellectual passion and intellectual betrayal. Brecht wanted to show the “behavior of a man who comes to realize that he is ethically unequipped to deal with the consequences of his own genius.”²⁶ As a Marxist, Brecht's agenda in this play is to blame Galileo for holding up the revolution that would destroy the oppressive class system of capitalism. For a moment in history –symbolized by the Carnival scene in the play– the new-thinking Galileo was as powerful as the Church and the nobility. Brought before the Inquisition, Galileo's martyrdom, according to Brecht, would have sparked a revolution. Instead of standing by his belief in reason and the people, Galileo cravenly betrayed society and science.

Brecht hoped his ‘epic drama’ would give rise to “theater of the scientific age ... to make dialectics into a source of enjoyment.”²⁷ His format for his plays is to create a dialectic (sometimes within a scene) –a thesis followed by an antithesis, guiding the audience to arrive at a synthesis. For example, Brecht has Galileo state his synthesis –that the people must use their reason and overthrow the capitalist hierarchy in the scene where Galileo speaks to the Little Monk: “Truth,” says Galileo, “will only conquer if we do. Reason's victory depends purely on human beings who are willing to employ it... [the possibility for] change is in [the people]” (Brecht, 49). Brecht's dramatic structure is a sort of theatrical version of the ‘scientific method: hypothesis, experiment, conclusion. Brecht wanted audiences to learn from his theater and to be inspired to action by it precisely because the topics that *Galileo* confronts are so crucial to individuals and society.

Brecht endeavors to estrange members of the audience sufficiently from the characters on stage –as opposed to having them completely lost in their identification with them– so that they will be able to think clearly. This spirit of taking nothing at face value is also a scientific one. Bentley wrote of Brecht's intention:

Brecht asks that we stand back... Object is to be seen as object, with astonishment. Brecht claims to derive this latter clause from science. Most people take for granted that apples fall; Isaac Newton was astonished. In Brechtian theater, the playwright is to be an Isaac Newton, and make Isaac Newton of his audience.²⁸

Brecht created several techniques to achieve his *Verfremdungseffekt*, or “Alienation Effect.” He used “historicization” in his plays (setting them in past eras thematically connected to the present); bright, white light; placards introducing scenes; song and music; and an acting style that has the actor “acting in quotation marks,”²⁹ rather than, in the Stanislavskian manner, ‘becoming’ the character.

There is an example of the way the “Alienation Effect” might look on stage as actors and props are used to enact the science of the play in the very first scene of *Galileo*. Here, Brecht turns Galileo’s toilette into a scientific demonstration of heliocentricity:

Galileo puts the iron wash-basin in the centre of the room.

GALILEO There. That’s the sun. Now sit in this chair.

ANDREA sits. GALILEO stands behind him.

GALILEO Now. Which side is the sun? Left or right?

ANDREA Left.

GALILEO And how may it get to your right?

ANDREA Well if you move it, of course.

GALILEO Isn’t there any other way?

He picks him up with the chair and rotates him through a semi-circle.

GALILEO Now where’s the sun?

ANDREA On the right.

GALILEO And did it move?

ANDREA Not really.

GALILEO So what did move?

ANDREA Well I did.

GALILEO (*shouts*) Wrong, you idiot! The chair.

ANDREA But I went with it

GALILEO Of course. The chair is the earth. You’re sitting on it. (Brecht, 3-4)

Brecht has Andrea and the furniture model the planets in an embodiment of the ideas of the play. Using commonplace things, or the actors themselves to enact the science, will be even a technique used more frequently used by Michael Frayn in *Copenhagen* as he has the actors move about on a bare, round stage thus modeling the subatomic particles of an atom.

Thus the “Alienation Effect,” as Brecht defines it, works to combat audience passivity. If an audience were to leave the theater with no inclination to think about what they have just experienced, that would defeat the purpose of Brechtian theater. *Galileo*, as *Copenhagen* will

also do, demonstrates the absence of an ivory tower in life and science, however much one might wish for a safe, consequence-free space. Brecht believed in the power of theater because “Art is never without consequences, and indeed that says something for it.”³⁰ Reality, too, is characterized by consequences, and Brecht would have his “Alienation Effect” create the distance an audience needs to consider this point through the action of the play.

Brecht designed epic theater as the successor to realist dramatic theater. In his writings, he noted these key differences between dramatic and epic theater:

Dramatic Theatre

wears down his [man's] capacity for action
the spectator is in the thick of it, shares the experience
he [man] is unalterable
man as a fixed point

Epic Theatre

arouses his capacity for action
the spectator stands outside, studies
he is alterable and able to alter
man as a process ³¹

Brecht did not want theater that neutralized the audience's desire to *do* something. He wanted theater to prompt his audience to engage and act outside the theater to change the structure of society along Marxist lines.

Yet it is important to understand that Brecht was not against audiences feeling emotion in the theater, nor was he against them being entertained. In fact, in Brecht's ideal theater, thinking and feeling, learning and entertaining, happen at the same time; they are not mutually exclusive. For his theater to be effective, both have to happen. Brecht asserts, “If there were not such entertaining learning, then the entire theater would not be able to instruct. For theater remains theater even while it is didactic, and as long as it is good theater it is also entertaining.”³² One can hardly hear Galileo quip; “They say it's easy to look beautiful in the Roman spring. Even I must look like a slightly overweight Adonis,” and not chuckle (Brecht, 37). What Brecht disliked was mindlessness, not humorlessness.

Brecht chose Galileo for his protagonist because, in Brecht's view, he is ultimately unheroic. This makes it possible for him to have Galileo declare, “I have betrayed my profession. A man who does what I have done cannot be tolerated in the ranks of science” (Brecht, 84). Brecht saw Galileo's recantation of Copernican thought as hindering the overthrow of capitalism and the social hierarchy it supports. Based on Brecht's theories, his commitment to Marxism, and his continual reworking of *Galileo*, it should be clear that Brecht wants the audience to condemn Galileo, all the more so because Brecht holds capitalism responsible for

the use of the atomic bomb (the production of which is the subtext of Galileo's final speech).⁴ Even so, I do not believe that the play works in the way that Brecht intended.

Brecht sets up what should be a simple progression from Galileo's improvement of the telescope (thus providing proof for the Copernican view of the solar system) to his discovery of planetary phases and motion to his abandonment of the people. There are three key scenes in the play: Scene 8, where Galileo, here Brecht's Marxist mouthpiece, debates reason versus faith with the Little Monk, a spokesman for those in power (the clergy, nobility and moneyed classes); Scene 10, an astronomy-themed street carnival where the populace is on the verge of revolution; and Scene 14, where Galileo judges himself a traitor to society and science. But throughout the play, Brecht continually introduces complications, so that while the audience may not condone Galileo's behavior, it is very hard for them to condemn him absolutely.

Galileo is not a typical Brechtian character because of his psychological complexity. Unlike, say, Mother Courage or Grusha in *Caucasian Chalk Circle*, it would be difficult for an actor to play Galileo while "standing beside" the character. Galileo *knows* what is at stake. He is aware that his work is tantamount to undermining the power of Church and nobility. He professes the same belief as did the burned heretic Giordano Bruno; but Galileo dismisses the danger to himself because, unlike Bruno, he has proof to support his theories. Just as his scientific descendent Heisenberg will passionately cry, " 'If it works it works.' Never mind what it means" (Frayn, 64). So Galileo's foolhardy attitude, such as that demonstrated in this encounter with the Florentine courtiers, comes out of his obsession with his science. In his desire simply to get the courtiers to look through the telescope, Galileo doesn't bother to contemplate the "philosophic implications" of his work, as Bohr would have phrased it (Frayn, 25):

PHILOSOPHER	Your Highness, gentlemen, what concerns me most is where this may lead.
GALILEO	It is not for scientists to ask where the truth may lead.
PHILOSOPHER	Galileo, the truth may lead us to absolutely anything! (Brecht, 30)

⁴ Brecht's reworking of the play is evidence that he felt the need to make his argument more watertight. The first version was written between 1937-1939, and was performed in 1943 at the Zurich Schauspielhaus in Switzerland. The second, 'American' version was reworked between 1945-1947, principally with actor Charles Laughton in California. Brecht was at work on a third version, in German for his Berliner Ensemble, at the time of his death in 1956. This paper mainly refers to David Hare's version of *Galileo*, updated in 2006 for the Royal National Theatre based on his 1994 version for the Almeida Theatre. (Hare, "Adapting Galileo." pp 2-3)

And one of Brecht's reasons for condemning Galileo is Galileo's habit of willfully ignoring "the wider audience" that his actions concern (Frayn, 17).

In the time since Galileo, some scientists, like Bohr and Heisenberg, learned the importance of trying to make their science accessible. Galileo also attempts to do this, as shown in another example of science enacted on stage:

GALILEO (*taking an apple*) Now look, this is the earth ...
ANDREA Oh no. No apples. You prove anything with an apple...
GALILEO Look, here is the earth. And here is you on it.
He puts a splinter into the apple.
GALILEO And now the earth rotates.
ANDREA And I'm upside down.
GALILEO No. Look. Where is your head?
ANDREA (*pointing*) There. Down below.
He turns the apple back.
GALILEO Isn't your head in precisely the same position? Aren't your feet still on the ground? You don't stand like this when I turn it, do you? *He takes the splinter out and turns it upside down.*
ANDREA No. Then why don't I feel the earth turn?
GALILEO Because you're turning with it. Everything around you is turning together.
ANDREA Then why does it look as if the sun's moving?
GALILEO rotates the apple again with the splinter in it.
GALILEO Look. The earth is below you. It's always there. You never feel it move. But now look up. There's the sun above your head. And now we turn. And what's above your head now?
ANDREA (*following the turn*) The stove.

GALILEO And where is the sun?
ANDREA Down below.
GALILEO Well then.
ANDREA That's brilliant. That's going make [Mother] really annoyed.
(Brecht, 5-6)

Galileo even writes in the vernacular in order to reach the common people. It is among the reasons the Inquisitor considers Galileo a danger. He tells the Pope,

I just ask you to imagine a world in which simple people were to trust only their own rational processes... without God, what is the only miracle that interests them? Why, making men equal... This evil man knows what he's doing when he writes his astronomical works not in Latin, but in the language of fishwives and merchants. (Brecht, 70)

But what upsets Brecht is that Galileo, fully capable of making his science comprehensible to anyone and everyone, backed off once he was threatened with physical pain. Galileo also knows what he is doing when he recants: he is saving his own skin. He "embarked on a campaign to change the world, then quit," as Bentley puts it, which is thoroughly

reprehensible in Brecht's estimation.³³ He is driven to fund his science; he *must* do research. Because of that drive he has sold the fruit of that research to those who would abuse the science. His compulsion blinkers *him* to the truth of his own circumstances: that the Church and the nobles who constitute the power structure do not care about proof, but about whether Galileo's theories and actions undermine their authority.

Galileo is fortunate to start out in a position where his confirmation of Copernicus does not rend the fabric of his world (at least not until the Inquisition summons him). When they first meet in Scene 8, the Little Monk tells Galileo:

My parents were peasants... Yes, they are poor, but in their poverty there is a certain order. There is a sense of the rightness of things... They have been told God is watching them. The world has been built so that each human being may act out their part. What would they say, my parents, if I were to tell them that they are really on a small piece of rock which ceaselessly revolves in empty space round a star which is in itself of no special importance? ... Do you really believe that is a kind thing to do? (Brecht, 46)

The Little Monk sees Galileo's discoveries as having the power to rip away the few, age-old consoling beliefs his family has. The Little Monk speaks from the point of view of the status quo, the old world that is likely to dissolve in the face of Galileo's discoveries.

This scene is an excellent enactment of Brecht's dialectic. Different sides of an issue are personified by the characters in a debate, not unlike the format for scientific treatises of old, such as Galileo's. Here, the argument ultimately discredits the Little Monk's point of view. Galileo's response to the Little Monk is vehement:

My new water pumps already bring the people miracles. Miracles worth more than the ridiculous servitude they suffer from now. Yet you come today, and you tell me, in the interests of maintaining their suffering, I must go on telling your parents lies... (Brecht, 47)

The Little Monk claims to speak out of compassion, but he is on the losing side of Brecht's dialectic—the side also personified by the cynical nobles and the Church. They are only concerned with maintaining the order that supports their own power and privilege. This means keeping the peasantry subservient.

Brecht puts the need for submissive masses into the mouth of Galileo's former student, Ludovico Marsili, in another scene structured as a dialectic. Marsili expresses his opposition to Galileo's work, saying,

LUDOVICO

It will come no doubt as bad news to you, but our peasants are not remotely concerned for the satellites of Jupiter... When

they come to the house with all their trivial complainings, my mother is forced to have a dog whipped in front of their eyes. It's the only way to impress on them exactly what civilization and order may be...

GALILEO It's not just dogs you whip to keep order, eh Marsili?
LUDOVICO You have a fine mind. It's a shame...
GALILEO Oh yes. He understands the danger. I might stir his peasants into thinking new thoughts. And his servants. His staff.³⁴

As with the exchange between the Little Monk and Galileo in Scene 8, here again are two points of view this time personified by Ludovico and Galileo. As earlier, Galileo comes out of the argument victorious. In the debate between the Little Monk and Galileo, Galileo speaks for Brecht, for Marxism. He sees no virtue in "the order of the empty larder," or in the peasants' suffering (Brecht, 47). He demands, "The conditions you speak of...Do you think it's God-given? Do you think it predestined? Do you really think it's how things have to be?" (Brecht, 46). Galileo, and science, through inventions like the water-pump and star charts have the ability to ease the cruel conditions under which the peasants live (Brecht, 17).

Nevertheless, Brecht complicates matters by having Galileo say of the people, "It is they who must change! We will give them inventions. But these inventions will bring them no benefit at all. Unless the change is in them" (Brecht, 49). Galileo puts forth an idea, but the people must make good use of it. Similarly, in *Copenhagen*, Niels Bohr will speak of responsible scientists who "don't do science for ourselves, but [for] others," implying that people at large are invested in Bohr and Heisenberg's science as well (Frayn, 38). But in this outburst of Galileo's, an aspect of Marxism mitigates some of the blame laid on him by Brecht: the belief that people mustn't rely on great men (of the bourgeoisie, or intellectuals such as Galileo) for salvation, but that they must save themselves. It is up to the people to better their lot in life, which is why Brecht (through Galileo) constantly encourages them to use their powers of reason. When Galileo recants, Andrea laments Galileo not standing up for reason, instead capitulating to the Church. Andrea cries, "Unhappy the land that has no heroes!" (Brecht, 75) But Galileo's rejoinder is, "Unhappy the land that needs heroes," (Brecht, 76). This is as a criticism not only of Galileo, but also of the people for not acting, especially when they were poised for a revolution only two scenes earlier.

Galileo's persuasion has overcome the Little Monk's qualms as a priest by tapping into his reason and curiosity as a physicist, as he tells him, "You can see that Venus has phases...It is plainly the truth. He who does not know the truth is an idiot. There is no virtue in ignorance. None. But he who knows the truth and chooses to deny it, he is something much

worse. He is a criminal" (Brecht, 48). But what is despicable about Galileo, a would-be champion of truth and the agency of the people, is that he becomes the very kind of person he describes as a criminal: one who knows the truth and denies it.

Though he is passionate about discovering scientific truths, Galileo becomes this person because he does not have a sense of responsibility for his findings. Galileo's description of the Little Monk's ravenous reaction to reading his paper on the moon and tides could equally apply to his own hunger for knowledge:

An apple from the tree of knowledge. Yes, and he's wolfing it down. He knows he's damned forever. And that will not stop him eating his meal. I sometimes feel that I would be willing to spend my whole life in a dungeon two hundred feet down, without light, in absolute darkness, if it meant I would then know what light really is. And then I would have to tell someone. (Brecht, 50)

By his own admission, Galileo needs to tell someone in order to brag, to share, to delight, to impress, to plead for more money. It is not enough for Galileo to look at the sky and know Copernicus was right; he is proud of his discovery and so he wants to share it. Galileo cannot keep the truth to himself, neither can he stop his pursuit of science. He is prey to the Faustian drive Bohr will talk about in regard to Heisenberg. The reason for Galileo's veritable obsession with his research is embedded in his language: he is addicted to the sheer pleasure of doing science. Research and discovery for him are an appetite. He speaks often of his need for money, not only to finance lens grinding and book purchases, but also for good food. The play begins with bottle of milk and ends with a brace of geese. Food and science are Galileo's passion. He does not think about doing science anymore than he thinks about eating food; he just does. The activities are of the same value to Galileo, neither more special than the other, each necessary to him. And so Brecht does not privilege him as a genius

And so Galileo's obsession with science endangers his wellbeing. With a reactionary Pope in power, Galileo has refrained from openly researching sunspots, but has secretly observed them. His zeal for studying this phenomenon has led him to observe the sun without protection. This severely damages his eyes. In Scene 9, Galileo fails to identify Ludovico when he enters. Noticing this, the Little Monk accurately surmises that Galileo's weak eyesight has been brought about by his ardor for science. Scene 14 shows that during Galileo's house arrest, he has continued to write secretly at night, worsening his eyesight. His passion for science keeps him from thinking about consequences –like his prideful assumption that the

Inquisition will not harm him— robbing him of his physical sight, an instance of the way the play embodies its ideas. Galileo's figurative lack of vision becomes literal by the end of the play.

Galileo fails to see that the presence of the Medici stars means more than simply that Copernicus was right. It means that man no longer occupies the central place in the universe. And in the medieval world, which maintained the very strong hierarchical notion of the Great Chain of Being from God through the princes and on through society, this destabilization filters down to everyone. Brecht shows the destabilization of society in the song from the Scene 9 carnival:

Some builders build a house to please their masters
They carefully make the windows and the shelves
Then they take one look at what it is they're building
And they decide they might as well move in themselves (Brecht, 63)

The consequence of this destabilization of society that the Church and nobility fear is that Galileo's discoveries ultimately reveal the subservience of the lower classes as needless. The Vatican's banning of Galileo's writings stymies the people, and even Galileo is thwarted. While his house arrest is comfortable, he cannot get his writings out to the world at large.

In Scene 9, the Carnival, Brecht suggests that Galileo could have been the impetus for the revolution of the common people. The crowd cries, "It's quite a heady proposition / that people could be masters of their fate" (Brecht, 62). The revelry of the carnival also provides an opportunity for the dancing to imitate the motions of the solar system, so that the words and the blocking demonstrate the key ideas of the scene. Here, people are starting to think differently, and to think for themselves. For Brecht and, by extension, for the audience, Galileo's ideas are not the greatest matter at stake. Playwright Lauren Gunderson observes, "As Andrea says in the play, 'Many of us believed that you stood for the liberty of teaching... Not then for any particular thoughts, but for the right to think at all.'"³⁵ The freedom to hold and pursue *any* ideas, however uncomfortable this may make the forces in power, is the issue. The chance for the revolution has been imminent (Scene 9).

Yet what confounds Galileo is that he never set out to meddle in Church doctrine. Even so, *Galileo* and *Copenhagen* demonstrate, science, politics, economics, religion, and art itself, are rarely exclusive enterprises, even if one wishes them to be. Initially, Galileo is not at cross-purposes with the Church. For Galileo Galilei biographer James Reston writes, "the intention of the Holy Spirit is to teach us how one goes to heaven, not how heaven goes."³⁶ The trouble is that the leap from doubting one tenet held by the Church to doubting

everything (and then challenging anything) is small. Without intending to, Galileo's work (in the eyes of the Vatican) is questioning the authority of the Church. This was absolutely not permissible during the Counter-Reformation. Even when Pope John Paul II reopened the Galileo case, "the apologists in the Vatican spoke openly of how Galileo would still be convicted today, since the essence of the affair was simple disobedience," no matter that Galileo was correct in his assertions.³⁷

The Church, here but one face of any oppressive/capitalist regime attacked by Brecht, works to protect itself. The cardinals are candid about quashing notions that challenge their authority. Galileo argues his side in yet another of Brecht's stage debates, weaving together both science and religion as he quotes from the Bible, showing himself quite adept in fields beyond his own expertise. He begins by encouraging the cardinals to use their reason:

GALILEO	[When I was young] I stood on a ship and cried out, "The shore is moving away." Today I know it is the ship that moves and the shore which stands still...
BELLARMIN	Let us move with the times, Barberini. If we can put Galileo's theories to practical use, if they help navigation, then we must not stand in their way. What we cannot allow are teachings which contradict the Bible.
GALILEO	The Bible. "He that withholdeth corn, the people shall curse him." Proverbs.
BARBERINI	"A prudent man concealeth knowledge." Proverbs...
GALILEO	"Doth not the truth cry aloud?"
BARBERINI	"Can one go upon hot coals and his feet not be burned?" Welcome to Rome, Galileo my friend. (Brecht, 38-39)

The Church (the whole capitalist system) is willing to profit from Galileo's science, but will brook no challenge to its authority. It will allow the use of Galileo's star charts for commerce, but not the accompanying astronomic theory. Indeed, the first remark, made by the Chancellor of the University of Padua, about Galileo's telescope is: "Has it occurred to you, [it is] a weapon with which, in wartime, we may see our enemy's ships a full two hours before he sees ours?" thus demonstrating from the beginning that the power structure is intent on exploiting science for military purposes –destructive purposes (Brecht, 12). Due to the need for funding in the capitalist world, science is beholden to those who would abuse it to their advantage, irrespective of ethics, or for the sake of discovering new scientific facts through research.

Galileo refuses to run from the menace of the Vatican. Galileo tells the industrialist Vanni, "I do not see myself in exile. I like my comforts too much" (Brecht, 65). But neither does he stand up to the Church for the same reason: he likes his comforts and has no physical bravery. Again, Brecht muddies the waters of his desired synthesis by letting the audience, but

not Galileo, know the Pope's command: "The very most you may do is show him the instruments" (Brecht, 71). Galileo's cowardice is genuine, but so was his ignorance at the time of his trial that he actually, "was never in danger" (Brecht, 84). By informing the audience that Galileo not actually be tortured, Brecht tries to eliminate the suspense of wondering "Should he give in to the Church or shouldn't he," in an effort to focus the audience's attention on the consequences of Galileo's actions. At the end of the play, when the finished *Discourses* give Andrea a reason to admire Galileo, Andrea is quick to justify Galileo's recantation. "Hands better tainted than empty," he exclaims, stating the position that Galileo's martyrdom would have served no beneficial purpose for science (Brecht, 82). But Galileo knows the truth, at least as Brecht sees it: "there is no scientific book only one man can write" (Brecht, 83). Had Galileo not written the *Discourses*, perhaps Andrea, or Johannes Kepler, or René Descartes, would have authored it. His recantation played into the hands of Church and nobility and it crippled science. His defiance would have seen him unharmed and his science and the revolt of the people victorious.

Galileo's recantation held up the progress of science and society's progress (toward the advent of the revolution for Brecht) with it. Reston comments, "The Counter-Reformation had confronted the Renaissance, and...won a disastrous victory... Science and faith clashed, and in their terrible conflict, the two were severed, to continue in divergent directions and to lose their common ground."³⁸ The reason for Galileo's submission was not, as Andrea would have it, part of a greater plan, nor was it, as Virginia proclaims, due to religious contrition. Galileo baldly states his reason: "I recanted because I feared physical pain" (Brecht, 83). It is as simple and as cowardly as that.

Yet in Scene 14, Brecht gives Galileo a remarkable final speech that ends by complicating his aim to make the audience despise him. It reveals Galileo in a hell of his own making, worse than anything the Inquisition could impose. Brecht added the speech during the first reworking of the play in the late 1940s –after the dropping of the atomic bombs. He remarked, "The atomic age made its debut at Hiroshima in the middle of our work. Overnight the biography of the founder of the new system of physics read differently."³⁹ If Galileo had not recanted, would the revolution we see the seeds of in the Carnival scene have occurred sooner? Brecht believed it would have, thus beginning the end of the capitalism, which Brecht held responsible for World War II and the use of the atomic bombs. Science would have been liberated from those forces that would suppress, or misuse it, like the Vatican, Vanni, or

someone like the Nazi scientist Kurt Diebner in *Copenhagen*. During his speech, Galileo bitterly cries,

If I had resisted! If I had said no, then scientists might have had a Hippocratic oath of their own. They might have promised their gifts to mankind. But instead I have fathered a race of inventive dwarfs who can be hired for anything... For those few years I was as strong as the authorities. And I gave my knowledge to those in power to use or misuse, as they wished. (Brecht, 84)

Historically speaking, for Brecht, Galileo is responsible for the use of the bombs, since standing up to the Vatican would have sparked the revolution that might have prevented WWII, a class war in Brecht's eyes.

Too late, Galileo understands only too well the full import of his obligations to the truth he so laughingly dismissed before the Medici court years before. He tells Andrea:

If scientists, intimidated by power, are happy to amass knowledge for its own sake [as Galileo was], then science will be crippled...you may discover all there is to discover; but your progress will be progress away from mankind. The gulf between you and the people will be so great that one day you will cry out with joy over some new achievement. And you will be answered with a universal cry of horror.⁴⁰

In their early years, Galileo taught Andrea that science demands contribution. But Galileo discovers that science also requires responsibility. It is very important for scientists to consider where their ideas lead and what their implications might be, lest there be such a cry of horror as that occasioned by the bombs dropped on Hiroshima and Nagasaki. Finally, grasping his culpability as a scientist leads Galileo to ask, "Can we deny ourselves to the crowd and still be called scientists?" (Brecht, 84) The answer is the play's synthesis: probably not—at least, not worthy scientists. The science matters, but so does the crowd.

Brecht's hoped for synthesis, that the audience will condemn Galileo completely, has several fissures in it. Brecht is aware of this because in the 1947 version of the play instead of concluding the play at Scene 14, he adds an epilogue. Rather than underscoring Galileo's guilt, it addresses the difficulties of trying to open people's minds, something Galileo *did* endeavor to do. Before he crosses the border, carrying Galileo's Discourses to Holland, Andrea lifts up a child to see that a supposed witch at her cauldron is merely an old lady stirring her porridge. Yet after he returns him to the ground, the boy shouts, "She *is* a witch!" to which Andrea replies, "You saw with your own eyes: think it over!" then leaves the boy, just as Galileo had abandoned him.⁴¹ David Hare's version deals with this compromising section simply by

cutting it entirely from the play. Not only does Hare's cut make the ending more hopeful, with Andrea taking Galileo's *Discourses* out of Italy relatively easily, but it strengthens Brecht's synthesis. Andrea's encounter with the boy is a repetition of Galileo abandoning the people. While Andrea's abandonment of the boy can help condemn Galileo, the fact that the boy still refuses to think rationally, despite having seen only a harmless old woman, would lessen Galileo's failure and damage Brecht's goal. After all, Galileo could only, and did only, present people with facts; he could not force them to accept them.

Like his Galileo, Brecht doesn't achieve the results he intended to produce. The audience is supposed to condemn Galileo for his treachery. Yet Brecht writes in the play's afterward that "it also takes courage to tell the truth about oneself," which Galileo has now done.⁴² Beyond the complication in the script itself, some of the problem is that there is a great deal of Brecht in Galileo –indeed what first appealed to Brecht was "the analogy between the seventeenth-century scientist's underground activities and those of twentieth-century left-wingers [such as himself] in Hitler Germany," writes Bentley.⁴³ Both Brecht and his Galileo have higher ideals than they are apt to live up to: while trumpeting Marxism, Brecht was driving around East Berlin in a luxurious pre-war DKW car⁵ and banking in Switzerland, while holding Austrian citizenship.⁶ Hare describes Galileo in all the versions of the play as "a man who meets a test and fails," though he did try to defend his ideas against the Church and stand up for society's powers of reason.⁴⁴

Brecht's play may not have realized his intent, but he has modeled scientific concepts and dialectic debates on stage so that the questions he poses about science and morality lose none of their importance. Intentions, the aims of actions, are tricky because the actions can easily go astray. And it is the direction and misdirection of intentions in science and human beings that form the meat of Michael Frayn's play *Copenhagen*. Like *Galileo*, *Copenhagen* enacts scientific concepts on stage to explore its themes. In both plays, the question of what happens and what to do when one's science gets into the hands of the state is raised. However, in Frayn's play, these explorations are performed as philosophical investigation, rather than political message.

Copenhagen owes a lot to Brecht. First, the sparseness of its staging conventions and its continual debating derive in part from Brecht's dialectic technique and theories of epic theater.

⁵ Copeland, Roger. Course Lecture: *History of Western Theater II*. April 2006.

⁶ Hayman, Ronald. *Brecht: A Biography*. New York: Oxford University Press, 1983. 340.

Second, *Galileo* ends on a note of alarm and regret over the creation of the atomic bomb, the iconic symbol of the most horrible achievement of science. Besides Galileo's final speech, the last scene placard shown to audience in the Laughton version of *Galileo* reads:

May you guard science's light
Kindle it and use it right
Les it be a flame to fall
Downward to consume us all.⁴⁵

Science can enlighten people, but it can also be a danger to them if not used correctly. *Galileo* is concerned with the scientist's relationship to science and society because such results as the atomic bomb are possible. *Copenhagen* is also deeply concerned with that same relationship between science and society and explores its questions about intention using characters representing the actual historical figures directly involved in the Allied and Axis bomb programs.

3

Copenhagen is a play about intentions. It is an exploration of the mystery surrounding why people do what they do. The play suggests we must try to understand why people do what they do before attempting to make moral judgments. Perhaps this is another reason it is hard to condemn Galileo completely, for he emerges on stage with more facets than Brecht intended. Brecht believed his dialectic to be like the scientific method. In science experiments, however, as in both of these plays, a plus b does not necessarily produce c. And as in a science experiment, on stage the unexpected can happen. Just as Brecht found a character and a moment in history that seemed to crystallize the problem he wanted to explore on stage, so the 1941 meeting between Niels Bohr and Werner Heisenberg offered the same possibility to Frayn. At a conference for scientists, theater artists and historians held at the Bohr Institute in 1999, Frayn commented, "drama does offer some parallels with the world of physics... There is now some coming together of the worlds of art, of story telling, and of physics."⁴⁶ Frayn capitalizes on the parallels between human behavior and scientific ideas –specifically, the Uncertainty Principle and Complementarity. In *Copenhagen*, Frayn wants to "make some informed estimate of [the characters'] motives and intentions," using physics and theater.⁴⁷ Modeling the scientific ideas through the activity on stage makes the science comprehensible and relevant to human actions and interactions. Through Frayn's elegant merging of disciplines, through the successive explications the Bohrs and Heisenberg propose during the play, the audience experiences the science applied to the characters.

Part of *Copenhagen's* excellence is that it does not dumb down its science. It enacts those concepts its characters discuss. Bohr expresses Heisenberg's Uncertainty Principle very succinctly, describing a conundrum in regard to the experience of skiing: "If you knew where you were when you were down you didn't know how fast you'd got there. If you knew how fast you'd got there you didn't know you were down" (Frayn, 24). And Heisenberg sums up Bohr's Complementarity while speaking of himself and his own relationship to Bohr, "I'm your enemy; I'm also your friend. I'm a danger to mankind; I'm also your guest. I'm a particle; I'm also a wave" (Frayn, 77). Bohr and Heisenberg recall examples from their past, from areas besides science, that demonstrate scientific theories at work, slowly acquainting the audience with quantum mechanics and making it relevant to their own everyday lives. The men bring up Schrödinger's cat, skiing, table tennis, card games, chess, cap pistols, even snowballs. Like Margrethe, the audience may not be fluent in "differential equations," but these other familiar activities make sense (Frayn, 38). Suddenly, aspects of quantum mechanics become graspable.

Frayn goes beyond the characters' conversation to explain the physics. The blocking and staging are metaphors for Complementarity and Uncertainty as the men employ their theories to answer their questions, and the constant watching of each other among the characters is a demonstration of the effect of observation upon the observed. The script is without stage directions, leaving the actors to move around the stage (usually and most successfully done in the round) as atoms orbit a nucleus. Though this kind of staging does not employ the usual host of Brechtian devices, it does owe a lot to Brecht in that it credits its audience with intelligence and imagination. According to the play's Danish director Peter Langdal, this treatment is also what enralls people:

Very often scenography takes away the imagination of an audience. If you build up a whole scene, you just sit there as an audience, very passive. The thing about this play is that when doing almost nothing in terms of effects ... you challenge the audience's fantasy, and I think they have a very... great [experience] when they watch it. That's the reason why they are attracted to it.⁴⁸

Stimulating the audience's 'fantasy' is a very Brechtian notion. As he wrote in *Galileo*, "Thinking is one of the great pleasures of being alive" (Brecht, 20). Brecht's staging techniques and writing style were aimed at getting the audience to use their own minds and not sit passively back during a performance, so the observers of Frayn's staged science, are also not supposed to sit passively back.

Frayn uses Bohr and Heisenberg's scientific theories to elucidate characters' reasons and intents in three "drafts," as though the characters were authoring one of their papers again, instead of trying to tease the truth out of the past. Though they are dead, the characters wonder:

Bohr: What exactly did Heisenberg say?

Heisenberg: And what exactly did Bohr reply?

Margrethe: What did Heisenberg tell Niels – what did Niels reply? The person who wanted to know most of all was Heisenberg himself. (Frayn, 34-35)

The first "draft" shows Heisenberg striving to remain in control and seeking Bohr's guidance and approval for his course of action. The second "draft" reveals that Heisenberg had not done an important equation necessary for producing the bomb, his usual skills as a physicist suffering without Bohr's critiques. And in the third and final "draft," Bohr discovers that Heisenberg had not done the calculation because he had not realized that one needed to be done, thus leaving Heisenberg to suppose that he, the Bohrs and their families, as well as Europe and the United States, were preserved from the atomic bomb by that indeterminate moment in Copenhagen when Bohr ended the conversation with Heisenberg. Throughout all the "drafts," Heisenberg hopes to win back Bohr's affection, their work together bringing them into a 'father-son' sort of relationship, not unlike that of Galileo and Andrea at times. The Bohrs and Heisenberg long to understand not only what happened, but their own intentions, because that will show whether they were right or wrong, good people, or bad people.

Yet if Brecht's play does not neatly produce the synthesis he wants from his audience, Frayn's play more successfully creates a kind of understanding, if not a clear, final answer to what brought Heisenberg to Copenhagen in 1941. Still, just as Brecht cannot quite seem to attain complete condemnation of Galileo, so Frayn cannot quite entirely redeem Heisenberg, or leave Bohr the untainted hero.

Heisenberg claims that asking Bohr, "If as a physicist one had the moral right to work on the practical exploitation of atomic energy," is what brought their fraught 1941 meeting in Copenhagen, as well as their friendship, to an abrupt end (Frayn, 36). After that remark, Bohr assumes Heisenberg *is* working on a bomb, which ultimately means giving Hitler better weapons of mass destruction, though Heisenberg insists his goal was a reactor. So, they determine to "start all over again," their most pressing concern being the need for "plain language," (Frayn, 39). So they begin the first "draft" part of the play, saying:

Bohr: We're going to make the whole thing clear to Margrethe. You know how strongly I believe that we don't do science for ourselves, that we do it so we can explain to others...

Heisenberg: In plain language.

Bohr: In plain language...but for Margrethe's sake...

Heisenberg: Plain language.

Bohr: Plain language. (Frayn, 39)

They are determined to make the science comprehensible to Margrethe, a layperson, and, by extension, to the audience as well. What is most important to Bohr and Heisenberg, but especially to Heisenberg, is the need to understand and be understood. Unlike Galileo, Bohr and Heisenberg are acutely aware of their responsibilities to others –as when Heisenberg cries, “But, Bohr, where will that lead?... I have to know what I am deciding,” wondering whether he is leaving his family and country vulnerable to an Allied atomic bomb (Frayn, 41 & 42). But with their Faustian zeal for doing research, it is hard to be as conscientious in practice and application of science as they are in their conversations about their work.

Ultimately, in the first “draft,” Heisenberg is seeking Bohr’s guidance for maintaining his control of the German nuclear program. He exclaims, “The German government is going to come to *me!* They will ask *me* whether to continue or not! ... I’m the one who has to decide! If the Allies are building a bomb, what am I choosing for my country?” (Frayn, 41 & 42)

Both scientists have a deep affection for, and sense of loyalty to, their homelands, which is at odds with their instincts as physicists. Fully aware that the Nazis would use atomic bombs indiscriminately, Heisenberg does not deny Margrethe’s accusation: “you wouldn’t dream of giving up such a wonderful opportunity for research” (Frayn, 75). Similarly, yielding to his Galilean compulsion to solve a problem in physics is what led Bohr to figure “out how to trigger the Nagasaki bomb” after one bomb had already been used (Frayn, 47). Desperate for some kind of sympathy, Heisenberg tells both Bohrs, “It would be [an] easy mistake to make, to think that one loved one’s country less because it happened to be in the wrong. Germany is where I was born. Germany is where I became what I am” (Frayn, 42). Bohr has expressed nearly the same feelings, quoting “Hans Christian Anderson whose words had become Denmark itself: ‘In Denmark I was born and there my home is...from there my world begins.’”⁴⁹ But perhaps equally deep, and even a little stronger, is their love of their science and of each other. They still have that meeting in Copenhagen, even though it will be an even

more “deeply awkward occasion” than the final meeting of the other teacher and student and father and son, Galileo and Andrea (Frayn, 8).

Heisenberg’s words about home strike a chord in the fatherly Bohr. Soon Bohr begins questioning him about his work and discovers how haphazardly Heisenberg’s program was conducted and Bohr’s reaction is a protective one. He chastens Heisenberg, telling him, “You were no longer running that program, Heisenberg. The program was running you” (Frayn, 51). Whether it is a bomb, or a reactor, or advising at Los Alamos, doing research of some kind is essential to these two men. It is as much a passion for them as it was for Galileo. Margethe’s comment about Bohr’s interest in Heisenberg’s return could easily pertain to the insatiable curiosity of Galileo, or of Andrea, or of the Little Monk: “So now of course your curiosity’s aroused, in spite of everything” (Frayn, 10). As deflated as Bohr’s accusation makes Heisenberg, it does elicit this remark from Bohr: “I should have been there to look after you.”⁵⁰

While Uncertainty, Complementarity, and fission may have become clearer to the audience, despite their determination to be able to explain their science and actions, the Bohrs and Heisenberg are nearly as mystified as they were at the beginning of their first “draft.” Margrethe looks at Heisenberg and notes,

He’s lost. He’s like a lost child. He’s been out in the woods all day, running here, running there. He’s shown off, he’s been brave, he’s been cowardly. He’s done wrong, he’s done right. And now evening’s come, and all he wants is to go home, and he’s lost. (Frayn, 52)

Home is not simply a safe house, but a return to Bohr’s good graces. And, of course, where Bohr leads the world scientific community will follow. His colleagues saw Bohr as their “spiritual father” in physics and deferentially dubbed him “the Pope” (Frayn, 38 & 39).

In a thematic echo of Brecht’s *Galileo*, both in regard to the Vatican’s trial of Galileo and Galileo’s trial of himself where he is both judge and jury, Frayn makes it clear in *Copenhagen* that Bohr never had to defend his actions during the war, whereas Heisenberg spent the rest of his life trying to explain his. *Copenhagen* can be read as the trial of Heisenberg by Bohr, as well as the audience, just as Brecht would have his audience judge Galileo. Heisenberg himself acidly points out that “explaining and defending myself was how I spent the last thirty years of my life,” just as defending himself, like a defendant on trial, is also what much of his part in the play is about (Frayn, 47). The scientific community’s ostracizing of Heisenberg is deeply ironic since, to judge by results, Bohr is actually the guilty man, not Heisenberg. For the German bomb program never came to fruition. But Bohr escaped Europe

and went to America, “to my play small but helpful part,” he admits, “in the deaths of a hundred thousand people... Whereas you, my dear Heisenberg, never managed to contribute to the death of one single solitary person in all your life” (Frayn, 91). In this, Heisenberg is like Galileo, who is not directly responsible for the deaths for which Brecht blames him. Each play functions as a judgment of Galileo and Heisenberg. Galileo is judged by the Church, Andrea, his colleagues, himself and the audience; Heisenberg is judged by the Bohrs, colleagues and himself, as well as the audience. In another plea for understanding from Bohr, Heisenberg bitterly remembers, “At least we tormented ourselves a little beforehand,” adding that after the war “a lot of physicists wouldn’t even shake my hand. Hands that actually built the bomb wouldn’t touch mine” (Frayn, 43 & 47).

But back in 1941, Heisenberg was not hoping for Bohr’s help in vindicating himself, nor did he think he could get Bohr to prevent the Allies from creating an atomic bomb, and he was still going to keep working on the reactor, despite the dangerous condition in that lab. He scarcely listens to the Bohrs’ qualms about safety:

Bohr: If you ever had got [the uranium] to go critical, it would have melted down, and vanished into the centre of the earth!

Heisenberg: Not at all. We had a lump of cadmium to hand

Bohr: A *lump* of cadmium? What were you proposing to do with a *lump* of cadmium?

Heisenberg: Throw it in the water...

Bohr: What water?

Heisenberg: The heavy water. The moderator that the uranium was immersed in.

Bohr: My dear good Heisenberg, not to criticize, but you’d all gone mad!

Heisenberg: We were almost there! We had this fantastic neutron growth! ...

Bohr: You didn’t know anything down in that cave. You were as blind as moles in a hole. Perrin said that there wasn’t even anything to protect you all from the radiation.

Heisenberg: We didn’t have time to think about it.

Bohr: So if it *had* gone critical...

Margrethe: You’d all have died of radiation sickness. (Frayn, 50-51)

The procedures of Heisenberg’s wartime lab seem so slap-dash that the Bohrs’ concerns for safety becomes almost parental, not just professional. Bohr is stunned by the working

conditions, while Heisenberg, in the grip of his passion for science, cries, “We were almost there! We had this fantastic neutron growth!” (Frayn, 50) Heisenberg’s scientific excitement and Galileo-like zeal caused him to lose “all contact with reality down in that hole” of a lab (Frayn, 50).

Still, the characters have only established that mentioning exploiting atomic energy derailed Bohr and Heisenberg’s conversation, not what it was Heisenberg wanted from Bohr so badly that he came to Copenhagen in the midst of the war. This propels them into a second “draft,” as they ask:

Heisenberg: Why did I come?

Bohr: Tell us once again. Another draft of the paper. And this time we shall get it right. This time we shall understand. (Frayn, 51)

In this second “draft,” the two men try to get back to the collaborative rapport they shared before the war. And in this “draft” the work habits of the two men are staged to mirror their science and further involve the audience as observer. The blocking, as well as the physics, is embedded in the language. Bohr paces as he listens to Heisenberg discussing the Uncertainty Principle, this irritates Heisenberg, who exclaims, “You can never know everything about whereabouts of a particle, or anything else, even Bohr now, as he prowls up and down the room in that maddening way of his, because we can’t observe it without introducing some new element into the situation...which have an energy of their own and which therefore have an effect,” like light on the particle, or Heisenberg’s or the audience’s gaze on Bohr (Frayn, 67-68). Heisenberg’s lines indicate that Bohr must be orbiting him like an electron at this moment. When the energy of the two men becomes too charged, Margrethe often steps in to act like a neutralizing agent to diffuse the tension, wryly saying, “I shouldn’t let you sit anywhere near each other, if I were the teacher” (Frayn, 66). But the exchange of ideas and research, however maddening or explosive along the way, was crucial to the progress of Bohr and Heisenberg’s work before the war. Heisenberg recalls,

And who led the way for everyone else [in physics]?

Margrethe: You and Niels.

Heisenberg: Well, we did.

Bohr: We did.

Margrethe: And that what you were trying to get back to in 1941?

Heisenberg: To something we did in those three years...Something about the way we worked. Something about the way we did all those things...

Bohr: Together.

Heisenberg: Together. Yes, together. (Frayn, 61)

Sharing among physicists is grist for their mills. As they discuss the 1920s, Bohr and Heisenberg mention various colleagues whom they inspired, and whose work spurred their own research: Born, Jordan, Schrödinger, Fermi, Chadwick, Dirac, Gamow, Landau, Goudsmit, and Pauli. Bohr remembers them as “electrons on the outer orbits around us all over Europe...Everyone in and out of each other’s departments” (Frayn, 59). Heisenberg even likens the coveted “private office next to [Bohr’s]” to the “electron on the in most orbit around the nucleus” that is Niels Bohr (Frayn, 58). At this moment, Heisenberg could be positioned near the edge of the stage, while Bohr occupies a central position, with a now-empty chair next to him drawing Heisenberg’s (and the audience’s) gaze, the stage picture an echo of their past collaborations.

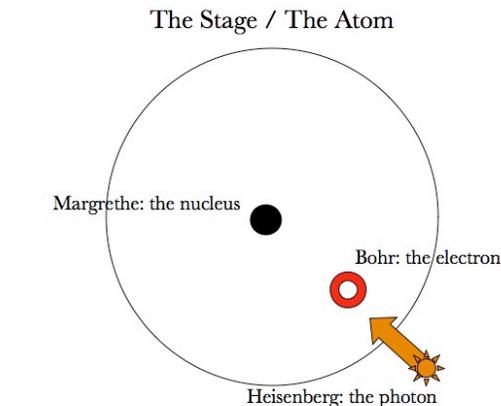
Working off each other, critiquing, arguing, experimenting, and drafting in conjunction with one another was the way Bohr and Heisenberg did their best work as physicists, the pursuit so important to them both. Heisenberg needs Bohr’s presence to help elucidate his work in physics, but also to make his own past clear. Bohr’s reactions to Heisenberg will enable him to discover things about himself. Heisenberg is the “one bit of the universe that [Heisenberg himself] can’t see” (Frayn, 72). But he can deduce things about himself through the medium of Bohr, Bohr’s reactions to him being like “the series of collisions between the passing electron and the various molecules of water vapor” in the cloud chamber (Frayn, 66-67). As Frayn observes, “One can’t communicate with oneself unless one communicates with others.”⁵¹ This is similar to the way things work on stage: actors need to observe each other to see if their actions are succeeding, and all of the actors need an audience to find out how the play is working.

Thus Bohr and Heisenberg set out working together. The first “draft” reveals Heisenberg’s keenness to keep doing research and maintain his program. He also hopes to get some advice on how to proceed in managing the program from Bohr. And in the second “draft,” Frayn applies the physics even more literally to his staging of the characters as they more overtly become subatomic particles in their own shared quest for a particle’s location and

course: which is to say, their search for their own intentions. They have already been moving about the stage like subatomic particles. Now they deliberately take on specific quanta like theatrical roles. Heisenberg stages an experiment with Margrethe as a nucleus, Bohr as an electron and himself as a photon. The actors move, or stand like the subatomic parts assigned them by Heisenberg, on the bare, circular stage, which is a single atom. The gaze of the audience is like many photons, continually hitting the atom, changing its behavior –that particular performance– ever so subtly, as the actors sense their audience’s reactions in the theater. The audience’s active observation is a key ingredient in the performance –the experiment. In the following beat from the second “draft,” Frayn transforms the theater into a cloud chamber, the actors into quanta, and the audience is the light, as well as the observing scientist:

Heisenberg: Listen! Copenhagen is an atom. Margrethe is its nucleus. About the right scale...Now, Bohr’s an electron. He’s wandering about the city somewhere in the darkness, no one knows where...I’m a photon. A quantum of light. I dispatched into the darkness to find Bohr. And I succeed, because I manage to collide with him...But what’s happened? ...he’s been deflected. He’s no longer doing 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 happening to you, to their piece of light, then they can work out what must have happened to me! The trouble is knowing what’s happened to you! Because to understand how people see you we have to treat you as not just as a particle, but as a wave. (Frayn, 69)



Heisenberg, the photon, collides with Bohr, the electron, but, in so doing, they are *both* deflected. Heisenberg concludes, “We can’t completely understand your behavior without seeing it both ways at once, and that’s impossible” (Frayn, 70). This description may well be

⁷ *Copenhagen* © Joan Marcus, 1998.

the closest to the truth it is humanly possible to get. It is possible that Heisenberg wanted to build a safe reactor *and* to be able to build the first atomic bomb. For as the men later observe of themselves, purposes scatter when being put into action, just as particles scatter when they are hit by light.

This beat demonstrates how *Copenhagen* fits nicely into what Brecht hoped for: that is, a “type of theater which not only releases feelings, insights and impulses...within the particular historical field of human relations in which the action takes place, but employs and encourages those thoughts and feelings which help transform the field itself.”⁵² For Frayn implies throughout *Copenhagen* that the application of quantum physics is as important as the theory behind it. Frayn’s play, along with his postscript and writings, reveals that he, like Brecht, believes the audience’s “sharing an experience” with the actors is essential so that they can “come to grips with” the play’s ideas and continue being conscious of them outside the theater.

But Margrethe is unimpressed by Heisenberg’s demonstration. While the men become momentarily absorbed in the wonders of physics, she is upset by Heisenberg’s single-minded pursuit of such dangerous physics and his gall in consulting her husband about it for the sake of Denmark’s enemy. With fervor to match Madame Sarti’s in her rants against Galileo, Margrethe accuses Heisenberg of not building the bomb because “you didn’t understand the physics” (Frayn, 79). Bohr hounds Heisenberg just as he did in the old days, asking question after question. Bohr discovers that Heisenberg had not done the diffusion equation for the critical mass of U235 necessary to make the bomb. Heisenberg mistakenly believed it was harder to make the bomb than it actually was. This made it easier for him to control the program obsessively in order to try to build a reactor. He bluffed himself.

Thus the first two “drafts” show Heisenberg’s need to consult with Bohr, both as scientist and as a philosopher of sorts. Heisenberg knows he is not at his peak as a physicist without the collaboration and interaction possible among colleagues of the pre-war years. The circulation of ideas and experiments was vital to progress, but Heisenberg is isolated in Germany. And it is hard to be responsible in isolation, whether it is Heisenberg in his cave lab, or Galileo in his own self-absorption. Heisenberg’s skill as a physicist suffers especially without Bohr. But what is not in doubt about 1941 is that Heisenberg wanted to speak with Bohr. The Danish actor who played Heisenberg remarked,

I think Heisenberg came to Copenhagen because he opened up a door to something he was scared about, and then he needed to come back to his father

figure, who also opened up the same door, so they could hold hands...And that's what theatre is all about, hold hands; trying to know yourself by knowing each other.⁵³

This is precisely what Bohr and Heisenberg's theories tell them: a person is often two things at the same time. The theater is a fitting place for this to be demonstrated, for as the actor who played Niels Bohr, David Burke, notes,

Acting is mostly a twin-track...activity. In one track runs the role, requiring thoughts ranging from, say, gentle amusement to towering rage. Then there is the second track, which monitors the performance: executing the right moves, body language, and voice level; taking note of audience reaction and keeping an eye on fellow actors; coping with emergencies such as a missing prop or a faulty lighting cue.⁵⁴

Burke's awareness of himself as both actor and character is the theatrical equivalent of, for instance, quantum mechanics where photons can be both waves and particles.

Complementarity means one can know where someone else is, or where one has been, but where one is in the moment is indeterminable. Bohr notes, "He sees me. He sees Margrethe. He doesn't see himself" (Frayn, 86). Thus Heisenberg needs the Bohrs help to make an estimation of what he intended by that 1941 meeting.

The "drafts" of what transpired in the meeting circle around the feasibility of Heisenberg creating an atomic bomb, keeping the tension taught between Heisenberg and the Bohrs however much he needs them to be at ease to clear up his past. The first "draft" makes the German bomb a technical impossibility because Heisenberg kept the program underfunded. The second "draft" makes the German bomb a theoretical impossibility because Heisenberg failed to do the diffusion equation. And so Heisenberg asks yet again, "Why did I come to Copenhagen?" Bohr answers by proposing, "One more draft, yes? One final draft!" (Frayn, 86)

At the start of the third "draft," the characters narrate more than they have in the previous two "drafts." They do they re-enact their words and relive their emotions but their focus is more on their own and each other's reactions this time. It is as though they are more engaged in the observation of their actions in this "draft" than they are in the re-enactment of the actions themselves. The third "draft" begins with Heisenberg arriving at the Bohrs' home for their meeting:

Heisenberg: And once again, I crunch over the familiar gravel to the Bohr's front door, tug at the familiar bell pull. Why have I come? I know perfectly well. Know so well that I've no need to ask myself. Until once again the heavy front door opens.

Bohr: He stands on the doorstep blinking in the sudden flood of light from the house. Until this instant his thoughts have been everywhere and nowhere, like unobserved particles, through all the slits in the diffraction grating simultaneously. Now they have to be observed and specified...

Heisenberg: How difficult it is to see even what's in front of one's eyes. All we possess is the present, and present dissolves endlessly into the past. Bohr has gone even as I turn to Margrethe...Margrethe slips into history even as I turn back to Bohr...

Margrethe: I watch the smiles in the room...

Bohr: I glance at Margrethe, and for a moment I see what she sees and I can't –myself...

Heisenberg: I look at the two of them looking at me, and for a moment I see a third person in the room as clearly as I see them...

Bohr: I look at him looking at me, anxiously, pleadingly, urging me back to the old days, and I see what he sees. (Frayn, 86-87)

The actors' heads and gazes move back and forth among one another to match their lines, encouraging the audience's attention to do the same, following the characters' leads to "specify" their observations. In a small theater, the audience sees the actors, but also sees each other seeing the actors. The sensation of being watched can turn one's own attention inward, as well as allowing one a fleeting look at oneself reflected back from another. As Bohr comments: "I glance at Margrethe and for a moment I see what she can see and I can't –myself" (Frayn, 87). The audience is being made aware of the effects of observation among the characters, but also among themselves as spectators as they are involved even more closely in the action. It is important that the audience be deeply tuned in for the final "draft" so that they can follow the characters' train of thoughts; for this draft leaves the characters satisfied enough so that they feel no need to go any further.

In the third "draft," Bohr proposes they enact a "thought-experiment" (Frayn, 88). The experiment is that Heisenberg's words about atomic exploitation don't send Bohr off. Instead, Bohr stays to talk and discovers that Heisenberg hasn't "calculated [the diffusion equation.]" You haven't considered calculating it. You hadn't consciously realized there was a calculation to be made" (Frayn, 89). Heisenberg fumbles for reasons for not doing the calculation: it would have been a waste of time, the amount of U235 was likely to be too large; he was not actually trying to build a bomb; it never occurred to him to calculate it. Bohr is astounded. The

Heisenberg he knew “calculated everything! The first thing you did with a problem was the mathematics!” (Frayn, 84) In their thought-experiment, Heisenberg begins to calculate and finds the necessary amount of U235 to be considerably less than he supposed. He now realizes how horrifyingly easy it might have been for the Germans to produce a bomb.

Margrethe finally grasps the situation, saying, “That was the last and greatest demand that Heisenberg made on his friendship with you. To be understood when he couldn’t understand himself” (Frayn, 89). Heisenberg wanted Bohr to understand that he (Heisenberg) didn’t want to make a bomb *if* he could help it, thus propelling him to Copenhagen for reassurance in the face of the Nazi government and the suffering of the war. Margrethe continues, “And that was last and greatest act of friendship for Heisenberg that you performed in return. To leave him misunderstood” (Frayn, 89). For Bohr never stayed long enough to speak fully with Heisenberg and never made him realize how easily the bomb might be made if he’d done the equation. Thus Bohr never exposed this tremendous lapse on the part of a fellow physicist.

The characters suppose that they and their families were “preserved, just possibly, by that one short moment in Copenhagen”—by Bohr’s ending the conversation and Heisenberg’s failure to do the calculation (Frayn, 94). They needed three “drafts” to get there, for just as in their physics all the facts they have to go on are “a series of glimpses” into their past, like an electron shot into a cloud chamber (Frayn, 66). They have used physics to get their answer.

Frayn gives no definitive answer for why Heisenberg visited Bohr in *Copenhagen* beyond Heisenberg’s wanting to figure out what he wanted by seeing Bohr. In an interview, Frayn said that Heisenberg went “because he wanted to know what his own intentions were by trying them out on Niels Bohr... That he didn't quite know what his own attitude was and he wanted to discuss it with Bohr.”⁵⁵ However, Frayn’s characters do reach a mutual understanding of what came out of that visit. The Bohrs and Heisenberg believe “that one short moment in Copenhagen” between the men somehow spared them from the atom bomb (Frayn, 94). And since intentions can only be glimpsed, as the men’s physics prove—and even then after the fact, or by another person—so they “will never quite be located or defined” (Frayn, 94).

If the audience is left with a Heisenberg, who is not quite as bad as initially held to be by public opinion, then Bohr is not quite so good. Unlike Galileo, whose hopes for his science and awareness of what is at stake complicates Brecht’s attempt to pass a moral judgment upon

him, the Bohr and Heisenberg of *Copenhagen* support Frayn's belief that one needs to understand a person's motives, as well as the results of his actions, before judging him. To judge only by results, Bohr is morally guilty, Heisenberg innocent. The Allies built and dropped the atomic bomb. The Germans did neither. Frayn's Bohr is aware of this, quietly saying, "If people are to be measured strictly in terms of identifiable quantities," which Heisenberg bitterly interrupts with, "Then we should need a strange new quantum ethics. There'd be a place in heaven for me" (Frayn, 92). Both men's words indicate that they believe that they, as scientists, are morally answerable to society in the same way as any other individuals. Similarly, in *Galileo*, Andrea tries to give special treatment to Galileo, who bitterly rejects the notion of a different code of morals. Andrea reasons with Galileo saying:

ANDREA	...Your hands are tainted, we said. You say: better tainted than empty.
GALILEO	Better tainted than empty? Sounds realistic. Sounds like me. New science, new ethics. ⁵⁶

As physicists, Bohr and Heisenberg know that it is not possible to judge people based on identifiable quantities. And intentions are not such quantities; moreover, "measurement is not an impersonal event that occurs with impartial universality. It's a human act" (Frayn, 70). The characters of *Copenhagen* engage in the act of 'measuring' one another, of sizing each other up, throughout the play. The audience knows from their lines and their behavior (intonations, facial expressions, gestures and blocking) that the characters have certain biases, as well as an emotional and intellectual stake in what they observe about one another and themselves. In addition to observing the actors in the intimate space of a theater in the round, the audience can observe other audience members. The staging of the play includes the audience in what is transpiring on stage *and* among themselves. The audience all see the same three people and hear the same words, but they also see every other person has a "particular viewpoint;" their seat in the theater and in their own mind (Frayn, 72). Every individual in the audience is going to respond to those shared observations in slightly different ways. Bohr remarks on the difficulties of measuring, "The universe exists only as a series of approximations. Only within the limits determined by our relationship with it. Only through the understanding lodged inside the human head" (Frayn, 72). Measuring, whether it is of electrons, or of a person's motives or conduct, is prone to human error. Therefore, it is not entirely perfect or impartial. It is personal and unique as is each audience member's experience of the performance.

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Frayn pursued a philosophic project, while Brecht's was a political one. *Galileo* and *Copenhagen* enact how relevant the relationship between science and society is, not just to those in the production, but to those in the audience as well. Galileo, Bohr and Heisenberg are scientists who believe they should be involved with, and respect, "the crowd" (Brecht, 84). The plays teach "the crowd" to pay attention to the discoveries made by scientists like these so that those discoveries may be used responsibly.

Brecht and Frayn dramatize these characters and events so as to embody their ideas about social progress, epistemology and history. Brecht and Frayn wanted to appeal to the emotions of the audience as well as the intellect. Brecht believed "it would be quite wrong to try to deny emotion to [the modern] theater. It would be much the same thing as trying to deny emotion to modern science."⁵⁷ Science historian Robert Marc Friedman noted at the conference on *Copenhagen* held at the Bohr Institute, "No medium can better convey the immediacy of emotions [than theater]— and science entails not only cold logic but also hot passion."⁵⁸ With their arguments and their humor, these plays try to kindle "flames," not only among their characters, but also between actors and audience, and between the audiences and the world outside the theater (Frayn, 13).

Both physics and theater bring together sub critical masses to create a reaction. These plays ask daunting questions about society's trust in science and its use of it. Perhaps it is easier to ask such things in the context of the theater, a place built for actors and spectators to confront ideas that can be overwhelming. Brecht and Frayn have to "stage" their ideas, just as Galileo, or Bohr, or Heisenberg do in their drive to publish. The "apple" of knowledge is too tasty to keep to oneself (Brecht, 50). Brecht wrote in *Galileo's* Afterward: "But the truth cannot merely be written; it must be written *for someone*, someone who can do something with it."⁵⁹ That 'someone' is the audience. What Brecht and Frayn hope for is that the audience will bring what they've gained through the plays into their actions beyond the stage after the curtain comes down.

End Notes

- ¹ Frayn, Michael. "Copenhagen Revisited." The New York Review of Books. 28 March, 2002. 2.
- ² Carpenter, Charles A. Dramatists and the Bomb: American and British Playwrights Confront the Nuclear Age, 1945-1964. Westport CT: Greenwood Publishing Group Inc., 1999. 12.
- ³ Hye, Allen E. The Moral Dilemma of the Scientist in Modern Drama: The Inmost Force. New York: The Edwin Mellen Press, 1996. 123.
- ⁴ Shepherd-Barr, Kirsten. Science on Stage: From Doctor Faustus to Copenhagen. Princeton: Princeton University Press, 2006, 4.
- ⁵ Shepherd-Barr. Science on Stage. Princeton: 38.
- ⁶ Roach, Joseph R. The Player's Passion: Studies in the Science of Acting. Newark: University of Delaware. 1985. 224-255.
- ⁷ Djerassi, Carl. "When is 'Science on Stage' really science?" Rev. of Science on Stage: From 'Doctor Faustus' to 'Copenhagen, by Kirsten Shephard-Barr. American Theater Jan. 2007: 102.
- ⁸ Hye. The Moral Dilemma of the Scientist in Modern Drama. 8.
- ⁹ Canton, Ursula. "Interview with Michael Frayn." Theatre Archive Project. The British Library, University of Sheffield and AHRC. 27 February 2004.
<<http://www.bl.uk/projects/theatrearchive/frayn.html>> 2.
- ¹⁰ Hall, Peter Sir. Exposed by the Mask. London: Oberon Books, 2000, 20.
- ¹¹ Hall. Exposed by the Mask. 80.
- ¹² Martin, Carol & Henry Bial. Brecht Sourcebook. New York: Routledge, 2000. 28.
- ¹³ Bentley, Eric. The Life of the Drama. London: Methuen, 1965. 150.
- ¹⁴ Hye. The Moral Dilemma of the Scientist in Modern Drama. 92.
- ¹⁵ Hall. Exposed by the Mask. 107.
- ¹⁶ Frayn, Michael. "Copenhagen Seminar Lecture Transcript." Available at <<http://www.nba.nbi.dk/files/sem/coplang.html>> 19 November 1999.
- ¹⁷ Brecht, Bertolt. Trans. John Willett. Brecht on Theater: The Development of an Aesthetic. New York: Hill and Wang, 1957. 15.
- ¹⁸ Brecht. Development of an Aesthetic. 166.
- ¹⁹ Bentley, Eric. "The Science Fiction of Bertolt Brecht." Galileo. Bertolt Brecht, Charles Laughton trans. New York: Grove Press, Inc., 1966. 13.

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- ²⁰ Brecht. The Development of an Aesthetic. 278.
- ²¹ Frayn. "Copenhagen Seminar Lecture Transcript." 1999.
- ²² Dörries, Matthias, ed. Michael Frayn's Copenhagen in Debate: Historical Essays and Documents. Berkeley: Office for History of Science and Technology University of California, 2005. 109.
- ²³ Dörries. Copenhagen in Debate. 115-116.
- ²⁴ Canton. "Interview with Michael Frayn." 3.
- ²⁵ Frayn. Copenhagen. 99.
- ²⁶ Hare, David. "Adapting Galileo." The Life of Galileo Program. The Royal National Theatre. June 2006. 4.
- ²⁷ Brecht. The Development of an Aesthetic. 277.
- ²⁸ Bentley. The Life of the Drama. 161.
- ²⁹ Esslin, Martin. Brecht: The Man and His Work. New York: Doubleday & Company, 1961. 130.
- ³⁰ Brecht. Development of an Aesthetic. 151.
- ³¹ Brecht. Development of an Aesthetic. 37.
- ³² Brecht. Development of an Aesthetic. 80.
- ³³ Bentley. "The Science Fiction of Bertolt Brecht." 25.
- ³⁴ Brecht, *The Life of Galileo*. 59.
- ³⁵ Gunderson, Lauren. "Science on stage: Why science works for theatre." Hybrid Vigor: Life and Death, Issue 5 (Fall 2003.)
- ³⁶ Reston, James Jr. Galileo: A Life. New York: HarperCollins Publishers, 1995. 3.
- ³⁷ Reston. Galileo: A Life. 141.
- ³⁸ Reston. Galileo: A Life. 171.
- ³⁹ Bentley. "The Science Fiction of Bertolt Brecht." 16.
- ⁴⁰ Brecht. *The Life of Galileo*. 84.
- ⁴¹ Brecht, Bertolt. Charles, Laughton, trans. *The Life of Galileo*. New York: Random House, 1966. 128.
- ⁴² Brecht, Bertolt. "Writing the Truth: Five Difficulties." *Galileo*. Bertolt Brecht, Charles Laughton trans. New York: Grove Press, Inc., 1966. 134.

⁴³ Bentley. "The Science Fiction of Bertolt Brecht." 16.

⁴⁴ Hare. "Adapting Galileo." 4.

⁴⁵ Brecht. *Galileo*. Charles Laughton trans. 129.

⁴⁶ Frayn, Michael. "Copenhagen Seminar Lecture Transcript." Available at <
<http://www.nba.nbi.dk/files/sem/coplang.html>> 19 November 1999.

⁴⁷ Frayn. "A Postscript to *Copenhagen*." 97.

⁴⁸ Langdal, Peter. "Copenhagen Seminar Lecture Transcript." Available at <
<http://www.nba.nbi.dk/files/sem/coplang.html>> 19 November 1999.

⁴⁹ Moore, Ruth. Niels Bohr: The Man, His Science, & the World They Changed. Cambridge: The MIT Press, 1985. 288.

⁵⁰ Frayn, *Copenhagen*, 52.

⁵¹ Frayn. "Copenhagen Seminar Lecture Transcript." 19 November 1999.

⁵² Brecht, Development of an Aesthetic, 190.

⁵³ Henning, ?. "Copenhagen Seminar Lecture Transcript." Available at <
<http://www.nba.nbi.dk/files/sem/coplang.html>> 19 November 1999.

⁵⁴ Frayn, Michael and David Burke. The Copenhagen Papers: An Intrigue. New York: Henry Holt and Company, 2000. 29.

⁵⁵ Canton. "Interview with Michael Frayn." 3.

⁵⁶ Brecht, *The Life of Galileo*, 82.

⁵⁷ Brecht, Development of an Aesthetic, 23.

⁵⁸ Friedman, Robert Marc. "Copenhagen Seminar Lecture Transcript." Available at <
<http://www.nba.nbi.dk/files/sem/coplang.html>> 19 November 1999.

⁵⁹ Brecht. "Writing the Truth: Five Difficulties." *The Life of Galileo*. 140.