Embodied Astronomies: Performances of Telescopes and Other Detection Devices

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Embodied performance is essential to the practice of astronomy. I propose that theatre provides a popular space in which people who are not science experts might participate in the production of science ideas. This process is particularly apparent when science machines are represented on the theatrical stage. My methods are drawn from cognitive theory, performance studies, and close readings of plays and other performance texts. This dissertation focuses on plays, performances, and films for which the telescope is central to the action of plots that explicitly deal with questions about the pursuit of the unknown.

The first chapter, "History: Telescopic (mis)Information on the Early Modern Stage," examines the doubled narratives in Thomas Tomkis's *Albumazar* (1614) and Aphra Behn's *The Emperor of the Moon* (1687). Both of these plays textually perform points of view that are skeptical of the usefulness of the telescope as applied to the practice of astronomy. Close readings of the scenes that feature telescopes reveal that the machines enact their own narratives within the metaenvironment of the theatre.

Radio-telescopes take the stage in the second chapter, "Criticism: Credit and Authority in the Performance of Trustworthy Astronomy." In this chapter, telescopes appear in plays and performances that stage social criticisms of the institutional practices of late twentieth century astronomy and its related, theoretical sibling, cosmology. Lauren Gunderson's play, *Background* (2003) and the film, *Contact* (1997), based on the novel by Carl Sagan, dramatize inequalities of access and authority that plague the performance of science in the domain of the laboratory.

The final chapter, “Praxis: Towards an Accessible Performance of Astronomy,” examines performances from scientific and theatrical domains that explicitly endeavor to stage equitable science practice. The American astronomer Vera Rubin broke boundaries of access within her career, and publicly advocated for the inclusion of women and other minorities in the field of astronomy. Performance artist Laurie Anderson blurs the art-science divide with her one-woman show, *The End of the Moon* (2005) whereby she further articulates the networked system of contemporary culture in which politics, science, and the arts all share the stage.

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PREFACE

I was raised in the company of women scientists. While I do not identify as a scientist, it is no surprise that, as a part of the socio-scientific assemblage of my upbringing, I should find myself captivated by questions about science as a performance studies professional. This dissertation would not have come to be without the influence, presence, and lifelong support of my mother (the botanist) Phyllis Appler, Dr. Donna Ware (the herbarium curator), Ruth Beck (the ornithologist), Margery Inderbitzen (the chemist), and Joanne Reckis (the mathematician). There have been many other significant teachers and theatrical collaborators, along the way, but these women have been particularly remarkable in their dedication to their chosen fields and their ability to share that passion with many general audiences of students and interested amateurs.

I owe a huge thanks to the many individuals and institutions who have supported this interdisciplinary dissertation, which is the culmination of several years of performance research. “Embodied Astronomies” is the critical product of a performance research agenda that I set for myself in 2010. I am grateful to Fulbright IIE for granting me the funds to travel to Switzerland in 2011 so that I could research particle colliders and clown technique for the composition of a musical play about quantum physics for puppets and masks. I am also thankful for the residency that the Dimitri School provided during that Fellowship. I have been lucky to research this project in residence at other institutions as well. I must thank the Huntington Library for awarding me a Dibner Fellowship in the History of Science and Technology, where I was able to enrich my research through access to rare primary sources and dedicated time and space to write. Thank you, Dr. Cynthia Hunt of the Carnegie Institute of Science Observatories for sharing the plate archives

with me! And, thank you very much to Dr. Don McCarthy, astronomer and founder of the Adult Astronomy Camp at the Mt. Lemmon SkyCenter.

This line of thinking has sustained me throughout my time as a graduate student at the University of Pittsburgh. Thank you to Cynthia Croot, who helped me fine-tune my focus on Vera Rubin. Many, many thanks to Vera Rubin, who, after much pestering, agreed to chat with me on the phone about dark matter and women in science. Thanks to Dr. Kathleen George, Stacey Cabaj, Gale McNeeley, and Maria Enriquez, who gave me feedback on "In the Still of the Night." Thank you so much to the teachers who supported me and gave me great notes. Thank you to Dr. Jennifer Waldron, my advisor. Thank you to my committee members, Dr. Bruce McConachie, Dr. Michelle Granshaw, Dr. Paolo Palmieri, and Dr. Ryan McDermott. Thanks to other teachers, colleagues, and editors who have responded to pieces of this work: Dr. Josh Ellenbogen, Dr. Amy Cook, Colleen O'Reilly, Dr. Dorothy Chansky, Dr. Sara Freeman, and Dr. Jocelyn Buckner. Thanks also to my father (the optometrist) David Appler, who helped me build a Galilean telescope out of a cardboard wrapping paper tube and a couple of lenses from the office. Thank you so much to my husband, David Bow, who read this dissertation from cover to cover.

1.0 INTRODUCTION

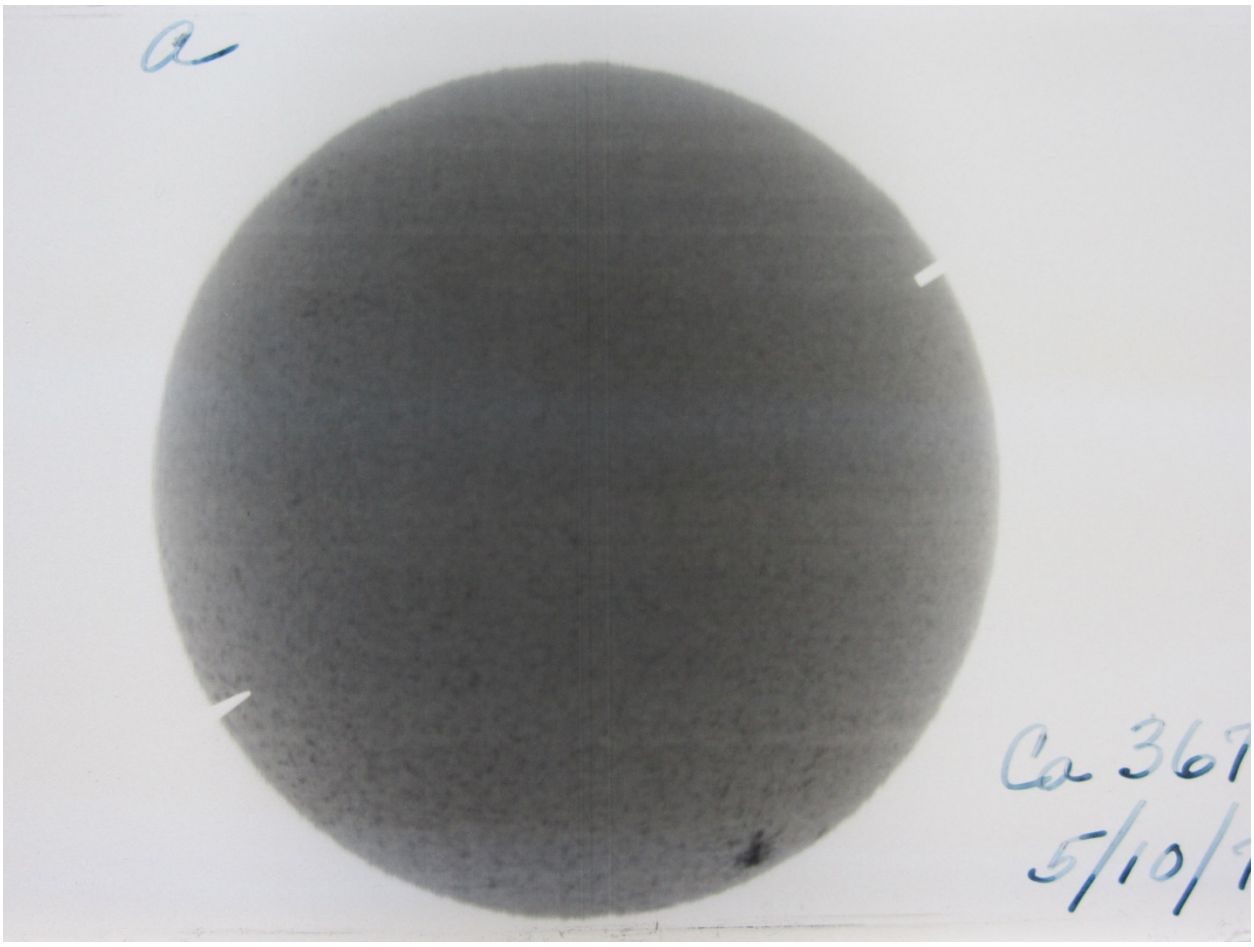

Figure 1: Solar photograph taken on 10 May 1975 at the Mt. Wilson Observatory. Courtesy of Carnegie Observatories.

This is a photograph of the sun that was captured on the day I was born. I include it at the top of this dissertation as a composite representation of the many concepts that are involved in the following discussion about performances of telescopes and other detection devices. First of all, it

is an image taken through a telescope—one example of a performance trope that carries through all of the examples in this dissertation. The image is of a familiar object, the sun, but due to its negative, black and white composition, it might seem unfamiliar without a caption. The manipulation of familiar images to communicate new information about celestial objects and events is part of the work performed by telescopes in the domains of science and the arts. One of the themes that will surface throughout this piece is that of emotional connection to new science concepts. I wish that I could include an index of all of these solar photographs so that each person who reads this dissertation might enjoy a curious glance at the sun's weather on the day of their birth. In so doing, they might identify with a doubly familiar image—the sun and their birthday—in order to immerse themselves in the following material.[1]

Finally, this photograph is part of a larger performance tradition of astronomy that is practiced at Mt. Wilson. The observatory's situation is no longer ideal for nighttime astronomical observation because of the air and light pollution that has encroached upon it from nearby Los Angeles and its suburbs. However, the solar telescopes are still in use for astronomy research. In addition to experiments performed with these telescopes, every day, someone at the observatory uses one of these solar telescopes to draw a picture of the day's sunspots by hand, using paper, pencil, and a projection of the sun. This embodied astronomy practice might seem archaic (it is essentially the same method that Galileo and his contemporaries used to observe sunspots in the early 1600s), but it is just this physical, hybrid practice that involves human body, telescope, pencil, paper, and historic tradition, that makes the legacy of astronomy meaningful to a general

[1] Dr. Cynthia Hunt, who is in charge of social media and outreach for Carnegie Observatories, often uses these solar images as a way to introduces newcomers to the Observatory's archives.

audience.[2] One doesn't need an advanced degree in astrophysics to trace a projected image, and it is this kind of hook that is necessary to perpetuate an accessible model of astronomy practice.

A performance studies approach to astronomy reveals historical biases that have been held on both sides of what C.P. Snow has infamously dubbed the "two cultures" divide between the arts and the sciences.[3] These biases will be raised in Chapter 2, "History: Telescopic (mis)Information on the Early Modern Stage," which considers Thomas Tomkis's *Albumazar* (1614) and Aphra Behn's *Emperor of the Moon* (1686), and shall inform the rest of the dissertation. A performance studies perspective highlights the ways that the representation of the domain of science has become an important part of performance. Chapter 3, "Criticism: Trust and Authority in the Performance of Credible Science," examines Lauren Gunderson's play, *Background* (2003), and the film *Contact* (1997), conceived by Carl Sagan, in order to identify the socio-scientific critique that can be embedded in performances set within culture of scientific communities, which are in turn a part of the greater culture in which they operate. The final chapter, "Praxis: Towards an Accessible Performance of Astronomy," moves forward from late twentieth century critiques of the performance of science. It examines observatory and theatrical performances from the early twenty-first century that model ways to bridge the false gap between the sciences and the arts. Images of deep space objects in live performance and news media provide a familiar means by which a general audience might access the domain of astronomy. Equality of access has been a problem for the field of physics and astronomy in particular, and a performance studies lens

[2] The Carnegie Observatories archive also contains volumes of these daily drawings of the sun.

[3] In his 1959 treatise, "The Two Cultures," Snow suggests that scientists and members of the literary elite are not able to communicate with one another. Written within the very particular social situation of Cambridge University's dining halls, Snow's comments sometimes come across as dated. His criticism, which he claims to be writing from an interdisciplinary perspective, still falls into the trap that suggests that the literary intellectuals have more work to do than scientists in meeting the gap between the "two cultures."

uncovers the work that is already being done to level the playing field. More work in the overlapping fields of performance studies and the sciences will be able to further highlight avenues of access between the sciences and the arts for a diverse population culture.

1.1 BEGINNING IN THE MIDDLE: ACTANT OBJECTS AND PERFORMANCE STUDIES

Bruno Latour suggests that it is best to begin a thought in the middle, rather than at the end or at the beginning, in order to maintain a sense of the whole.[4] This dissertation is a comparison of plays and performances that feature telescopes from the seventeenth century to plays, performances, and films that also feature telescopes that premiered at the turn of the Millennium. I begin in the middle, with Dion Boucicault's *The Octoroon, Or, Life in Louisiana*, which premiered in 1859, a year before South Carolina's secession from the United States. Boucicault's melodrama is the perfect theatrical event with which to begin this dissertation for two reasons: 1) the plot hinges on the actions of an object, and, 2) that object is referred to as a telescope. Although the telescope in *The Octoroon* is a camera, the naming of the device as a telescope is important because theatrical performances that stage telescopes are telling components of the cultural assemblage of the practice of astronomy. By 1859, telescopes were a familiar technology, but cameras were new. Boucicault assists audiences in their engagement with a technological plot line by framing the new technology of the camera within the familiar vocabulary associated with telescope. In doing so,

[4] "As soon as we start from the middle, as soon as we invert the arrows of the explanation, as soon as we take the essence accumulated at the two extremes and redistribute it to the whole set of intermediaries, as soon as we elevate the latter to the status of full-fledged mediators, then history in fact becomes possible. Time is there not for naught, but for real" (Latour, *We Have Never Been Modern*, 81-2).

the action that surrounds the camera qua telescope in *The Octoroon* provides avenues of access to science across a wider cultural domain than would have otherwise been possible. Boucicault's placement of the term telescope within the dialogue of slave characters opens up a broader conversation about diversity and access to the domain of science as it is staged on the nineteenth century stage.

A polytemporal explosion in the domains of art and science is triggered in 1859 when one of Boucicault's characters in *The Octoroon* refers to the play's primary actant object, a camera, as a "telescope." Jonathan Gil Harris builds upon Latour's concept of the actant object and describes its explosive agency. According the Harris, repercussions of an object's actant nature can appear at different temporalities, even as the object and its qualities change over time. A transhistorical argument, according to Harris's reading of Latour, "insists on unexpected conversations between diverse agents across time" (Harris, *Untimely*, 166). This explosive moment in the history of the telescope onstage suggests some of the important themes that will resonate backwards and forwards throughout this dissertation as I argue for the relevance of a history of the science machines as they are represented onstage. Those themes are the act of capture, the mediation of information, and social status.

Harley Erdman's provocatively open summary of *The Octoroon* situates Boucicault's melodrama in a manner that can be read across boundaries of time and space:

> A white man commits a violent and unjustified act of brutality against a black man. The white man does not know that a camera has caught the crime on film. The crime, which would have otherwise gone undetected, is thus publicly revealed. The seemingly incontrovertible evidence of the film is presented before a jury. Justice seems about to be done. But before such justice can be delivered, chaos ensues. Monumental structures go up in flames. The innocent suffer and perish. Justice

> seems far away, at least in society as constructed here on earth. (Erdman, "Caught," 333).[5]

In the summer of 2015, these words reverberate in new ways as protests against police brutality sweep the United States in the wake of publicized video recordings of several police killings of unarmed black men. During the same time period, deep space cameras shared the news headlines with the New Horizons space probe's close-up images of Pluto that make, "the United States the first nation to send a space probe to every planet from Mercury to Pluto" (Barnett, "Pluto").[6] The plays discussed throughout this dissertation do not explicitly deal with questions of race and conquest, but many address aspects of social inequality as a part of the social assemblage of science practice.

Latour's project is to establish a system of cultural analysis that considers objects as actant in culture and nature. This approach envisions science objects that appear in performances in an array of contexts. Latour describes this kind of work as "mediation" (Latour, *Modern*, 46.):[7]

> An intermediary… simply transports, transfers, transmits energy… It is void in itself and can only be less faithful or more or less opaque. *A mediator, however, is an original event and creates what it translates as well as the entities between which it plays the mediating role.* If we simply restore this mediating role to all agents, exactly the same world composed of exactly the same entities cease being modern and becomes what it has never ceased to be – that is, nonmodern. (*Modern*, 78)

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[5] "Caught in the 'Eye of the Eternal': Justice, Race, and the Camera, from 'The Octoroon," was published in 1993, when the memory of the Rodney King trials would still have been fresh in the memories of *Theatre Journal*'s reading audience. Erdman's analysis is not Latourian, but the language he uses to describe the camera that is central to *The Octoroon*'s plot is quite close to Latour's, especially with phrases such as, "the play constructs the camera as an instrument, even an agent of justice that will expose the truth of a racially charged act of brutality" (333).

[6]The relationship between the technologies involved in scientific experiment and geographical/interplanetary exploration is an undercurrent of this dissertation. It will resurface briefly in the discussion of Aphra Behn's *Emperor of the Moon* in Chapter 2, a short passage about Paul Godfrey's *The Blue Ball* in Chapter 3, and Laurie Anderson's *The End of the Moon* in chapter 4. There is more to be said about the relationship between the device of the telescope and the scenario of the conquest, but that is another project.

[7] Latour sets up his own breakable binary by setting the term "mediation" against "purification," which he describes as a modernist approach to sociology and history.

When Latour refers to "all agents," he includes actions, objects, animals, and machines in his discussion. Actancy is like agency, but lacks the intention that human agents apply to their actions in the world.Drawing on the work of Mark Hansen and others, Jennifer Waldron underscores theoretical turns towards a model of "emergence" for human-machine relations in which "interactions between the human and the technical produce results that cannot be controlled from inside either system" (Waldron, "Dead Likeness, 3). In this context, at what point does a human cease to be an agent? N. Katherine Hayles's discussion of virtual gaming points to the ways in which such emergent human-machine interactions imply that "players not only play the game but are also played by the game, disciplined by the game's logic into an identification made more intense by the kinaesthetic and embodied aspects of game play" (Hayles, 315). This theme is taken up largely in Chapter 4, "Envisioning an Accessible Performance of Astronomy," within the context of performatics and the posthuman. Here, I have used Diana Taylor's term, "performatic," originally applied in an Americas context, and placed it in a socio-scientific one. Chapter 4 engages at length with the combination of the term with Donna Haraway's provocative notion of informatics. I use the term performatics to deal with acts of performance that engage with the body, with data, with machines, and with social inequality.[8]

Boucicault's *The Octoroon* can be understood as an "original event," out of which the invention of the telescope becomes a transhistorical, socio-technological phenomenon through hybrid networks that involve data, machine, environment, and human. *The Octoroon*'s dramatic action revolves around two entangled plots: one has to do with the potential financial downfall of an antebellum estate, and the second concerns the murder of the slave, Paul. Scudder, a Yankee inventor, turns up at the plantation with a "photographic apparatus" (*Oct.* I). After the murder,

[8] This theory is unpacked in much more detail in Chapter 4.

M'Closky (the white murderer) steals evidence that would have saved the plantation so that he can deprive Zoe (the octoroon) of her freedom by bidding on her at auction. Wahnotee, "an Indian Chief or the Lepan Tribe" and friend to Paul, is brought in as a suspect in Paul's murder (*Oct.* "Program").[9] Just as the lynch trial has all but condemned Wahnotee to death, LaFouche (a minor character) turns up with the smashed camera, which Wahnotee had destroyed in a fit of despair upon discovering Paul's dead body earlier in the play. Pete (an elderly slave), "*who has been looking about the camera*," produces "a picture [he] found sticking in that… telescope machine…" (*Oct.* IV). The image reveals M'Closky holding Wahnotee's hatchet, standing over the dead Paul. It is evidence enough for the lynch trial to free Wahnotee and condemn M'Closky.

The capacity of the camera to capture an image is related to that of the telescope. It is just this techno-linguistic trick that is performed in Boucicault's *The Octoroon* when a telescope captures an image, apparently on its own. The images produced by Boucicault's camera/telescope intervene into the action of the play and mediate the event of the lynch trial. Boucicault's telescope/camera exemplifies the idea of a Latourian hybrid because it is an object that performs the functions of a camera, but is referred to by the name of another object. Boucicault's camera performs in the play at a moment of transition, and thus its actions as camera and its name of "telescope" allow for a Latourian analysis of the object as transdisciplinary due to its social performance and its scientific name.[10] The hybrid nature of this object as it appears onstage allows a conceptual blend to transpire in the metatheatrical system of the 1859 theatre. Audience members

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[9] Joseph Roach, in his article, "Mardi Gras Indians and Others: Genealogies of American Performance," corrects Boucicault's narrative and identifies Wahnotee as a member of the Choctaw Nation (Roach, 479).

[10] In a Latourian analysis, objects that aren't often grouped together for what he refers to as "social" purposes can be rearranged in order to find new connections and new meanings that derive from their function. He explains, "At first, bringing objects back into the normal course of action should appear innocent enough. After all, there is hardly any doubt that kettles 'boil' water, knifes 'cut' meat, baskets 'hold' provisions… Are those verbs not designating actions?" (Latour, *Reassembling the Social*, 70-71).

are presented with visual information—an object that looks like a camera—and textual information—a verbal reference to that object as a telescope. Audiences receiving these two different pieces of information via different perceptive capacities would then combine the information in their imaginations while enjoying the rest of the action. The imaginative work performed in the theatre allows audience members to participate in the conceptual blend of telescope/camera as they engage in the science-oriented plot of *The Octoroon.*[11] This kind of imaginative engagement with science as a part of society was at work as early as 1614, when Thomas Tomkis describes telescopes as "engines" that "catch stares" in *Albumazar* (1614), discussed in Chapter 2 (*Alb.* I.iii). In the twenty-first century, telescopes are still capturing images of stars, planets, galaxies, and many other objects in outer space that were never before accessible to human perception because they were simply out of our range of vision. Performances that feature telescopes are likewise still engaging curious audience members in the conceptual blend of science and society in the metaenvironment of the theatre.

The camera qua telescope in *The Octoroon* is a trickster due to its hybrid nature.[12] When Scudder first introduces the device, he verbally provides a photographic context, explaining that he quit his hobby as an inventor to take up, "the photographing line" (*Oct.* I). He states that he arrived at the plantation with "his apparatus," and "took the Judge's likeness and his fancy" (*Oct.* I).[13] Scudder frequently refers to it as an apparatus, not a camera. Boucicault, in his stage directions, does call the apparatus a camera, but also uses "apparatus" as a synonym for "camera,"

[11] For a more detailed discussion of conceptual blending and the theatre, please refer to Bruce McConachie's *Engaging Audiences: A Cognitive Approach to Spectating in the Theatre.*

[12] The trickster nature of the social cyborg, as theorized by Donna Haraway, will become an important point of reference, particularly in Chapter 4.

[13] The camera captures the attention of the judge on Scudder's behalf. This is similar to the manner in which the telescope will capture the attention of Pandolfo in *Albumazar*.

even though an apparatus is a much more general term. Although Boucicault slips between the terms "apparatus" and "camera," none of the characters in the play ever name the device as a "camera." Most follow Scudder's lead and call it an "apparatus." Twice, characters refer to the device as a "telescope." New technologies are often referred to by different names as they emerge into popular use.[14] As shall be discussed in Chapter 2, the telescope underwent a similar process of variable naming as it became a more and more familiar object over the course of the seventeenth century. It is therefore interesting that the term "telescope," which had become a more fixed term by the eighteenth century, is used to refer to a camera in Boucicault's *The Octoroon*.

I suggest that Boucicault deliberately places the word "telescope" in the mouths of slave characters, rather than scientist characters, in order to lower the tone of photographic technology so that the theatre-going audience of New York in 1859 would be able to understand how the device in *The Octoroon* works, and therefore ensure their comprehension of the scientific aspects of the melodramatic plot.[15] Paul, who is murdered by M'Closky while in the midst of having his portrait taken, asks Scudder in Act II, "Say, Ms'r Scudder, take me in dat telescope?" (*Oct.* II) and Pete revives Paul's language at the end of the play. In Chapter 3, I discuss Steven Shapin's tone-lowering approach to the history of science as it applies to late twentieth century films and plays that deal with astronomy and cosmology content. Shapin suggests that the domain of science has

[14] Erdman briefly describes the many names for the telescope that were applied during the mid-nineteenth century. He lists "frequently hazy, ghost –like images [that] were indeed impressionistic "types"—daguerreotypes, tintypes, ambrotypes—rather than artifacts which could serve as convincing representations and compelling recreations of reality… By 1855, the daguerreo*type* had ceded to the photo*graph* as a trope for the product of these various processes, and with it the inexact art of the daguerreotype," (Erdman, "Caught," 339).

[15] Please refer to Adam Sonstergard's article, "Performing Remediation: The Minstrel, The Camera, and *The Octoroon*," for a thorough discussion of the complicated mechanics of blackface as part of the apparatus of mid-nineteenth century performance in New York. It is important to keep in mind two important factors: 1) *The Octoroon* premiered the year before South Carolina's secession from the Union, and so Yankee interpretations of southern lifestyle were certainly generalized and politically skewed, 2) *The Octoroon*'s audiences were not watching black actors onstage, but white actors in blackface playing minstrel stereotypes of characters and thus had a host of expectations of this kind of performance that were not at all related to the rest of the play or its plot.

come to occupy a space in the popular imagination reserved for an elite group of people, predominantly white men of means. His science historiography endeavors to expose the everyday elements that make up the performance of science. Such an approach effectively lowers the tone and begins to make the domain of science more accessible—practically and imaginatively—to a diverse population. As shall be discussed in greater detail in Chapter 4, performances that stage telescopes can provide a sense of familiarity with a potentially new subject and thereby spark an active learning process in the body-minds of spectator-participants. Telescopes, by 1859, had been around for over two hundred years. Cameras, on the other hand, were new.[16] Paul assists the audience's comprehension of the camera's function by verbally associating it with the familiar telescope, which was popularly understood to make distant objects appear to be closer by means of lenses.[17]

Boucicault's concern that the audience will understand the mechanics of the camera is clear at the very beginning of Act II, when Scudder's camera works its magic. Scudder explains what a photographic plate is and also informs the audience that "one of them is prepared with a self-developing liquid, that I've invented" (*Oct.* II).[18] All parts of the photographic assemblage, including its multiple names, are apparent in this scene. Of particular importance is the witness of, "George and Paul looking on at back" (*Oct.* II). Paul's experience of the photographic performance is shared by the audience. Throughout, Paul mixes telescope and culinary terminology as he explains—verbally and physically through asides to George and the audience—the mechanics of

[16] The term, "camera" had obviously emerged as a term for a photographic apparatus by 1859, since Boucicault uses it, but the word itself has a rich history that had been more associated with chambers and rooms for centuries before the term was applied to photography.

[17] The use of chemically treated plates to capture astronomical images developed in tandem with advancements in photography throughout the nineteenth century.

[18] Erdman makes sure to point out that the self-developing solution is a fiction.

the photographic apparatus. He uses a kitchen analogy that serves to familiarize the audience with the concept of exposure time necessary to produce images captured by the photographic apparatus. After Scudder exposes the plate and "*takes out his watch*," Paul comments, "Now it's cooking" (*Oct.* II). Paul, excited at the prospect of having his own picture taken, continues to invoke the kitchen analogy as he tries to convince Scudder to do so by pointing out that the Yankee has prepared four photographic plates, which he calls, "dishes," already (*Oct.* II). Paul's ersatz association works as comedy, but also proves his analogical demonstration of the science of photography in 1859.[19] Paul continues with this analogy after Scudder leaves. "[H]ere's dem dishes—plates…," Paul exclaims as he instructs Wahnotee in the process of staging his portrait (*Oct.* II). As Paul waits for Wahnotee to return (and the sufficient time to elapse for the plate to be exposed), he remarks that the "time [Wahnotee is] gone just 'bout enough to cook dat dish plate" (*Oct.* II).[20] The audience, learning with Paul, would understand that waiting for a chemically treated photographic plate is akin to waiting the appropriate time for something tasty to come out of the oven. Multiple senses—vision, memory, taste—are brought into the service of enlisting the audience in the process of science/photography so that they might better engage with the later events of the plot when the plates are discovered later in the play.

Paul's attempt to perform the experiment of photography on his own authority backfires tragically in his murder at the hands of M'Closky, and this raises questions of access and privilege

[19] Erdman urges his reading audience to remember that the process of photography as it was performed on Boucicault's stage was not an accurate description of the science of the times.

[20] Certainly, the racialized performance of Paul, the slave, would also have been a part of the assemblage of the photographic science of capture as it was performed on the stage of the Winter Garden Theatre in New York at its premiere in 1859. As mentioned above, themes of conquest, race, ability, and access surface at times throughout this dissertation because they become detectable through a feminist approach the performance of science towards which this dissertation works. However, a thorough discussion of race, conquest scenarios, and the performance of science is the work of another project.

that are associated with the rise of science as a dominant location of cultural authority in the West. As this dissertation moves from early modern performances that on the surface reject the authority of the mediated image and into the twentieth and twenty-first centuries when those scientists have been replaced by the images themselves, it is important to pause in the mid-nineteenth century with the example of Boucicault's "telescope" in order to mark the moment when the mediated image begins to trump eye-witness as a credible representation of the truth. Adam Sonstergard presses on the relationship between authority and access in his article, "Performing Remediation: The Minstrel, The Camera, and *The Octoroon*":

> [Paul] can exist within two systems of representation simultaneously: as a character with a camera, he could embody the potential to create his own representations. But as a white actor appearing onstage in blackface, he also serves as a reminder of whites' exclusive power over the representation of blacks. (383)

If we take Sonstergard's criticism one step further, Paul's failure to complete the capture of his own photograph suggests not only the subordination of blacks under white power, but also the relegation of the practice of science (here, synecdochally represented by the camera) as the exclusive domain of white men. Yet, the final product—the developed image—is discovered by a black man, Pete. As we shall see in Chapter 2, the narrative that emerges when one traces the actions of and with the staged machine is different than that which can be understood through the text alone. In this case, the object-oriented narrative reveals that science is not the exclusive domain of whites, but is accessible to everybody. In Chapter 4, I explore ways in which the performance of science already embodies ideals of community, equal access, and recognition of the individual as vital to the whole. Paul's murder scene, witnessed only by the camera, and the audience, implicates even nineteenth century audiences as a part of the assemblage of the racially imbalanced performance of science. Audience members learn about the process of photography through an empathetic identification with a black character (that would have been performed by

a white person in blackface) through that character's familiar performance of the science of photography. Although the moral of the textual narrative may have reinforced the racial biases of the day, the science, as it was performed in the theatre, tells an opposite story of authority and access to the domain of science.

Boucicault dramatizes a point in the history of the United States at which the photographic image was beginning to come into its own as a trustworthy mediator of information that would otherwise remain outside the realm of unaided human detection. Josh Ellenbogen, in his book, *Reasoned and Unreasoned Images: The Photography of Bertillon, Galton, and Maray*, argues that the mid-late nineteenth century was a time when photographic experimentation began to produce information as well as record it, which raises questions about photography's capacity to accurately represent the truth. Similar criticisms regarding the telescope's potential to distort images of reality were raised during the seventeenth century, largely through the medium of the stage, as will be discussed in the following chapter.[21] A Latourian analysis of the Boucicault's camera leads to the interpretation of the object as mediator, "*an original event and creates what it translates as well as the entities between which it plays the mediating role*" (*Modern*, 78). Boucicault's camera is and is not a telescope; it is a hybrid technology that functions as a camera under the name of something that performs the same metaphorical function, while also achieving a different practical end. It simultaneously hearkens back to the early seventeenth century embodied metaphors of the Galilean telescope's capacity to "catch" stars, but also looks forward to the present moment in which scientists incorporate cameras and other digital imaging technologies into their methods for

[21] Dingley raises the important point that *The Octoroon* was unusual in its literary support of the camera's authority of witness. He cites many examples from contemporary mid-Victorian literature that concern, "the theme of the misleading photograph," and claims that to be more indicative of public opinion regarding the new technology than the outright faith in the reproductive capacity of the camera as it is performed in *The Octoroon* (Dingley, "Unreliable," 43).

viewing distant objects in space. Boucicault's telescope is also a social machine, and the space that it detects is the racial, class-oriented, and regional spaces that separated people in the United States as the country was at the brink of Civil War.

Erdman shares a pertinent quip from an 1859 *New York Times* review of *The Octoroon*: "Everybody talks about *The Octoroon*, wonders about *The Octoroon*, goes to see *The Octoroon*, and thus *The Octoroon* becomes, in point of face, the work of the public mind" (*NYT* in Erdman, 336). This quote summarizes the network of extended cognition at work in the not-so-distinct domains of science and art, especially when science concepts are represented by staged science machines. Notions of extended, enacted, and embodied cognitive systems are explicitly discussed in Chapter 3's example of how astronomy is performed in *Contact*. The importance of embodied, emotional engagement with science concepts as they are represented in performance is taken up again in Chapter 4, in which the performance examples deliberately trigger sense experience, or memories of sense experiences, in an effort to deepen engagement with the performance of science for a diverse public. Live performances that feature science devices such as the telescope constitute one expression of public, productive curiosity about that technology. During the seventeenth century, and now, people talk about the telescope, wonder about the telescope, go to see plays (and films) about telescopes. The domain of science becomes public through performances that invite curious audience members to deepen their interest, attention, and actions in the company of other components of the arts-science assemblage necessary astronomy practice.

1.2 *A LOOK BACK: SIDEREUS NUNCIUS* AND THE MEDIATION OF THE PREVIOUSLY UNKNOWN

Galileo's *Sidereus Nuncius* (1610) is an early example of a text that describes situated cognition as both embodied and extended. Galileo's scientific process involved both personal experience and repeated observations of natural and laboratory phenomena. Galileo's method required multiple avenues of trust and credibility for its success: 1) he trusted his own observational skills and his capacity to remember observations accurately; 2) he trusted the tools that he used to enhance his perception of celestial objects and phenomena; 3) he relied upon a variety of media to communicate his ideas to groups of his peers and other bodies of cultural authority (i.e., the Catholic Church) who were empowered to grant (or revoke) his socio-scientific credibility. Galileo's written works were products of his cultural situation and the natural world that he observed. The process of transduction—the communication of information across different media—is also caught up in this confluence of scientific trustworthiness, social credibility, and cultural authority. The transductive process will be discussed at length in different theatrical examples throughout this dissertation,

N. Katherine Hayles offers a definition of transduction about the generation and communication of science concepts as they are encountered by science experts and non-experts alike. Citing James Berkley's analysis of Edgar Allen Poe, Hayles invokes the dramatic power of mimesis to communicate data while also providing a framework for the transfer of power from one agent to another through mediated interactions: "Mimesis, in [Berkley's] account, becomes a transducer transferring the power to evoke wonder and terror from one site to another, while the sublime sets up the transfer by presupposing that a connection exists between environment and system, stimulus and affect, externalized object and internalized subject" ("Refiguring," 313). In

a theatrical context, performance transforms information found in the world and transduces that information through the dynamic body of a performing agent. Mimetic transduction moves information from one medium (the page) to another (the stage, screen, or other performance venue) so that audiences might understand that information differently. Embodied transduction that occurs in a science-oriented theatrical context can empower audiences to participate in science concepts even when social norms deny the non-scientist access to the domain of science. Theatrical transduction is also empathetic and often results in the creation of an array of culturally imaginative possibilities for audiences of science-oriented performance.

Sidereus Nuncius announces Galileo's discovery of new stars (Jupiter's moons) as well as mountains on the moon, and explains how Galileo made these discoveries by adapting Hans Lipperhey's refractive telescope.[22] Science historian Albert Van Helden claims that, "*Sidereus Nuncius* was the product not of an intellect, but rather of an instrument" (Van Helden, *Sidereus*, Preface," vii).[23] For Van Helden, the telescope itself was the news. Amy Cook considers the textual publication as the cognitive object that so altered the course of observational astronomy. Cook

[22] In *Sidereus Nuncius*, Galileo goes to great lengths to describe his process of mechanical adaptation of Lipperhey's telescope: "About ten months ago the rumor came to our ears that a spyglass had been made by a certain Dutchman by means of which visible objects, although far removed from the eye of the observer, were distinctly perceived as though nearby. About this truly wonderful effect some accounts were spread abroad, to which some gave credence while others denied them. The rumor was confirmed to me a few days later by a letter from Paris from the noble Frenchman, Jacques Badovere. This finally caused me to apply myself totally to investigating the principles and figuring out the means by which I might arrive at the invention of a similar instrument, which I achieved shortly afterward on the basis of the science of refraction." (Galileo, *Sidereus Nuncius*, trans. Van Helden, 36-7). Galileo goes on to assert that in order for the reader to replicate the observations discussed in *Sidereus Nuncius*, a telescope similar to his own is necessary, and a common tool made to Lipperhey's standards would not suffice.

[23] He goes on to describe Galileo's indecision in naming the book, either *Astronomicus Nuncius* or *Sidereus Nuncius*, as well as the problem that he faced as a translator from Galileo's original Latin from 1610. "*Nuncius*," like other Latin words, can be translated either as "message" or "messenger". Should he translate the text as the *Starry Messenger* or the *Starry Message*? Van Helden traces the history of translation of this term, compared with Galileo's original intent, apparently other notes and descriptions of the text indicated that the work was an announcement itself, not a treatise on some new kind of messenger. Nevertheless, Van Helden opts to title his translation in the tradition of most English translations, as *The Starry Messenger.*

argues that *Sidereus Nuncius* is a textual medium that translates Galileo's empirical observations for a scientifically interested, but mechanically deprived, public. She claims that by, "[i]ntegrating the visual distortion of the telescope into the text, Galileo makes *The Starry Messenger* into a visual instrument for readers to see what he has seen" (Cook, 56).

There is a third medium at work in *Sidereus Nuncius*: Galileo's body-mind**.** Information about the new "stars" and mountains on Earth's moon were doubly mediated by Galileo. The first mediation occurs through the transductive powers of the telescope itself by which means an image of a distant object such as a crater on the moon is augmented through the telescope lenses and received by the human eye as larger and more detailed than that same crater would appear through naked-eye observation. The second mediation is Galileo's communication of that new information through drawings that he made, by memory, after the observational event. Galileo created two very different types of illustrations in *Sidereus Nuncius* to translate his observations for his reading audience: 1) realistic representations of the moon's surface, and, 2) deliberately distorted stars within recognizable constellations. In order for Galileo's mediated images to hold meaning for his readers, the audience must trust Galileo's competency as an astronomer to relay accurate and reliable information through all of the media available to him.

The telescope mediates traditions of science over the passage of time, just as it mediates information about space between places. The telescope, as it appears in the performances discussed here, transduces information about astronomy concepts as they have appeared at different historical epochs and invites turn-of-the-millennium audiences to participate in that thought process. Peter Galison, in *Image and Logic*, distinguishes places of experiment such as the laboratory as microenvironments that exist within a macroenvironment of the larger world or culture of which they are a part. I would also add a metaenvironment of performance that

encounters socioscientific problems to this discussion. Galison describes the transduction of experimental science practice with a particular interest in subatomic physics. In doing so, he describes the assemblage of people, technologies, and places that constitutes a hybrid platform for knowing quantum space. Galison believes that science does not exist apart from culture, but is a part of culture.[24]

Although Galison's example pertains to the culture of particle physics, his language can be extended to the cultural analysis of astronomy. Galison's analysis of particle physics traces transference of science concepts and traditions across historical epochs by tracing the objects necessary to the performance of that science. The same idea is at play in this dissertation, as the object of the telescope transduces ideas among the cultural domains of science, theatre, film, and society. His historiographical intervention underscores the importance of writing histories that are "dense and specific enough to understand the limits of malleability of objects and meanings as they travel from domain to domain" (*Image*, 436). The telescope is considered here as a cognitive artifact with the explicit capacity to transduce information in a tripartite manner: 1) across epochs of time—the culture of astronomy is transmitted with each new application of machines called telescopes by every new scientist or amateur astronomer to apply it to her or his research; 2) across distances of space—the telescope communicates information about distant objects to an observing agent; 3) across disciplinary boundaries—staged telescopes in performances (humanities) transduce information about astronomy (sciences) to audiences that may or may not be made up

[24] Using the study of subatomic physics as his platform, and subatomic detection devices as his transductive objects, Galison traces an evolution of twentieth century sub-atomic physics machines in order to articulate a history of science practice that moves from prioritizing imagistic representation (by users of cloud chambers) to a practice that prioritizes "pure" data generated enacted by the counters. Counters generate data in experimental circumstances that are reproducible. Evidence transduced through cloud chamber images can produce novel findings, but such results are often uncontrollable and difficult to repeat within the microenvironment of the laboratory.

of theatre or science experts, even as non-science experts participate in the practice of that science in an artistic domain.[25] The theatrical metaenvironment produces new cultural knowledge that incorporates science concepts.

Introductions of machines such as telescopes and particle colliders to science practice alter not only the world in which humans live, but also the ways in which humans perceive themselves to live in that world. Edwin Hutchins, in *Cognition in the Wild,* uses the example of the computer to explain how machines have come to define human ontology. He suggests that:

> [t]he computer was made in the image of the sociocultural system, and the human was remade in the image of the computer, so the language we use for mental events is the language that we should have used for these kinds of sociocultural systems to begin with. These are not examples of metaphorical extension from the base domain of mental events to the target domain of cultural activity. Rather, the *original* source domain for the language of thought was a particular highly elaborated and culturally specific world of human activity: that of formal symbol systems. (Hutchins 364)

Humans did invent machines called computers, but in doing so, they created a world in which their inventions now have the capacity to act upon their inventors. Hutchins' 1995 description of the world is not a horrific vision of machines gone mad as depicted in such science fiction fantasies as the film *Terminator* (1984) or the television series *Battlestar Galactica* (1978-1974 and 2003-2009). Rather, Hutchins describes the world in which we live, where objects that are the result of human invention act upon human will and ingenuity in a way that Latour might argue is not entirely inert. Hutchins's technologically-oriented cognitive theory will become of particular interest in Chapter 3's treatment of human-machine performances involved with educational and empathetic acts of science-oriented performance.

[25] It might also be seen to transduce information from the microenvironment of the theatre to audiences of science experts, since plays and films that feature telescopes and other detection devices are likely to attract audiences who have an interest in science content. Bridging the gap between science and the arts is a two-way street.

Self-referential perspective changes with the introduction of each new technology designed to expand, enhance, or alter humans' perceptual capacity. In an attempt to understand the natural philosophical perspective of Goethe's novel, *Wilhelm Meisters Wanderjahre*, (1795-1796), Hartmut Böhme describes a scene in which the protagonist is presented with a quintessentially eighteenth century metaphysical dilemma of the sublime after gazing through a telescope by including the following passage:

> Overwhelmed and amazed, he covered both eyes. The colossal ceases to be sublime; it exceeds our power to understand, it threatens to annihilate us. 'What am I in the face of the universe?' he asked his spirit. How can I stand before it, stand in its very midst? (360)

This quote is a superb demonstration of the philosophy of immanence as it manifests in Goethe's novel.[26] Böhme goes on to state that this scene from Goethe's late eighteenth century novel is indicative of an early seventeenth century phenomenological crisis:

> Wilhelm then experiences an effect familiar from the early history of the telescope: a confusing loss of context. The 'most artificial means' focus on a tiny section of the heavens and 'now it stands disproportionately in my imagination,' … Wilhelm remarks, and he therefore loses the relationship both to the heavens in their entirety and to himself. (361)

The description of the protagonist's loss of self in the face of the sublime aided by a context impossible to achieve without a telescope might have been a consequence of the telescope's invention. Böhme links this phenomenological crisis to the invention of the telescope, but the attribution of that crisis to seventeenth century thinkers is anachronistic. An examination of works by natural philosophers and playwrights who engaged in what scholars now would deem interdisciplinary thought—those who wrote plays as well as scientific tracts in the manner that

[26] Boucicault was certainly influenced by Goethe's writing, as he dramatized a version of Goethe's Faust, *Faust and Margaret*, in 1854. Immanence is another, much-discussed perspective from which to understand the role of the camera in Boucicault's *The Octoroon*, wherein the camera becomes a medium for God's will.

Goethe also did in the eighteenth century—reveals an array of anxiety, excitement, and suspicion of the telescope, but not in Goethe's storm and strife terms. Seventeenth century performances tended to incorporate the light touch of comedy in their perusals of new inventions, whereas turn-of-the-millennium performances combine elements of horror, humor, and wonder, in order to maintain a playful approach to technological innovation and the opportunities it presents while still acknowledging technology's capacity for damage to the macrocosm in which it operates.[27] The final example of this dissertation, Laurie Anderson's *The End of the Moon*, marks a posthuman, socio-scientific point at which lived experience must be broken into its constituents in order to comprehend the whole.

1.3 MOVING FORWARD FROM THE PRESENT: ACCESSIBLE ASTRONOMY IN ACTION AT THE MOUNT LEMMON SKYCENTER

The University of Arizona's Adult Astronomy Camp is situated at the Mt. Lemmon Observatory, on and around an old US Air Force radar station in the middle of Coronado National Forest, just outside of Tucson, Arizona. Adult Astronomy Camp is one example of the growing number of ways that astronomy professionals are working to address issues of access to astronomy across many cultural domains. Chapter 4, "Envisioning an Accessible Performance of Astronomy," touches on the importance of outreach to the field of astronomy, with specific attention paid to Vera Rubin's feminist writing towards a diversification of participants in the field, as well as a

[27] Anderson's *The End of the Moon* most explicitly addresses the potential of scientific advancement to end in disaster at the level of global warfare.

brief discussion of the role that the Hubble Space Telescope (HST) images play in capturing the attention of diverse audiences of news media. The assemblage of human agents at Astronomy Camp attests to its project of science accessibility. Astronomy Camp is led by astronomer Dr. Don McCarthy, but the graduate and undergraduate research assistants are allowed many opportunities to lecture on their areas of expertise, lead informal conversations among the motley crew of curious adult campers while helping with technical aspects of astronomical observation. The camp works not only to allow access to people who are not astronomers to the domain of astronomy, but it also allows young astronomers from diverse backgrounds the opportunity to hone their expertise through the instruction of interested amateurs.

The main event at any astronomical observatory is, of course, the active telescope time. The telescopes at Mt. Lemmon are reflecting telescopes that range from 20 to 61 inches and they are used for educational and research purposes throughout the year.[28] These telescopes incorporate mirrors with a maximum diameter of 61 inches. Astronomy Camp's first night of observation at the 61-inch telescope was quite an event. We drove there just after dark, full of anticipation. After a quick tour of the observatory dome, instructions from a graduate student intern regarding proper use of the computer that controls the telescope, and a warning to NEVER move the hydraulic flooring with the ladder underneath the scope itself (to avoid damage to the telescope, the ladder, and possibly people on the lift), we finally turned off the lights. The machinery turned on with a

[28] An interesting phenomenon that has developed in the field of astronomy is the application of old telescopes to outreach and education. Many observatories such as Mt. Lemmon and Mt. Wilson, outside of Pasadena, CA, maintain historic telescopes for the purposes of education and science tourism. These observatories in particular do contribute to current astronomical research, but as more advanced telescopes are increasingly situated in non-urban locales such as Chile's Atacama plateau and beyond Earth's atmosphere, 60-100" telescopes outside of urban areas are becoming less useful for some astronomy projects, but more useful for the project of diversification of the field. These historic telescopes draw audiences of interested amateurs for the re-purpose of outreach science education. The connection between old observatories as tourist destinations and diversification of access to professions in physics and astronomy is worth further investigation.

tremendous clang. The window to the sky slowly opened, and the floor–the telescope and people along with it–rotated in order to orient the telescope towards the first celestial object of the evening. Dr. Don McCarthy played Andrew Lloyd Weber's "Music of the Night" accompany the opening of the dome to the clear, Arizona night, for increased theatricality. It was kind of perfect.

A short list of microenvironmental elements for the practice of observational astronomy at Adult Astronomy Camp includes objects and agents such as telescopes, computers, astronomers, graduate assistants, astronomy campers, astronomical almanacs,[29] warm clothes, coffee, the internet, telephones, ladders, observatory dome, notebook, pen, flashlights, and cameras. Macroenvironmental elements include a clear sky, celestial objects, former military base, collaborating observatories from across the street and across the globe, institutional funding, and a political state that supports and condones astronomical research. The metaenvironment consists of embodied expertise in the form of astronomer Dr. Don McCarthy, his assistants, the various specialties of each Astronomy Camper, and, perhaps, the soundtrack to *Phantom of the Opera*. The old Air Force radio dome serves as classroom, kitchen, and lounge also falls into this category because it is the place where discussions about astronomical concepts are held outside the space of the observatory. These last elements could also be grouped within the microenvironmental category, but, because so much of this chapter has to do with embodied performance, I am

[29] An astronomical almanac provides the hopeful astronomer with a list of celestial events and objects and their position in the sky for any given year. When using a large telescope such as the 61" reflective telescope at Mt. Lemmon, the observer refers to the almanac for the object's coordinates, and types those coordinates into the computer, which is connected to the assemblage of machines in the observatory. Once the coordinates are entered into the computer, the operator/astronomer presses a button, and the whole apparatus rotates so that the telescope is pointing in the right direction in the sky. It is then up to the astronomer to focus the telescope in order to view the object. Sometimes minor adjustments in position need to be made in order for the object to come into view. In these cases, expert knowledge on the part of the astronomer is needed in order to find the desired object according to its relative position among the celestial objects surrounding it. The astronomical almanac is an essential part of the assemblage of observational astronomy. A good example is *The Astronomical Almanac Online*, co-published by the United States Naval Observatory and Her Majesty's Nautical Almanac Office. It can be found at http://asa.usno.navy.mil.

grouping performing bodies in the metaenvironmental category that is a conceptual space where micro-and-macroenvironments meet.[30]

One of the most striking revelations that I had at Astronomy Camp was that mechanical aids can seem to deplete the level of detail that my human eye is able to perceive when observing distant celestial objects through the 61-inch telescope. Discrepancies between what is available to the naked eye and what is detectable through the use of what Joanna Picciotto, citing Robert Hooke, refers to as "artificial organs" is a theme that recurs throughout this dissertation.[31] The potential for the telescope to be used to mislead the captivated observer as performed in Behn's *Emperor of the Moon*, will be discussed in Chapter 2. Chapter 4 explicitly addresses the many modes of detecting and transducing data about unseeable outer-space objects, and how those representations satisfy (or fail to) the curiosity of interested human agents about those objects and their previously undetectable elements.

Galileo's detractors had a reasonable point. Up until Galileo's improvements upon Lipperhey's telescope design, telescopes had been deemed untrustworthy because of grainy, lumpy, and discolored glass that did not transduce consistently larger, clearer images through the machine.[32] In my limited experience of looking through the 61" telescope at Astronomy Camp, I found that images were not consistently the same when different media were applied to viewing

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[30] These categories are overlapping, due to the premise of this dissertation—that the domains of science and other parts of culture are indistinct. In this example, environmental categories serve to identify places on the socio-scientific cultural spectrum where science concepts are generated, transduced, and integrated into a society of scientists and non-scientists.

[31] "[T]the microscope and telescope were prosthetic supplements for the lost faculties of the first man's body; through the 'adding of *artificial Organs* to the *natural*' fallen humanity was regaining that body's powers. To claim, as [Joseph] Glanvill did, that Adam had not needed '*Galilaeo*'s tube' in order to contemplate distant planets and that 'he had as clear a perception of the earths moon, as we think we have of its quiescence' was really to celebrate contemporary technologies and discoveries," (Picciotto, "Performing the Garden," 27).

[32] Please see Rolf Willach's *The Long Route to the Invention of the Telescope* for an in-depth, practice-based history of the invention of the telescope in which he tests different kinds of glass that would have been available to natural philosophers from the Nimrud Lens (dating from 900-700B.C.) through the seventeenth century.

the same object during the same observation session. By taking pictures with a digital camera attached to the viewing lens of the telescope (a secondary mediating machine), astronomy campers created an image-based document of our experience, but the pictures we took looked different than what we were able to see without the camera's mediation. The mediated documentation failed to accurately represent the embodied experience of looking through the telescope.

Sometimes, astrophotography attempts to re-create the experience of looking through the telescope. Other times, it uses old images to communicate new information, in which case replication of the observational event is not always the goal. The attempt to produce increasingly detailed representations of distant astronomical objects is a type of performance that changes over time and with each new telescope applied to astronomical observations. As shall be discussed at length in Chapter 4, old photographic images of the same celestial objects remain a part of the assemblage of the performance of astronomy because astronomers often refer to these older images to verify new findings or to find new information latent in older photographs.

For example, one of my favorite observational objects has become the Ghost of Jupiter, or, NGC 3242, a planetary nebula.[33] Here is an image of The Ghost of Jupiter, taken at the Mt. Wilson Observatory's 60" telescope in 1916:

[33] A planetary nebula is a dying star, and not a planet at all. As the star ages and burns through its fuel, its outer layers of gas expand. These are the rings or clouds visible through the telescope. A more detailed, yet still accessible to a non-expert public is available in Nola Taylor Redd's article, "Planetary Nebula: Gas and Dust and No Planets Involved," on space.com. The Ghost of Jupiter is also known as NGC 3242 (NGC stands for "New General Catalogue," which is a list of "nonstellar astronomical objects" compiled by Johann Dreyer (1852-1926) and published in 1888) (Moché, Dinah L., *Astronomy: A Self-Teaching Guide*, 160). The Ghost of Jupiter was discovered by William Herschel in 1785. It is located in the Hydra constellation ("Astronomers Rehearse New Image of Planetary Nebula NGC 3242 (Jupiter's Ghost), *Sci-News.com*).

Figure 2: NGC 3242, William Duncan, 6 May 1916. Courtesy of the Carnegie Observatories.

The Ghost of Jupiter is notable for its many rings of color. The image above, like its contemporary astronomical photographic plates, is in negative. Below is a film negative of a plate of the same object that was taken in 1939. The Kodak film negative of the original negative plate creates a positive image of the Ghost of Jupiter:

Figure 3: NGC 3242. Kodak negative of the plate taken by William Duncan, 14 January 1939. Courtesy of the Carnegie Observatories.[34]

The images are familiar, similar enough to one another that they are recognizable as the same object, but the image is mediated a second time in order to learn something different, or in order to better replicate the original observational event. What is missing from these early images of the

[34] This is a negative reproduction of an original photographic plate, taken in 1939. The original plate is missing, but the process of viewing an object in negative is an attempt to stage the object in terms that more closely represent the original observational experience. In this case, a negative image of a negative image (astrophotographic plates are negative images) creates a positive image.

Ghost of Jupiter is the tremendous amount of color that some can see when observing it through a powerful telescope. When I observed the Ghost of Jupiter through the 61" telescope at Mt. Lemmon, I could see at least five rings of color radiating from its nucleus, but the image we captured with a digital camera at Astronomy Camp only shows shades of blue.

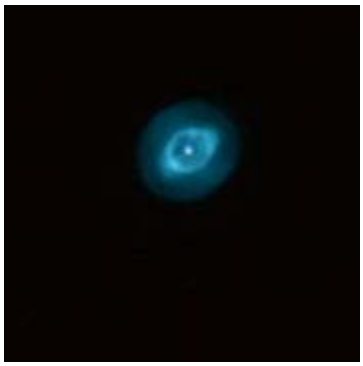

Figure 4: Ghost of Jupiter, taken as a group at Adult Astronomy Camp. Mt. Lemmon SkyCenter. May, 2014.

Which image most accurately represents the truth of the Ghost of Jupiter? It's a tough call, considering that there are about 1,400 light years separating the site of the observation event (at the observatory) and the astronomical event itself (in deep space).[35]

I am surprised at how quickly I came to doubt my own sense perception. The mediation of the 61" reflective telescope allowed me to see a range of color, but the addition of a second mediating device intended to document my empirical observation removed a level of detail. The object—the Ghost of Jupiter—remained constant in both observational instances, but the different

[35] The rings of light visible through the 61" telescope as well as the Spitzer Space Telescope are various materials shed by the star as it dies. The Spitzer Space telescope is an infrared telescope, designed with the explicit task of observing infrared light in astronomical objects. Because light that exists in the infrared spectrum is not visible to the naked human eye, energy that exists on the infrared spectrum is artificially colored. In the case of the Ghost of Jupiter Nebula image above, infrared emissions are depicted as red. Various colors depend on the instrument used by the observer. Interpretation of that visually obtained (mechanically aided) information depends on the skill (or, trustworthiness) of the agent performing the observation. More about deep-space explorations and reliance on machines for knowledge about the unseeable will be discussed in the fourth chapter.

media altered my ability to perceive the object in a consistent manner. The act of viewing the same object through the camera's screen caused me to doubt the memory of my initial observation. I first referred to a third medium—my initial drawing of the observation in which I had noted five rings of color—to assure myself of what I thought I had seen. After consulting my notes, I then turned to a fourth medium—the internet—to find another observer's image-based evidence that my memory of a multi-colored Ghost of Jupiter was correct, real, repeatable, verifiable. My amateur experiment in essence reenacts the process that astronomers use on a daily basis: they refer to familiar images of objects when new information about them is suddenly detectable using a different technology. This process places embodied experience of novel observations in a curious light; to what extent can an individual astronomer trust her or his observation of distant celestial objects in the face of a history of photographic and/or data-driven evidence that contradict individual, embodied perception? This question is addressed briefly in Chapter 2's historical introduction to problems of authority and image, but it is taken up at length in Chapter 4's discussion of mediation and astronomical object.

The Galilean telescope served as one level of mediation between seventeenth century natural philosophers and the celestial objects of their inquiries. *Sidereus Nuncius* was one of many textual media by which the veracity of observations made through telescopes was argued. The public nature of *Sidereus Nuncius* took astronomy out of the domain of so-called pure science and into the domains of the public, education, and entertainment. Theatrical references to and reproductions of telescopes mediate popular attitudes about the pursuit of knowledge that has to do with the unknown while also mediating audience curiosity about the astronomical subject and the machines used in this kind of research. My amateur experience at Astronomy Camp blends domains of expert astronomy praxis, amateur astronomy performance, and military infrastructure,

within a performance studies analysis. In the following examples, I would like to consider the impact that shifting the telescope's domain from the laboratory to performance has on the networks of trust and credibility that run throughout the hybrid culture of science and society.

2.0 HISTORY: TELESCOPIC (MIS)INFORMATION ON EARLY MODERN STAGES

Ronca: Ha you found the glasse within that chamber?

Pandolfo: Yes.

Ronca: What see you?

Pandolfo: Wonders, wonders.

-Thomas Tomkis, *Albumazar*, 1614

2.1 REASSEMBLING THE "NEW SCIENCE" IN THE SEVENTEENTH CENTURY THEATRE

Throughout the seventeenth century, visual information obtained through the lens of the telescope was suspect, and theatrical performances that featured the telescope perpetuated a culture of anti-mechanical skepticism while simultaneously sparking audience curiosity about new technologies. Galileo Galilei (1564-1642) announced his application of the telescope to the practice of astronomy in 1610 with the publication of *Sidereus Nuncius*, or, *The Starry Messenger*.[36] What followed was a European battle of philosophies over the veracity of the celestial objects made visible through

[36] There is evidence that Thomas Harriot, an English astronomer, made drawings of the moon before Galileo did, but his drawings were not formally published in the same manner as Galileo's, and there is some question as to the legitimacy of the dates found on the drawings. See Chapman, "A new perceived reality" (2009).

the telescope's lenses.[37] Playwrights such as Thomas Tomkis (c. 1580-after 1615) and Aphra Behn (1640-1689) participated in this public debate by adding theatrical spectacle as another medium by which non-scientist theatrical spectators might consider the implications of human existence in a universe in which Earth was not at the center, and that contained more objects in it than traditional authorities on the subject had previously thought.[38] In this chapter, I suggest that staged representations of the telescope throughout the seventeenth century evidence a gradual shift in popular opinions about the "new science." The comparison of two key productions, Tomkis's *Albumazar* (1614) with Behn's *Emperor of the Moon* (1687), demonstrates a subtle acceptance of the telescope over the course of the century. Even though the texts of these plays deliver the popular anti-mechanical prejudice of the times, the appearance of the telescope on the seventeenth century stage indicates a curiosity about this "new science" that eventually hooks popular audiences into participating in scientific thought processes through a Latourian assemblage of staged objects, science ideas, and live human bodies performing in the domain of the theatre.

In *Reassembling the Social*, Latour calls for an analysis of science as a social activity, "a very peculiar movement of re-association and reassembling" (7). In this analysis of seventeenth century plays that feature telescopes, I will consider stage movements as social acts that re-assemble science concepts within a socio-cultural context in order to enact and enliven non-scientists as participants in the domain of science throughout the seventeenth century. In *Albumazar*, a gullible old protagonist, Pandolfo, becomes the target of an elaborate theft. A

[37] A very technical reason for mistrust of the lens was that up until seventeenth century advancements in lens grinding techniques, glasses made for augmenting vision were often bubbly, tinted, or not standardized, and were often as capable of occluding vision as augmenting it.

[38] In later works, Galileo used his observations made through the telescope to support a heliocentric model of the universe first introduced by Copernicus.

demonstration of a Galilean telescope lures Pandolfo into a snare that involves elements of superstitious astrology as well as the tools and techniques of the emerging discipline of astronomy.[39] In *Emperor of the Moon*, a large telescope teaches the dreamy Dr. Baliardo (and the audience) about the dangers of becoming enchanted by the visions seen when looking through the telescope's distortive lenses. The telescope as it was staged at Dorset Garden also functioned to capture audience interest. These two productions were staged on opposite sides the Interregnum and on either side of the formation of London's Royal Society. Different stage conventions would have influenced the ways in which telescope technology would have been performed at either Cambridge's Trinity Hall or Dorset Garden. Details about both production venues are scarce. Nevertheless, the contexts of each performance's original productions—the likely make-up of the audience, conventions involving the use of props and stage technologies, and popular opinions about the "new science"—give clues as to how ideas about telescopes would have been performed and how they would have been received in theatres. A Latourian perspective helps in understanding how theatrical performance matters to the historical development of science concepts and practices. He states:

> Although science possesses its own impetus, some features of its quest are necessarily 'bound' by the 'social limitations' of scientists who are 'embedded in the social context of their time': although art is largely 'autonomous,' it is also 'influenced' by social and political 'considerations' which could account for some aspects of its most famous masterpieces. (3)

Although the plays discussed in this chapter are not the most famous of their times, they do appear at key moments of the history of science, and thus indicate how the telescope, as part of the early

[39] A Galilean-style telescope is simply a tube, about a meter long, which uses the refractive qualities of two lenses to augment the image of the target object. Telescopes were invented later in the seventeenth century that required longer tubes, more lenses, and also mirrors for their astronomical performances.

modern socio-scientific assemblage, provided audience members the means by which to participate in that scientific content, even when a textual analysis rejects the telescope as a ridiculous object.

What became known as the "new science" began to emerge with Galileo's empirical observations and developed in England most famously by Sir Francis Bacon. In 1660, London's Royal Society took up Bacon's standard of natural philosophy and became the central institution for scientific inquiry in England during the latter half of the seventeenth century.[40] The "new science" advanced the idea of experimentation and experience as a means of exploring the natural world that in theory prioritized embodied encounters and observations of natural phenomena (including things astronomical) over deductive reasoning.[41] This experimental mode of learning emerged at the same time as the invention of machines that altered the human capacity to observe things outside of themselves.[42] The relationship between humans and their mechanical inventions is uncomfortable and contradictory, but this contradiction can be understood anew by re-assessing that hybrid relationship through the perspective of performance studies in addition to the history of science. Latour suggests that the introduction of new technologies historically catalyzes new understandings of the human condition in relation to them:

> A new vaccine is being marketed, a new job description is offered, a new political movement is being created, a new planetary system is discovered… In each instance, we have to reshuffle our conceptions of what was associated together because the previous definition has been made somewhat irrelevant. We are no longer sure about what 'we' means; we seem to be bound by 'ties' that don't look like regular social ties. (6)

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[40] https://royalsociety.org/about-us/history/. 12 July 2015.

[41] In practice, many of these "new scientists" performed a hybrid technique that actually relied upon Aristotelian logic despite their professed adherence to empirical observation.

[42] Note that the term "experimental," in its earliest English usage, had to do with witness, and was used to describe first-hand experiences. The *OED* gives the following definition: "Of a witness: Having actual or personal experience of anything." Over the course of the seventeenth century, the term came to be associated with the domain of the laboratory.

The relationship between science and society is examined here through the unexpected tie of the theatre, as seventeenth century theatre-makers incorporated new, perception-enhancing technologies such as the telescope into their dramatic plots.[43] Playwrights such as Behn and Tomkis incorporated the telescope into their metaphoric and embodied vocabularies in live production in order to discuss the social implications of these new devices in terms that ranged from celebration, to criticism, to hesitant speculation.[44] When telescopes are featured onstage in scenes that dramatize their central purpose—to make distant objects appear closer and clearer to the observer—they point to the ethical debate that surrounded seventeenth century empirical science praxes: should astronomical observations made with the aid of the telescope be considered more or less truthful than observations made with the naked eye?

Albumazar and *Emperor of the Moon* are plays that physically represent telescopes on the stage along with human actors. The presence of staged telescopes allows two narratives to unfold before the audience: the first is the comedic banter tossed about by the actors as they make fun of new technologies that may, on the surface, seem absurd; the second narrative can be read through the interactions among the staged machines and human agents onstage and in the audience. This second, embodied narrative does not necessarily reject technology out of hand. Tomkis and Behn

[43] Similar arguments can also be made about the microscope, which shares a fraught history of emergence throughout the seventeenth century.

[44] In 1608, Dutch spectacle-maker Hans Lipperhey was granted a patent from the States General in Hague, Holland, and the chapter of the telescope was added to a global history of astronomical technologies. In 1609, Galileo made his adjustments to Lipperhey's design, which he then published in *Sidereus Nuncius* in 1610. Aaron Butler cites the first dramatic reference to the telescope in an English drama as appearing in John Webster's *Duchess of Malfi* (1613), but its first appearance on the English stage was in Tomkis's production of *Albumazar* at Cambridge in 1614. For more information about all kinds of glasses on the English Renaissance stage, please refer to Aaron Butler's dissertation, *Glass Perspectives: Optics and Virtue in English Renaissance Drama* (2000). The telescope is also referred to at length in Thomas Shadwell's (1642-1692) production of *The Virtuoso* in 1676. However, the telescope doesn't perform in this play as it does in *Albumazar* and *Emperor of the Moon*. The telescope appears as one piece of Royal Society business that Shadwell mocks in his parody of the "new science."

offer their audiences the opportunity to become part of an experiment by representing telescopes on their seventeenth century stages. Audience members witness human-machine interactions in the performance of science as it is represented in the theatre. This is one way that the domain of the theatre becomes tied to creative space of the domain of science. Non-science expert audience members might come to contemplate contemporary issues of astronomy with both embodied and textual theatrical narratives in mind. Staged technologies can capture audiences' interest in technology and engage audience members as participants of the distributed cognition systems made possible by the addition of the telescope to the practice of astronomy. Even though the text might dismiss the new machines of the "new science" as superfluous to unaided human vision, the hybrid assemblage of audience agents and actant staged objects increases popular access to a domain that was commonly construed to be elitist in practice.[45] The theatricalized telescopes in these plays perform in ways that metaphorically embrace the underlying mechanics necessary to the domain of astronomy.

So, what do seventeenth century staged telescopes *do*?

- They **capture** the attention and curiosity of human agents. In doing so, staged telescopes **mediate** ideas about astronomy in the domain of the theatre, and thereby create science-arts **mediators** of the audience members who attend productions of these plays.
- They **represent** their functional cousins in the domain of astronomy, as objects of **technological wonder.** Within this context of **wonder**, the telescopes that appear onstage are often performed as capable of **enchanting** those who use them.

[45] Behn in particular makes frequent cutting references to the Royal Society as a cabal, or secret society. Shadwell also theatrically eviscerates the Royal Society and its members in several scenes of *The Virtuoso*.

- They also **represent** the discipline of natural philosophy when they appear as props in the hands of scientist characters.
- It is possible that, at times, staged telescopes could have **projected** images, or could have been incorporated into staged spectacles**.** Behn's technical performance and the potentially invisible performance of Tomkis's telescope both present examples of the ways in which audience members are enlisted as parts of a Latourian **assemblage** of the performance of science in the domain of the arts.

For example, in Aphra Behn's *Emperor of the Moon* (1687), the introductory telescope scene can be (and often is, in extant interpretations of the play) read solely for the bawdy banter between Dr. Baliardo, Scaramouche (his servant), and Charmante (his niece's love interest) in which the human interactions around the telescope ridicule the "new science" and its mechanical trappings. If the telescope in this scene is analyzed in terms of how it performs as a part of an assemblage that also includes the human agents onstage, a very different story surfaces—one in which all actant objects and intentional agents are tied together in the assemblage of the performance of astronomy in the seventeenth century, regardless of the sentient parts' opinions about the technologies that are represented onstage. Behn capitalizes upon the Dorset Garden's particular mechanical advantages and thereby highlights the importance of wonder at theatrical technology in arts-science integrative cognitive system.

2.1.1 The telescope as an actant object

We have now moved backwards from the initial example of Boucicault's *The Octoroon*, in which the telescope serves as a pivotal point of reference as an object with the potential to capture images of other objects. Here, it is important to remember Latour's premise that objects are capable of

functioning as culturally generative mediators: "*A mediator… is an original event and creates what it translates as well as the entities between which it plays the mediating role*" (*Modern*, 78).[46] Mediators generate culture. Telescopes capture stars. Cameras capture images. Telescopes onstage, along with actors, playwrights, stagehands, and props capture the attention of the fictional (or fictionalized) characters that appear with them as well as the imaginations of the audiences who are also participant to the culturally productive performance of science.

Latour expands upon this aspect of Actor Network Theory (ANT) in *Reassembling the Social* as he articulates an object's capacity to act in the role of mediator:

> If action is limited a priori to what 'intentional', 'meaningful' humans do, it is hard to see how a hammer, a basket… could act. They might exist in the domain of 'material' 'causal' relations, but not in the 'reflexive' 'symbolic' domain of social relations. By contrast, if we stick to our decision to start from the controversies about actors and agencies, then *any thing [sic]* that does modify a state of affairs by making a difference is an actor—or, if it has no figuration yet, an actant. Thus, the questions to ask about any agent are simply the following: Does it make a difference in the course of some other agent's action or not? Is there some trial that allows someone to detect this difference? (Latour, *Reassembling*, 71)

The telescopes that appear on the seventeenth century stage "make a difference in the course of some other agent's action." As we shall see, the way that the telescope is performed in Tomkis's *Albumazar*—was it mimed or was it a prop?—matters to the socio-political network of scientists, royals, university fellows, and other audience members who participated in the experiment of that production at Trinity Hall in 1614. The possible capacity of the staged telescope in *Emperor of the Moon* to project images as well as capture interest matters with regard to the playwright's expression of her understanding of telescope technology, its relevance to cosmological discussions of the time, and the audience's participation in the performance of related technologies. The

[46] Italics original.

telescope acts to capture not only stars, but human agents who also participate in the arts-science network of astronomy.

In this Latourian analysis, objects are not magically enchanted to act as if they were human, although the supernatural empowerment of objects to materially act upon other objects and intentional human agents is part of a discussion of the telescope as it appears in the astrological context of Tomkis's *Albumazar*. Instead, Latour acknowledges the social potential that objects performatically—through hybrid networks that involve data, machine, environment, and human—realize within extended cognitive systems such as the performance of astronomy at different points in the seventeenth century. He explains, "The project of ANT is simply to extend the list and modify the shapes and figures of those assembled as participants and to design a way to make them act as a durable whole" (*Reassembling,* 72). Objects are an essential component to imagination, ingenuity, invention, and other creative acts. The acknowledgment of the role that objects play in the performance of science is important to the understanding of science as a culturally significant enterprise. And, the recognition of the elements of this assemblage that are not traditionally viewed as participant to the production of science objects and ideas (humans such as playwrights, objects such as stage props) can likewise be seen as tied to the social performance of science. The relevance of the object to the performance of science should become increasingly evident as we move towards an accessible performance of science over the course of this dissertation.

2.1.2 The telescope as an object of wonder, enchantment, and curiosity

Both terms, *enchantment* and *wonder*, have rich meanings within early modern science and performance discourse, and even during the seventeenth century there existed some slippage of meaning between the two. For this argument, enchantment's *OED* definition applies as either an

"action or process of enchanting, or of employing magic or sorcery," or a physical/emotional state resulting from an object or agent's "alluring or overpowering charm; enraptured conditions; [or] (delusive) appearance of beauty." The *perspicill* (Galileo's original term for the telescope) represents popular science content in Tomkis's *Albumazar*. Tomkis's telescope prop is a theatrical metonym, "a thing used or regarded as a substitute for or symbol of something else" (*OED*). In the Latourian assemblage of the performance of science in the metaenvironment of Tomkis's 1614 production, the *perspicill* is performed in a manner that replicates the science machine's function to capture distant objects that enter its gaze. As a theatrical metonym, the *perspicill* stands in for the nebulous state of astronomy in 1614 and the popular opinion in which political and scholarly authorities held that discipline at Cambridge and in the court of James I. As shall be discussed shortly, the manner in which the metonymous *perspicill* is performed matters in determining what light the astronomy was held at the time.[47] As a Latourian mediator, the *perspicill* captures the gullible Pandolfo by means of its presence in a network of ideas, agents, and objects that include astronomy, astrology, thieves, and glasses. There is a long history of magical glasses as tools for heretical acts of witchcraft and the occult, and this history is referenced as characters in *Albumazar* encounter the telescope for the first time.[48] The magical capacity for enchantment is also embodied by the character of Albumazar, who purports to perform occultish acts of astrology masked by his employment of the tools of natural philosophy, or, astronomy.[49]

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[47] I suggest later that perhaps the prop did not actually appear, but may have been mimed.

[48] For more on this history, please refer to Butler's *Glass Perspectives.* Hugh G. Dick discusses the shift from astrology as a magical practice to astronomy as a scientific discipline at length in the introduction to his 1945 edition of *Albumazar*.

[49] The historical Albumasar (Abu Ma' shar Ja 'far ibn Muhammad ibn 'Umar al-Balkhī) lived and practiced astrology in Iraq during the 9th century CE and died in 886 CE. His works, along with other Arabic documents and artifacts, were translated into Latin in Europe during the thirteenth century. For more background on the influence of Arabic natural philosophers on Western European natural philosophy and mysticism, please refer to Vicky Clark's dissertation, *The Illustrated Abridged Astrological Treatises of Albumasar: Medieval Astrological Imagery in the West.*

To become enchanted by a thing was dangerous territory for an English theatre-goer during the seventeenth century. Both plays discussed here engage with the mystical, heretical associations that were made between glasses and their users. These plays serve as moral instructions that educate audience members about the consequences of falling prey to illusions caused by the telescope's wonderful capacity to enhance naked-eye astronomical observations; in both *Albumazar* and *Emperor*, the most probable consequence of putting stock in images captured by a telescope is to be made a fool of by one's peers for believing in tricks of the eye produced by the device. Still, natural philosophers had been pondering the causes of nature's wonders for centuries before the advent of the telescope and its cousin, the microscope.

Wonderment plays a subtle role as a simultaneous catalyst for science inquiry and a trick to capture gullible fools. *Albumazar*'s "Galilean" telescope enchants its target, Pandolfo, through its potential to enhance human eyesight. Behn's *The Emperor of the Moon* is full of mechanical wonders of the stage, but Baliardo berates himself for falling prey to wonderment, even as the audience shares in his experience of this particular emotional state. The royal context of the original productions of both *Albumazar* and *Emperor of the Moon* matters immensely to the messages that the texts delivered. *Albumazar* premiered before a royal audience of James I and Charles I, and Behn's *Emperor* premiered closer to the end of the century, for James II. This matters to the messages contained within the textual narratives of these productions because the text would likely have been written to please the royal audience.

The natural philosophy that came to embrace the telescope was promoted by members of the Royal Society, but the British public was still skeptical about the telescope and its society. Theatrical satire was one means of engaging in such public criticism of an elite group. Many of the gags that come up in the plays discussed here deliver the moral that reason must temper

physical sensation, for if one succumbs to images produced by devices such as the telescope, one runs the risk of taking false information for the truth. Picciotto articulates the English natural philosopher's counter-argument to that point of view by showing how natural philosophers of that time embraced these "artificial organs" as a means by which humans could come closer to experiencing the world in a manner similar to a prelapsarian Adam. She cites Robert Hooke:

> The microscope and telescope were prosthetic supplements for the lost faculties of the first man's body; through the 'adding of *artificial Organs* to the *natural*,' fallen humanity was regaining that body's powers. To claim, as [Joseph] Glanvill did, that Adam had not needed '*Galilaeo*'s tube' in order to contemplate distant planets and that 'he had as clear a perception of the earth's motion, as we think we have of its quiescence' was really to celebrate contemporary technologies and discoveries. (Picciotto, 27)[50]

The telescope rendered the observer innocent. This came with the caveat that such experience was to be balanced by the responsibility of taking on the work of Adam in identifying and naming the world's creatures. The telescope aided human vision, but with it came a responsibility to labor.

Telescopes (and microscopes) allowed those who looked through them to see more of the world, and thus were capable of sparking an emotional state of curiosity within the observing agent. Curiosity was what caused the Fall in the Garden of Eden. Philosophers found their way around that semantic obstacle by distinguishing between two different types of curiosity: idle curiosity and the curiosity promoted by Francis Bacon and his followers (i.e., the Royal Society). Picciotto states, "Well beyond the laboratory, the Baconian image of paradise as 'a place Consecrated for sober Discipline' inspired contemporaries to discover the subject of innocence in the laboring collective" (Picciotto, 36)"[51] Later in this chapter, I will suggest that audience members might have

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[50] For a much more thorough discussion of politics, Protestantism, labor, and science, please refer to this article, as well as her book, *Labors of Innocence*. Waldron also takes up similar themes within a dramatic context in her book, *Reformations of the Body*.

[51] She gives further evidence for the sinfulness of idle curiosity by quoting John Salkeld's *Treatise of Paradise, and the Principall Contents Thereof* (1617): "God would not have men idle: not an ill item for our lazie gallants, who

been curious about the novel science object that its staged counterpart represented. While both play texts are full of jokes about the relative usefulness of the telescope and the gullibility of those who use it, the device became a curious hook for the audience that paved the way for audience members to participate in the performance of seventeenth century science in a manner perhaps not intended by the playwrights.

Picciotto's invocation of the "collective" and the term "spectator" as scientific observer lends itself to a Latourian analysis of *Albumazar* and *Emperor of the Moon*. She describes the seventeenth century natural philosopher as:

> [t]he lone investigator identified with a body he didn't have and [who] behaved in ways it was impossible for any person, saddled with a sensitive body and individual prejudices, actually to be: innocent, unprepossessed, uncontaminated by dogmas and opinions. The authority conferred by the spectatorial body to which he stood in prosthetic relation was nobody's to claim. But if no individual was entitled to the state of total knowledge and power the experimentalist sought, humanity as a whole was. (Picciotto, 32)

Picciotto articulates the desire of the seventeenth century natural philosopher to attain an "innocent" perspective through the use of artificial organs like the telescope.[52] She also describes the relationship between the individual and the whole. A Latourian analysis takes into account not only the proto-cyborg hybrid of the observer-and-telescope, but also includes the collective of all spectators assembled in the theatre to participate as witnesses to the drama that unfolds before them. An idle curiosity about these science machines might capture audience attention, but once enmeshed as participant to the entire cognitive system *including the actions performed by objects*

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thinke their gentilitie to consist in idleness, and a point of honour to live of other mens labour: but even in this (I am of opinion) that God doth punish them, that they have more griefes, and more discontent in their idle pleasures, then others in their most wearisome toiles, and labours, which though it be a most voluntary bondage, yet is it likewise the most base, and cruell slaverie to the base appetites…" (Salkeld in Picciotto, 35).

[52] The eventual bodilessness of the liberal scientist is a discussion that I will take up in more detail in the following chapter.

on the stage, those audience members might get caught up in a more Baconian state of curiosity, which, "puts contemplation and delight at the heart of work and exercise; so did experimentalist practice" (Picciotto, 28). The experience of the theatre can transform a spectator into an experimenter.

2.1.2.1 An Aside from Ben Jonson: Just how wonderful was the telescope on the seventeenth century stage?

Behn's *Emperor* and Tomkis's *Albumazar* highlight paradoxical attitudes towards the telescope. This early modern ontological dilemma—to be defined in terms of the human body alone or in terms of the human body in relationship with human inventions—is embodied by the characters as they interact with the telescope. Other works of fiction, drama, and theory of the times commented upon the questionable capacity of contemporary science machines to enhance human perception for the better. Christopher Marlowe's *Dr. Faustus* is a key example of the philosophical consternation instigated by rapid advancements of technology at the turn of the seventeenth century. Published in 1616, after the emergence of the telescope into the popular imagination, the play features many more mechanical elements as it pursues questions about the human pursuit of knowledge and power through unnatural means.[53] Natural philosopher and playwright Margaret Cavendish contemplated the telescope at great lengths in philosophical and fictional accounts, but ultimately conceded that while she might be convinced that microscopes had some merit, she did

[53] Please refer to Waldron for a discussion of Marlowe's *Faust* with respect to political and religious influences at work in early seventeenth century England. In addition to more famous revivals of the play in subsequent decades, Faust was revived throughout the seventeenth century. An especially interesting resurrection of that particular magician at the end of the seventeenth century is discussed by Judy A. Hayden in her article, "Harlequin, the Whigs, and William Mountfort's Doctor Faustus" (2009).

not favor the telescope as a reliable means for the study of nature.[54] Francis Godwin's 1638 work of fiction, *The Man in the Moone* considers travel to the moon by means of a flock of exotic geese. As mentioned above, Thomas Shadwell satirizes the Royal Society and many experiments and devices associated with it in *The Virtuoso* (1676). John Milton's imagination of the telescope and its many applications are discussed throughout *Paradise Lost* (1674).[55] Many of these examples from literature, theory, rhetoric, and philosophy of the seventeenth century were concerned with the battle between the body's physical sensations that were necessary to the project of observational astronomy and reasonable explanations thereof.

Ben Jonson is one of the more famous dramatic satirist of Galileo's *perspicill.* He takes the instrument and its related lore to task throughout *The Staple of News* (1625). The device remains

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[54] "Many ingenious and industrious artists take much labour and pains in studying the natures and figures of celestial objects, and endeavor to discover the causes of their appearances, by telescopes, and such like optic instruments; but if art be not able to inform us truly of the natures of those creatures that are near us; how may it delude us in the search and enquiry we make of those things that are so far from us? We see how multiplying glasses do present numerous pictures of one object, which he that has not the experience of the deceitfulness of such glasses, would really think to be so many objects. The like deceits may be in other optic instruments, for ought man knows. It is true, we may, perhaps, through a telescope, see a steeple a matter of twenty or thirty miles off; but the same can a natural eye do, if it be not defective, nor the medium obstructed, without the help of any such instrument, especially if one stand upon a high place... Some affirm, they have discovered many new stars, never seen before, by the help of telescopes; but whether this be true, or not, or whether it be only a delusion of the glasses, I will not dispute… I only endeavor to deliver my judgment as reason directs me, and not as sense informs, or rather deludes me; and I chose rather to follow the guidance of regular reason, rather than of deluding art" (Cavendish, *Observations upon Experimental* Philosophy, 135-6). In her epic work of philosophy-of-science-fiction, Cavendish's Empress entertains demonstrations of a microscope, but rejects the use of the telescope quite vehemently. She instructs the animal/human hybrid creatures of her "new world" to break their telescopes for their inability to resolve observational disputes better than reason: "the Empress began to grow angry at their telescopes, that they could give no better intelligence; for, said she, now I do plainly perceive, that your glasses are false informers, and instead of discovering the truth, deluded your senses; wherefore I command you to break them, and let the bird-men trust only to their natural eyes, and examine celestial objects by the motions of their own sense and reason… if these glasses were true informers, they would rectify their irregular sense and reason; but, said she, nature has made your sense and reason more regular than art has your glasses, for they are mere deluders, and will never lead you to the knowledge of truth…" (Cavendish, *Blazing World*, 27-28). Cavendish is an interesting figure in the history of science. She travelled in mixed circles of English and French philosophers and nobility, which, as discussed above, likely influenced her beliefs.

[55] Picciotto discusses the moral implications of the various uses of the telescope—by angels, devils, and humans—that appear in *Paradise Lost* at length in "Reforming the Garden." Picciotto also briefly mentions a plan of Milton's to pen a play based on *Paradise Lost*, but that it never transpired. More research into this unrealized project would be interesting to a thorough study of literary and dramatic use of the telescope during the seventeenth century.

a recurring trope of the play's comedy, while the culture of the news is Jonson's specific target. In this play, Galileo features as one example of a scientific target of popular satire. In Act II, scene ii, the protagonist Pennyboy Junior and his entourage are assembled in the news office. In a general discussion of the news/gossip one of characters, reading the paper, remarks, "They write was found in Galileos study,/ A burning Glasse (which they have sent him too)/ To fire any Fleet that's out at Sea—" (Jonson, *Staple*, 30).[56] Jonson opens the play by mocking the telescope as a plaything of the wealthy; as his protagonist, Pennyboy Jr., dresses himself he asks the audience to, "bring all your helps, and perspicills,/ To see me at my best advantage, and augment/ My forme as I come forth…" (Jonson, n.p.). Although it is really his new pocket-watch to which Pennyboy Jr. directs the audience's attention, the instruction for the audience to grab their nearest *perspicill* places the Galilean tube in a similarly satirical context.

Jonson rehearsed many of the jokes that appear in *Staple of News* in his earlier masque, "News from the New World Discover'd in the Moone," which premiered in James I's court in 1620, Jonson questions the sincerity of anything published as news as the Printer attests: "I'le give any thing *[sic]* for a good Copie now, be't true or false, fo't be newes" (Jonson, "News," 40).[57]

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[56] Unless otherwise noted, references to *The Staple of News* come from Harvard's Houghton Library's 1631 edition. References to Galileo occur within a longer discussion of an apocryphal story about the exaggerated capacities of the telescope and other glasses for use in the naval theatre of the military. Here, Jonson deliberately conflates, according to Anthony Parr's 1988 edition, the historical General Spinoza and a Jesuit priest, Father Spinola who died in Nagasaki in 1622. Although Parr makes the connection between the Jesuit and the general as primarily a reference to the Spanish war machine, I suggest that the satire goes further in order to whet the audience's appetite for the reference to Galileo that follows. The character Fitton remarks, "Witness the engine that they have presented him/ To wind himself with up into the moon,/ And thence make all his discoveries" (Jonson, III.ii.41-43). Given that Galileo is the next object for the assembly's jeers, it makes sense to understand the reference as a critique of machines invented for astronomy, but also applied to the art of war. This story is also related in Giambattista della Porta's *Magiae Naturalis*, first published in 1558).

Jonson's interest in science did not premiere with "News from the New World." One of his most famous plays, *The Alchemist* (1610), satirizes alchemy (a hybrid practice of chemistry and astrology in the way that astrology was a hybrid of astronomy and astrology at about the same time), and was surely one of Tomkis's greatest influences, in addition to della Porta. "News of the New World" serves as a prototype of sorts for Jonson's later play, *The Staple*

The news under scrutiny is that of explorers' accounts of the Americas, in particular the news published by Dutch explorer "J.H. van Linschoten" (Jan Huyghen van Linschoten, 1563-1611), who published his *Discourse of Voyages into the East and West Indies* in English in 1598. Conquest of the Earth quickly segues to fantastical explorations of the Moon. When the subject of lunar travelogues is raised, the tools by which natural philosophers explore the surface of the moon are criticized with as much vehemence as the questionable tales associated with New World exploration. The Printer and the Chronicler voice their opinions of the telescope, which, in 1620, was only the most recent means of travel to the moon:

> Printer: … I know it, a thing no bigger than a Flute-case; a neighbor of mine, a spectacle-maker, has drawn the Moone through it at the boare of a whistle, and made it as great as a Drum-head twentie times, and brought it within the length of this Roome to me, I know not how often.
>
> Chronicler: Tut, that's no news; your perplexive Glasses are common… (Jonson, "News," 40)[58]

Jonson's 1620 masque links concerns with the credibility of eye-witness reports with suspicion of a populace of philosophers captivated by a perception-enhancing device pronounced "common" only twelve years after its invention. The question at the time was not how to see the new details of the moon, but how to incorporate that knowledge into a culture that did not necessarily value information about the world that did not pertain to their everyday experience of it.

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of News (1631), which mocks news sources in general, but makes fun of the telescope and the philosophical explorer in particular.

[58] As the conversation ensues, the ways that people have "travelled" to the moon over the course of history are discussed. Dreaming, poetry, and sometimes flying are considered. The First Herald Explains: 1 Herald: No I assure you, he rather flew upon the wings of his Muse. There are in all but three ways of going thither; one is Endymions way, by rapture in sleepe, or a dreame. The other Minipus his way, by wing, which the Poete tooke. The third, old Epedocles way; who when he leapt into Aetna, having a drie seere bodie, and light, the smoake tooke him and whift him up into the Moone, where he lives yet waving up and downe like a feather, all soot and embers coming out of that cole-pit; our Poet met him, and talkt with him" (Jonson, "News for the New World," 42).

2.1.3 Emotions as a curious element of the assemblage of the performance of science in the seventeenth century

Audience emotions are an important part of how staged telescopes engage theatre audiences in ways that are slightly different than actors performing without these machines onstage. As discussed above, the emotional states of wonder and curiosity were likely part of how audiences received staged human-machine interactions throughout the seventeenth century. There is a difference between wonder at novel technologies as they appear in a scientific context, wonder at technologies as they appear in public performances such as theatre and news media, and the wonder in response to stage technology itself. Telescopes that were performed onstage constitute an essential component of the connective tissue that links the domain of theatre to the domain of science in the Latourian assemblage of the performance of science as it was distributed throughout English culture during the seventeenth century. Audiences were made participant to the experiment of the theatrical spectacles which they attended. As such, they would have responded to all elements represented on the stage, the stage machinery notwithstanding. Perhaps they would have been captured in a state of wonder by the performances that surrounded the staged telescopes. Perhaps these audiences would have been hooked from the outset if the appearance or mention of the telescope caught their idle curiosity.

Carl Plantinga suggests a particular mode of emotional audience engagement that may give some clue as to how idle curiosity could have taken on a more Baconian twist in the event of witnessing a staged telescope in performance. He introduces the term “artifact emotion” by which

the spectator judges a technical aspect of the performance (26).[59] A critical engagement with the technical process of performing in conjunction with these objects would have augmented the audience experience of that object's performance. Idle curiosity at the introduction of an object could have transformed into a curiosity that, "promoted a humble willingness to invest care and take pains in producing knowledge of 'things themselves'" (Picciotto, "Reforming, 28). Picciotto points out that, "Truth production depended on the production of new experiences," which the premieres of the plays discussed here certainly were (27). As collective constituents of the theatrical experiment, curious audience members constructed truths based on their artifactual engagement with the telescopes as they were depicted on the stage.

2.2 ASTROLOGY, ASTRONOMY, *ALBUMAZAR*!

Albumazar is a play filled with things, from mundane household goods, to lists of ancient and contemporary alchemists and magi, to Albumazar's collection of astrological tools such as astrolabes, horoscopes, and almanacs. Originally penned by Giambattista Della Porta as *Lo Astrologo* (*The Astrologer*) in 1606, *Albumazar* follows a fairly standard *commedia dell'arte* plot in which an old man, Pandolfo, wishes to marry Flavia, the inappropriately young daughter of his friend, Antonio, who is long lost at sea. Albumazar and his team of novice astrological thieves identify Pandolfo as their target in a plot that reinforces a mistrust of science gadgets such as the telescope because of their association with the heretical practices of astrology, magic, and witchcraft. Like Ben Jonson's *The*

[59] *Moving Viewers: American Film and the Spectator's Experience*. This emotion could be in response to any kind of technique, ranging from the craft of the actor, to the skill of the playwright, but it also has to do with audience response to the specific performance of staged objects and stage technologies.

Alchemist (1610), *Albumazar* pokes fun at popular applications of natural philosophy such as astrology, alchemy, almanac-making, and horoscope-reading, as well as the people who turn to such sources to solve their problems.[60] *Albumazar* is the earliest play that features a telescope on the stage; its prominent inclusion indicates the complicated relationship between astronomy and astrology, science and science fiction. The specific nature of how the telescope would have been performed is taken up at great length later in this chapter.

2.2.1 9 March 1614: Thomas Tomkis and the Premiere of *Albumazar*

Tomkis's *Albumazar* premiered on Thursday, 9 March 1614 at Cambridge College's Trinity Hall as a part of the festivities that surrounded a royal visit by James I and his son, Charles I. Most of Trinity Hall's Bursar's Accounts from the months surrounding this visit are dedicated to its preparation. Further evidence of the preparation can be found in letters written during the months leading up to this royal visit. Alan H. Nelson includes a letter from Roger Parker to Owen Gwyn, Master of St. John's College in his comprehensive edition of the papers associated with the Cambridge University theatres:

> (*5 January [1614]*, *Grub Street*, *London*)
>
> Salutem &c good Mr Dr. Gwyn, the Erle of Shrewsbury is nowe in London & therefore if yowe have not moved hym against the kings comminge to Cambridge

[60] There was a theory that circulated largely because of a 1668 revival of the play that attributed *Albumazar* to Jonson, due to its similarity to *The Alchemist.* The author of the prologue to that production, allegedly John Dryden, wrote, "And Johnson of those few the best chose this,/ As the best modell of his master piece;/ Subtle was got, by our Albumazar,/ That *Alchemist* by this Astrologer,/ Here he was fashion'd, and I should suppose,/ He likes my fashion well, that wears my Cloathe" (*Covent Garden Drollery: A Miscellany of 1672*). This theory that Dryden had written *Albumazar* before *The Alchemist* has been debunked by authorities in the field. Material evidence in the Bursar's Accounts of Cambridge University that Thomas Tomkis was paid for the writing and production of *Albumazar* in 1614. This will be discussed in more depth later in this chapter. It is, however, very likely that Tomkis would have emulated Jonson in his playwriting. David Carnegie, in his article, "'Actors' Parts and the 'Play of Poore'" notes Jonson's popularity among scholars at Cambridge in the early seventeenth century, "Jonson's attitude to scholarship would make him popular at the universities…" (Carnegie, 19).

> noew yowe may conveniently doe it. For the kings comminge is deferred till the vijth of march against which tyme I heare that many Lordes wilbe there. **& therefore trynitye Colledge maketh greate provision for the well performance of all thinges & therefore have sent for all theyr auncient good actors that so theyr comedies may be answerable to the expectation.** the tyme was when St Johns had the best actors & teachers in all the Universitye & I dowbte [not] but they have as good nowe yet if I were worthy to advise yowe I would send for for summe or moste of those that they may bothe advise with yowe. & see the actors. & geve them theyr… assistaunce. (*Records of Early English Drama* (*REED*)*: Cambridge*, 534-5)

We know that there was an atmosphere of expectation surrounding these performances. In a later note that Nelson refers to as the "Dering Manuscript," a plan for the order of performances is given:

> On Tuesday ye 7 of March 1614 was acted before ye
>
> *King* in Trinity College Hall.
>
> 1. Aemelia a latine Comedy made by mr. Cecill Johannis
>
> On Wednesday night.
>
> 2. Ignoramus ye Lawyer latine and part English: Composed by mr. Ruggle Clarensis.
>
> On Thursday
>
> 3. Albumazar ye astronomer in English by mr. Tomkis Trinitatis
> 4. Melanthe a latine Pastorall made by Mr. Brookes (mox Doctour) trinitatis
>
> On ye next Monday,

5. The Piscatory an English Comedy was acted before ye University in Kinges college shich master Fletcher of yat College has provided if ye Kinge should have tarryed another night. (*REED*, 538-9)[61]

Further evidence for *Albumazar*'s production during this visit by the king is included in a letter from John Chamberlain to Sir Dudley Carleton on 16 March 1614: "… the third night was an English comedie called Albumazar of Trinitie Colleges action and invention, but there was no great matter in yt more then one goode clownes part…" (Chamberlain in *REED*, 539-40).

In addition to the above attribution of authorship to Tomkis, the Bursar's Accounts of Trinity Hall also evidence at least his payment for the job:

> Item given to mr. Tomkis for his paines in penning and ordering the Englishe Commedie at Our masters appointment…xx li (Trinity College Senior Bursar's Accounts in *REED*, 527)[62]

Tomkis, most authorities would attest, did not go on to have a luminous career as a playwright in England's Jacobean professional theatres. His contributions to the history of theatre, in addition to *Albumazar*, include the morality play, *Lingua: or the Combat of the Tongue, and the Five Senses for Superiority. A Pleasant Comoedie* (1607), for certain.[63] G.C. Moore Smith associates Tomkis

[61] It is unclear given the syntax if this note was written before or after the performances. Letters do not evidence the king's having seen the fourth show. Nelson surmises as much in his book, *Early Cambridge Theatres* (1994). He notes that *Albumazar* was likely the final comedy to have been performed before the king that March.

[62] Roman numerals indicate amount paid. Here I am interpreting "ordering" to mean tasks having to do with production and possible direction of the play. The senior bursar does mention Tomkis in a subsequent entry, having to do with preparing the conditions of the Hall for the play: "Item to mr Stanhope for Mr Tompkys at the same tyme for 1000 of pitt cole at 12 d and the carriage."

[63] *Lingua* was published in 1615, and most scholars date its first performance at Cambridge as having taken place in 1607. G.C. Moore Smith, however, suggests that the play might have been staged as early as 1602. Montague Summers cites an erroneous date for *Albumazar*'s original production as 1603. More research is required to determine what Tomkis was doing at Cambridge during those years, and if these references (both made during the early twentieth century) refer to early drafts of *Albumazar* or *Lingua*.

with a spate of "morality-type" plays and attributes his authorship to, "the imperfect *Locus*, *Corpus*, etc., *c.* 1604/5" and "*Pathomachia* (perhaps never acted, (*c.* 1617))" (8).[64]

Despite its origins as a college play, *Albumazar* enjoyed many revivals over the course of the seventeenth and eighteenth centuries. The earliest on record is John Dryden's 1668 production at Lincoln's Inn Fields, the Prologue to which is included in *Covent Garden Drollery* (1672).[65] There follow a number of plays that borrow from Tomkis's *Albumazar* either in story or in title in the first half of the eighteenth century. These include John Corey's *The Metamorphosis: or, The Old Lover Outwitted* (1704) at Lincoln's Inn Fields; a single performance of *Albumazar* (1744) at Drury Lane for which the Larpent Manuscripts note *The Astrologer* as an alternate title, written by "James Ralph from Thomas Tomkis"; *Albumazar* (1747-8) was revived for nine productions at Drury Lane; and perhaps most notably Garrick's revival of the play, with his own revisions, that enjoyed six performances at Drury Lane in 1773.[66] While Tomkis may remain a relatively unimportant playwright in the annals of English theatre history, *Albumazar* participates in a much

[64] To this list, Smith adds, "doubtfully…two shows, Band, Cuffe and Ruffe (entitled in its revised form Exchange Ware) and Worke for Cutlers. They were both printed in 1615, the former being entered on the Stat. Reg. as 'A Dialogue betweene Ruffe, Cuffe and Band' to Miles Patricke, 10 Feb. 1614/15, the second on 4 July 1615" (Smith, 8). The inclusion of Smith's attributions would be significant, especially *Pathomachia*, since it would place Tomkis as an active playwright after 1615, which no other scholar discusses. Nelson notes *Pathomachia* as anonymously penned, but also notes textual references to *Albumazar* and *Lingua*. He does not include any editorial speculation about Tomkis's potential authorship of the play.

[65] Samuel Pepys makes a note of this production in his *Diary*: "22nd [of February, 1668] … and thence to the Duke's playhouse, and there saw "Albumazar," an old play, this the second time of acting. It is said to have been the ground of B. Jonson's "Alchymist;" but, saving the ridiculousnesse of Angell's part, which is called Trinkilo, I do not see any thing extraordinary in it, but was indeed weary of it before it was done. The King here, and, indeed, all of us, pretty merry at the mimique tricks of Trinkilo" (Pepys, *Diary,* VII, 335).

[66] More research is required for this author to identify the content of the plays by Ralph and Corey. Moliere is listed as an alternate author of Corey's *Metamorphosis*, and a cursory glance at the Ralph manuscript in the Larpent collection looks like the character of Albumazar might have remained constant, the plot of the play seems to be quite different. Because these revivals took place in the eighteenth century, they remain outside the scope of this dissertation.

longer chapter, one that began with Tomkis's original source, the Italian playwright and natural magician, Giambattista della Porta.

2.2.1.1 Enter the Magician: Giambattista della Porta

Tomkis's *Albumazar* relies heavily upon Giambattista della Porta's original *commedia erudita, Lo Astrologo*, which was written in 1606—before Hans Lipperhey patented his telescope design and before the publication of *Sidereus Nuncius*.[67] Tomkis Britishizes della Porta's text by taking the empiricist allegories contained in the plot of the earlier play and adding a telescope that is performed as a questionable medium through which one might obtain reliable visual information. The presence of these themes at Trinity Hall in 1614 suggests a curiosity in empiricist scientific practice, even if the royal audience might have been skeptical about the use value of the telescope itself.

Giambattista della Porta presents an early example of the Renaissance scholar who worked across disciplines and genres in order to think through scientific and humanitarian problems. His hybrid practice embodies a scholarly and political culture on the brink of a disciplinary divide that curious agents wrestled with throughout the seventeenth century—on stages, laboratories, and other forms of literature that supported and engaged with the domains of art and science. His life was reflected in his written work, as Louise George Clubb attests in the flattering introduction to his biography:

> The Emperor Rudolph and the Duke of Florence sent embassies, and the Duke of Mantua came in person to see the Neapolitan wonder-worker who had penetrated the secrets of nature and was expected at any moment to discover the philosopher's stone. He could count as friends, admirers, or detractors the most learned men of his time – Kepler… Sarpi, Bodin, Campanella, Peiresc, and Galileo. The literate

[67] Please refer to High G. Dick's 1944 edition of Tomkis's *Albumazar,* which contains thorough comparative annotations that compare Tomkis's use of della Porta's original text.

> world know the results of Della Porta's investigations, experiments, and speculations through his heterogeneous publications… He wrote on cryptography, horticulture, optics, mnemonics, meteorology, physics, astrology, physiognomy, mathematics, and fortification, and when he died at eighty, he was preparing a treatise in support of his claim to the invention of the telescope. In his spare time, Della Porta wrote plays. (Clubb, xi)

Clubb diminishes della Porta's contribution to dramatic literature even as she praises his scientific achievements in the introduction to her study on Della Porta's life as a playwright. Her choice to relegate della Porta's playwriting practice to "his spare time" is odd because playwriting was a part of his intellectual process throughout his life. He wrote at least seventeen plays during his lifetime, exceeding in number, if not length, his achievements with regard to completed works of natural philosophy. In addition to writing plays, Della Porta also translated the works of Plautus and composed two scholarly dramatic texts: *Arte da comporre comedie* (The Art of Making comedy) and *L'arte del ricordare* (The Art of Memory). Although more recent scholars now acknowledge della Porta's contributions to the Italian theatrical tradition, the fact that Clubb chooses to introduce Della Porta's dramatic work as a hobby is emblematic of a modernist rift between the sciences and the arts.[68] This academic prioritization of science achievement over the artistic persists to this day; science is treated as a serious endeavor, whereas playwriting is often regarded as an amusement.[69] Clubb constructs an image of della Porta as a dramatist even while relegating his practice to that of an amateur, which he was not.[70] Playwriting was a consistent practice that ran parallel to Della Porta's work as a natural philosopher. The historiographical situation of della Porta as a thinker whose playwriting and science writing held comparable weight

[68] For more current discussion of della Porta's dramatic cultural contributions, please see *The Poetics of Imitation in the Italian Theatre of the Renaissance* (2013), by Salvatore di Maria.
[69] Kirsten Shepherd-Barr discusses this trend at length in *Science On Stage* (2012).
[70] Clubb's book is dedicated to tracing the evolution of Della Porta's dramatic works, which she considers to be an underrecognized contribution to modern drama.

in his work is significant to the articulation of the seventeenth century performance of science as a hybrid act that transpires in both the domains of theatre and science. Della Porta's plays *and* science texts mediated science concepts for the writer and his reading audience. Other writers discussed in this dissertation—from Aphra Behn to Carl Sagan—also did not limit their creative energies to a single discipline. Such trans-disciplinary creative practice supports theories of a culture as hybrid, overlapping, and not binary.

The historical Albumasar (Abū Ma ʻshar Ja ʻfar ibn Muhammad ibn ʻUmar al-Balkhī) lived and worked in Iraq during the ninth century and died in 886 CE. His works, along with other Arabic documents and artifacts, were translated into Latin in Europe during the thirteenth century. Catholic scholar-monks such as Roger Bacon would have been responsible for the translation of such works. Many scholars have demonstrated the overlap in astronomy and astrology, particularly under the very broad umbrella of natural philosophy, a trend that Hugh G. Dick addresses in his introduction to *Albumazar*. Vicky Clark remarks that literary and academic critiques against astrology were "against a corrupt practice of astrology, not against astrology itself," since universities, particularly in Italy, taught astrology within their walls. Likewise, late medieval and early Renaissance Catholic critiques of astrology were against its fatalistic aspect, not against the central conceit that celestial motions are related to earthly events.[71]

Even before Lipperhey's invention of the telescope in 1608, observational astronomy was a suspect disciplinary practice because of its popular association with astrology. Della Porta's playwriting and Tomkis's adaptive choices present evidence that a seventeenth century suspicion of astrology is really a translation of institutionalized anti-Semitism: a story of oriental conquest

[71] For a more detailed account of the intricacies of this argument, please refer to Clark's dissertation, *The Illustrated* Abridged Astrological Treatises of Albumasar: *Medieval Astrological Imagery in the West* (1970), and also the Hugh G. Dick's introduction to Tomkis's *Albumazar* (1944).

performed by the rejection of natural magic and "new science" machines. The blending of occult and science was evident within the umbrella field of astrology, of which Della Porta wrote in his perennially edited opus, *Magiae naturalis* (Natural Magic (1559)). It is in *Magiae Naturalis* that della Porta first mentions the historical Albumasar. In "The First Book of Natural Magick: Wherein are searched out the Causes of things which produce wonderful Effects," della Porta includes Albumasar in a list of historical natural philosophers who considered humankind's relationship to celestial objects. He states, "*Albumasar* said, That all things had their virtue from the Sun and the Moon," after citing a history of the influence of the power of the sun, moon and stars upon the earth from Ptolemy, Aristotle, Plato, and others (Porta, I.vii.9). This reference to the historical astrologer indicates della Porta's respect for natural philosophers (also known as magicians) who preceded him.[72] This is a very different depiction of astrology and astrologers than the way that the fictional character "Albumazar" is cast in *Lo Astrologo*, and this negative light extends to Tomkis's depiction of the astrologer in *Albumazar*.[73]

Just as astronomy and astrology were socio-historically linked disciplines in the early seventeenth century, so the finer points of astrology also warrant distinction in this discussion because they are the root of this early modern disciplinary confusion into which *Albumazar* played. Astrology contained within it two branches: natural astrology and judicial astrology. Natural astrology, according to Dick, adhered to the presumption that "heavenly bodies exercised certain powers upon the earth, but not all these were what we should call occult" (Dick, 18). Natural

[72] I.i.1 of *Natural Magick* describes della Porta's definition of the terms "magic" and "philosophy," basically summing up that the terms mean the same thing, depending on where you are located in the world. He cites Persia as the birthplace of magic, but that the term "magician" is given to all wise men in the way that "philosopher" is the name of wise men in the Western tradition.

[73]The reason for this negative depiction of Albumazar is related to Clubb's thesis that "*Astrologo* was most likely offered as the first proof of [della Porta's] reformation," that is, his recantation for the Roman Inquisition (Clubb, 17).

astrology would have included observations of such phenomena as light and heat emanating from the sun and the influence of the moon on the tides, but it did not indicate any sort of intentional relationship between celestial bodies and human affairs. Judicial astrology, on the other hand, would have included a belief in the "influence of the stars but also the prognostication of events or tendencies through knowledge gained by this study" (Dick, 18). Whereas natural astrology had to do with the observation and experience of earth-sky phenomena, judicial astrology dealt with superstition and magic.[74] Historical natural magician-philosophers such as Ptolemy, Aristotle, Albumasar, Roger Bacon, and della Porta would likely have adhered to both.[75] The fictional Albumazar also practiced both, but in the case of Tomkis's play, judicial astrology was the lure that drew the gullible Pandolfo to the astrologer, and natural astrology—the grain of truth embodied by the demonstration of the telescope—was the hook that finally ensnared the old man.

In the early seventeenth century, there would have been some overlap in the assemblage of objects and environments necessary to practice astronomy and astrology. Both arts required a sky filled with constellations, stars, planets and a solid Earth from which to observe them. They also

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[74] Dick articulates an important difference between the practices of natural and judicial astrology. Natural astrology, according to Dick, adhered to the presumption that "heavenly bodies exercised certain powers upon the earth, but not all these were what we should call occult." [You already used this exact wording in the main body paragraph above.]Stanton J. Linden identifies similar tracks within the field of alchemy, as "practical or exoteric alchemy and… esoteric, spiritual, or philosophical alchemy… the distinction between them is important.… Central to this second type is *knowledge* of the secrets of nature, not for the purpose of achieving dominion over nature, as with the philosopher's stone or a magical elixir, but rather a disinterested, unpragmatic knowledge of the of the origin, composition, and secret operations of all aspects of creation." (Linden, from "*Darke Heirogliphicks: Alchemy in English Literature from Chaucer to the Restoration*, in Harp, *Ben Jonson's Plays and Masques,* 389).

[75] Clubb intervenes into Dick's astrological analysis of *Lo Astrologo* and suggests that the play is not just an attack on astrology, which would seem insincere considering della Porta's self-identification as a natural magician, but that it was written as part of his recantation assigned by the Inquisition.[75] It is possible that Della Porta's anti-astrological argumentation in *Lo Astrologo* was itself a performance of philosophical reform. The Church's criticism was not entirely restricted to professions about Copernicanism, but the means by which astrological information was taught—through writing and the prioritization of experience. The Roman Inquisition, in the cases of the aforementioned natural philosophers, was as much a war on empiricism and interdisciplinarity as it was a war on anti-Catholic philosophy because of the danger that a desire for experiential proof would negate a capacity for faith in an incomprehensible God.

required a human agent to interpret the meaning of the arrangement of celestial objects of inquiry. Both disciplines also included a number of mechanical devices which the human practitioners used to interpret the motions of celestial bodies, but the ways in which these instruments were used, the kinds of data that the instruments generated, and the ends to which these data were applied were different, even within the field of astrology. Recognition of the difference between the two tenets of astrology is important because the dramatic conflation often results in the castigation of characters who claim to be practitioners of the "new science" but who also believe in the occult. Such dramatic representations reflect a popular confusion between laboratory processes and superstition, as is the case in a comic bit from Aphra Behn's *The Emperor of the Moon*, when the governess, Mopsophil, admonishes Scaramouch: "Run, Run Scaramouch, my Masters Conjuring for you like Mad below, he calls up all his little Divels with horrid Names, his *Microscope*, his *Horoscope*, his *Telescope*, and all his *Scopes*" (*Emp. I.i*). Mopsophil's indistinction between the occult and the "new science"—between lively creatures and science objects—is evident as she claims that Doctor Baliardo is "conjuring" rather than "calling" Scaramouch.[76] She does not distinguish between the "divels" of observational astronomy and judicial astrology, mixing natural philosophy with occultism in ways that reflect an attitude towards the science of experience that hadn't changed much since Tomkis adapted *Albumazar* for the English stage.

The roots of the conflated and conflicted interests in natural philosophy expressed in early seventeenth century drama began much earlier, through the performance practice of technical demonstrations. Anthony Grafton, in his article, "The Devil as Automaton: Giovanni Fontana and the

[76] Andrew Sofer interrogates the term "conjure" in his book, *Dark Matter*: "the magical utterance was *autonomous*. For Elizabethans the power to conjure inhered in the utterance itself… rather than in the will or intention of the speaker… the utterance constructs the speaking subject *as* conjuror; the spell makes the magus, rather than vice versa" (Sofer, *Dark Matter*, 19).

Meanings of a Fifteenth-Century Machine," suggests that Fontana's mechanical illustrations are an early example of the blurry edges separating the arts and the sciences in the late middle ages and into the early Renaissance. Fontana's texts provide how-to guides for the industrious engineer/magus to create illusory technics such as prototype magic lanterns and other mechanical shadow performances. Della Porta's late sixteenth century *Magiae Naturalis* similarly exposes the technique behind many mechanical and optical illusions but also hides the truth behind the glamour of astrological anecdotes. *Lo Astrologo* can be thought of as a dramatic technical demonstration against astrology because the play reveals the mechanism behind the heretical, yet popular, practice of judicial astrology performed by Albumazar. Tomkis's addition of the telescope to the Italian *commedia* takes della Porta's exposé one step further and physically demonstrates the mechanics of the telescope even as the play continues on its anti-astrological course. Della Porta and Tomkis can both be seen as following in the tradition established by fifteenth century engineers such as Fontana, who, "meant not only to advance the claims of engineering, but also to deflate those of magic and its critics," by creating deliberately transparent mechanical wonders (Grafton, "Devil," 55). Later in the seventeenth century, Aphra Behn can be seen to perform a similar theatrical trick in *Emperor of the Moon.*

2.2.2 Albumazar's *perspicill* as metonym for astrological superstition and astronomical discovery

The only science objects that manifest in the action of the play are the *perspicill* and the *otacousticon.*[77] The objects in the theatrical spotlight work to convince the protagonist Pandolfo that he should pursue an astrological solution to his romantic predicament. Albumazar and his

[77] The *otacousticon*, as depicted in this play, is a pair of ass ears that Pandolfo wears to demonstrate to the audience the ridiculousness of enhanced perceptive devices. Unlike the *perspicill*, this is not a real invention of the time. However, philosophers of the "new science" did invent *otacoustica*.

team of novice astrologer-thieves identify Pandolfo as their target in a plot that reinforces a mistrust of science gadgets such as the telescope because of their association with the heretical practice of astrology, magic, and witchcraft.

The *perspicill* is introduced in Act I, scene iii, when Albumazar's thug, Ronca, first cons Pandolfo outside of Albumazar's *phrontisterion* (shop of magical things). The curious object soon captures Pandolfo's attention, and he demands that Ronca explain the thing. Ronca acquiesces:

> Ronca: An engine to catch stares,
> A mase t'arrest such Planets as have lurk't
> Foure thousand yeares under protection
> Of *Jupiter* and *Sol*. (*Alb.* I.iii)

Ronca describes the *perspicill*'s ability to act upon distant objects in order to bring them closer to the observer. This description does not account for the instrument's abilities to make the object appear closer to the viewer, as Galileo does in *Sidereus Nuncius* when he describes his initial news that Lipperhey's "spyglass" was capable of causing, "visible objects, although far removed from the eye of the observer, [to appear] distinctly perceived as though nearby" (Galileo, *Sidereal*, 37). Tomkis's language invokes the metaphorical acts of catching stars and keeping them close, rather than viewing through an instrument that enhances human observational skills through lenses.

The *perspicill* is "an *engine* to *catch* starres," that Ronca uses to capture Pandolfo's interest through his embodied demonstration. The reference to the *perspicill* as an engine is part of the conflation of positive and negative ideas about the new invention that the European community was struggling with at the time. By referring to the *perspicill* as an engine, Tomkis brings to mind its status as an object of technological wonder, made by humans, but also a potentially sinful device. Jonathan Sawday cites Roman architect and engineer Vitruvius's distinction between engines and machines: "machines need more workmen and greater power to make them take effect… Engines, on the other hand, accomplish their purpose at the intelligent touch of a single

worksman" (Galileo, *Sidereus*, 37). When Tomkis chooses to refer to the *perspicill* as an "engine," he linguistically aligns the telescope with other morally questionable objects and practices. Protestants who conceived of engines as objects that would have deprived them of the grace of labor would likely have viewed the use of these instruments as an errant and potentially sinful act. But, as discussed by Picciotto above, an alternate Protestant point of view emergent at time rendered the "artificial organ" of telescope capable of bringing the curious-yet-industrious human closer to a prelapsarian Adam who might perceive Creation more clearly in order to better perform God's work. Tomkis, as the son of a Protestant clergyman and a Trinity Fellow, would have had several potentially conflicting influences on his creative thought. If he believed that the telescope separated the human from the grace of labor, then he might have written *Albumazar* with the intention of performing its popularly suspected negative attributes. If he followed the Baconian line of thinking, then he might have written the instrument to be performed in such a way that highlighted its popularly touted positive attributes.[78] Clues about the live production should indicate where Tomkis stood on the debate over the use-value of the telescope towards the betterment of scientific practice and as applied to daily life.

The telescope I.iii also synecdochally represents Albumazar; the telescope tricks Pandolfo in Albumazar's stead, with a little help from Ronca. Staged telescope, linguistic metaphor, and physical business work together in order for Ronca to successfully capture Pandolfo's interest:

[78] A potential influence of Bacon's writing on Tomkis's thought during the reign of James I is worth further investigation. Bacon also attended Trinity College, although much earlier. Bacon was there from 1573-1575 and Tomkis began his studies at Trinity College in 1597 and became a major fellow by 1604. In 1614, Bacon would have been working for James I as Attorney-General. Major works concerning natural philosophy would have been published and it is conceivable that Tomkis might have read them (*Advancement of Learning* (1605) and *Essays* (1612)).

Ronca: Sir, 'tis a *perspicill*, th'best under heaven:
With this Ile read a leafe of that small Iliade That
in a wall-nut shell was desk't, as plainly
Twelve long miles off, as you see Pauls from Highgate.

Pandolfo: Wonderful workman of so rare an Instrument!

Ronca: Twill draw the Moone so neere
That you would sweare the bush of thornes in't
Prick your eyes: the Chrystall
Of a large Arch multiplie's millions,
Worke's more then by point blanke: and by refractions
Opticke and strange… (*Alb.* I.iii)

Ronca's description of the *perspicill* contains a grain of truth. The machine works "by refractions/ Opticke and strange," which is not a lie. The kinds of telescopes that existed in 1615 were refractive telescopes, built with a combination of two lenses—one concave, one convex.[79] The extent to which Ronca later describes his ability to see through the telescope, however, is greatly exaggerated.

Ronca's demonstration of the *perspicill* contains a subtle lie that involves different bodies and a false concept of normative human sight. In Ronca's staged demonstration of the *perspicill*, Pandolfo sees for himself that he is not being tricked, even as he is. Ronca shares enough truthful information about the mechanics of the *perspicill* to make his lies almost believable to the characters, and laughable to the audience. While Ronca claims to be able to see as far as Rome through the device, an impossible feat for several reasons, he is careful to explain that Pandolfo

[79] The history of the invention of the telescope is fascinating and has been well-documented by others before me. For more information regarding the events leading up to the appearance of the machine, please see Van Helden, Albert, *The Invention of the Telescope*, Philadelphia: The American Philosophical Society, 1977. For an intricate discussion of lenses and accompanied by a practice-based system of testing the viability of early lenses, please see Willach, Rolf, *The Long Route to the Invention of the Telescope*, Philadelphia: American Philosophical Society, 2008. A philological discussion of the instrument might be found in Rosen, Edward, *The Naming of the Telescope*, New York: Abelard-Schuman, 1947.

will not be able to see that far, but that the *perspicill* will enable Pandolfo to see details of closer but still relatively distant objects:

> Ronca: So farre you can not: for this glasse is fram'd for eyes of thirty: you are nigh threescore
> But for some fifty miles 'twill serve you,
> With helpe of a refractive glasse that's yonder. For
> triall sir: where are you now?
>
> Pandolfo: In London
>
> Ronca: Ha you found the glasse within that chamber?
>
> Pandolfo: Yes.
>
> Ronca: What see you?
>
> Pandolfo: Wonders, wonders…. (*Alb.* I.iii)

At that time, eyeglasses were not made for individual prescriptions, but were sold at magnifications intended for distinct age groups, so it was not unusual to order a pair of glasses for "Eyes of thirty." Ronca embellishes the properties of the telescope, and by doing so convinces Pandolfo that it is much more powerful than it really is, when in reality the telescope's visual tricks were impressive in their own right, whether one experienced them through eyes of thirty or eyes of fifty.

2.2.3 Imagining the 1614 Production of *Albumazar* I.iii: Was the Telescope Even There?

Albumazar is the earliest play script to call for the telescope as part of the onstage action, but what evidence exists that a physical stage property would actually have been present onstage during the 1614 performance? And, what difference does that make in this discussion of the depiction of science machines onstage in the early seventeenth century? How did Tomkis intend this *perspicill* to be performed, and how would its performance have been received by audience members who

would likely have been in attendance at the 1614 production at Trinity Hall in Cambridge? In this section I will discuss the evidence for the appearance of a physical prop in *Albumazar*. The evidence I have been able to access suggests that perhaps a telescope did not appear at Trinity Hall in 1614, which sheds some light on Tomkis's opinions about Galileo's invention.

There is precedent for the use of props in university plays produced at Cambridge during the early years of the seventeenth century. Alan H. Nelson writes:

> Costuming for the plays was highly elaborate. Each college kept a stock of costumes which it drew upon year after year.… Players' gear figured prominently among college properties: St. John's, Queens', Trinity, and King's all compiled property inventories , some of which run for pages, detailing jackets, hose, heads, sigs, caps, armour, women's garments, and hand props. (*REED,* 719)

He goes on to cite evidence that, "[l]arger props and special effects were created or hired for the occasion.… A centaur was provided for the pastoral comedy *Scyros* at Trinity in 1612-13" (*REED*, 719). This record of special props having been used just a year before the original *Albumazar* production is a good indication that, were a *perspicill* prop needed for the production of the play, it could have been provided. This is especially probable due to the royal context of the play's production.

Stage directions and internal textual indications also provide some hints as to what actually happened onstage. Nelson refers to stage directions as evidence of actions and items that would have appeared onstage:

> The texts of plays written for performance in college halls conveys a great deal of information concerning production techniques… stage directions… give a sense of the action which might occur in any play.... Singing, running, and fighting; houses with multiple levels; dramatic entrances and exits; trumpets and gunshots; coronations and pitched battles; realistic sound effects; grotesque props—the college stage was vibrant with sights and sounds. (*REED*, 720-1)

Stage directions were not the only means for playwrights to indicate what actions were actually performed by actors onstage. Sometimes, objects are referred to through dialogic exchange. Other

means that Nelson suggests for proof of props' appearance in production are Bursars' accounts, which he cites extensively in *Cambridge* Vol. 1.[80]

Nelson's detailed archival summaries evidence that use of stage props was common for University productions at Cambridge. And, given the context of the royal visit, it is likely that Trinity pulled out all of the stops for this production. In fact, the Trinity College records that Nelson includes for the spring of 1614 in *Records of Early English Drama: Cambridge* are almost entirely devoted to preparations for the visit of King James I and his son, Charles I, to Cambridge. The Trinity College Senior Bursar's Accounts 4, among others, list items that would have decorated the general premises in honor of the king's arrival and other expenses related to the specific production of the comedies:

> …
> Item to William Short goeing to Audley end about
> Hangings and canopies at the Kines first coming v s
>
> …
>
> Item to James Manutij for Paynting the stage v li vii s vj d
> Item for payting the Rayles on the stage ij s vj d
> Item for payting the Sayleirs vs
> Item for glewe and nayles about the trees & stage ij s xj d[81]

Among the Bursar's Accounts is also the aforementioned note regarding payment to Tomkis for "penning and ordering" the play.[82] I could find no item in Nelson's edition of these records

[80] Nelson also cites Tower books as good sources for such information: "Tower books are one manuscript source in which cancellation has positive implications for a cancelled entry implies that the costumes [check spelling of this in original] and props were checked out, used in a production, and safely returned" (Nelson, *Cambridge: 2*, 748).
[81] Trinity College Senior Bursar's Accounts 4, Trinity College Accounts, in *Records of Early English Drama: Cambridge*, ed. Alan H. Nelson, 526-7.
[82] Trinity College Senior Bursar's Accounts, in *Records of Early English Drama: Cambridge*, ed. Alan. H. Nelson, 527. Here I am interpreting "ordering" to mean tasks having to do with production and possible direction of the play.

pertaining particularly to the presence of a prop for the Galilean telescope that is central to the plot in Act I scene iii of the play.[83]

The only evidence for the presence of a telescope onstage comes through the dialogue in I.iii. The first indication for the presence of a telescope occurs in I.iii. during the exchange between Pandolfo and Ronca, the science and social context of which has already been discussed above. Yet, the question of whether or not a physical prop actually appeared still remains. As Pandolfo approaches Albumazar's *phrontesterion*, he notices Ronca, and comments on Ronca's actions:

> Pandolfo: Sure this some novice of th'Artillery,
> That winks and shoots: sir, prime your piece anew,
> The powder's wet: tick. tock. tick. tock. (*Alb*. I.iii)[84]

Dick speculates that Pandolfo deduces from Ronca's actions with the telescope that he has mistaken the telescope for a gun at first. The second textual indication for action with the telescope occurs later in the scene, as Ronca demonstrates the telescope in order to capture Pandolfo's attention:

> Ronca: … I see the heavens incline to his [Albumazar's] approach.
>
> Pandolfo: What's tis I pray you?
>
> Ronca: An engine to catch stares,
> A mase t'arrest such Planets as have lurk't
> Foure thousand yeares under protection
> Of Jupiter and Sol. (*Alb*. I.iii)

Here, the only suggestion that there is an object on stage is Pandolfo's question, "What's this I pray you?" Reading between the lines, one can speculate that the actor playing Ronca now

[83] According to Nelson, the Bursar's Accounts are kept at Cambridge, and a trip to the premises would be required to attempt to prove whether a prop had been either borrowed from the Tower or purchased for the production.
[84] Tomkis, *Albumazar*, 1615, i.iii. Huntington Rare Books. Garrick's 1773 edition contains a stage direction that indicates Pandolfo should knock on the door. This use of onomatopoeia suggests that perhaps there was no door upon which to knock in 1614.

performs with the telescope as if he were looking at the sky. The implied gesture could have accompanied the line, "I see the heavens incline to his approach." Ronca's actions, presumably with the telescope, capture Pandolfo's attention and thus lures the old man into Albumazar's snare.

When Ronca finally describes the thing as a "*perspicill*, the best under heaven.…" he does so in technical detail that would have been appropriate for the wealthy and educated community in which this play was written and produced. Pandolfo exclaims, "Wonderfull Workman of so rare an instrument!" (*Alb.* I.iii). In this statement, Tomkis does two things: first, he describes the *perspicill* as a rarity, which perhaps it was at the time, but, as discussed previously, Jonson would describe the same device as "common" just five years later in his masque, *New News Discover'd on the Moone*, performed at court, also before King James I. The second thing that Pandolfo accomplishes in this statement is to praise Ronca's skill at manipulating the instrument when he addresses Ronca as a "wonderful workman." Tomkis acknowledges, through Pandolfo's wondrous state, the human labor involved in the use of the telescope, perhaps betraying a Baconian attitude towards the instrument. The human effort and expertise was worthy of wonder, but the machine was rare, uncommon. Perhaps it was invisible.

It is important to keep this possibility in mind: the telescope as it was performed on the stage of Trinity Hall before King James I and his entourage could have been a dumb show, or, pantomime bit embedded within the action of the rest of the play. So far, we have seen no evidence of stage directions that indicate that a telescope must have appeared as a prop for the 1614 production. The action that follows between Pandolfo and Ronca also does not bear evidence that the prop must be there in order for the action to proceed as indicated through the dialogue between the characters. Even when Pandolfo uses the *perspicill* later in the same scene, the action could have been mimed. So much of I.iii is written metatheatrically, to especially honor, acknowledge,

and please the royal entourage assembled for its production, that it would not be surprising if the performance were also special in some way. Perhaps a dumb show early in the action was a way for Tomkis to pander to the king's taste for masque in a play that had none in it. The scene is full of shameless compliments to the royal entourage, so such a scene would fit within the royal context.

Pandolfo exclaims again of his wonderment. And, again, the object that triggers his wondrous state is not the *perspicill*, but human beings. No stage direction indicates that Ronca hands the *perspicill* to Pandolfo. Rather, that action is indicated by the dialogue. Pandolfo tries the *perspicill* for himself, and when Ronca asks him, "What see you?" Pandolfo replies, "Wonders, wonders…" With this line, Pandolfo may be remarking on the capacity of the device to augment his vision so that he is able to see from London to Cambridge, but, he is also remarking on the wonder of the assemblage of royal guests in Trinity Hall at the time of the performance. People, not objects, are the wonders over which Pandolfo exclaims.[85]

Further evidence for or against the likelihood that an actual physical prop for the *perspicill* was used can be deduced from the existence (or lack thereof) of other props indicated in the text, either inferentially or through stage directions. In the same scene in which Pandolfo is introduced to the *perspicill*, Ronca engages Pandolfo in an experience with another one of Albumazar's wondrous instruments, the *otacousticon*. He describes this instrument in nearly as glowing terms as the *perspicill*:

> Ronca: In imitation of this Perspicill,

[85] The other guests are referenced through Pandolfo's description to Ronca: "A Hall thrust full of bare-heads, some bald, some busht./Some bravely branch't. RONCA: That's th'University/ Larded with Townes-men" (Tomkis, *Albumazar*, 1615, I.iii.). This text, were it accompanied by actions (with a mimed or real telescope) would adhere to the University decree on the order of audience members as they should have been arranged in the Hall for the performance during the royal visit. Nelson posits a similar theory in *Early Cambride Theatres*. His observations, however, are strictly related to the royal audience, not the use of the telescope in performance.

> [Albumazar] Hath fram'd an Instrument that multiplies
> Objects of hearing, as this doth of seeing,
> That you many know each whisper from Proster John
> Against the winde, as fresh as 'twere delivered
> Through a trunke, or Glosters Listning wall. (*Alb.* I.iii)

Here, it would be simplest to imagine that there were a physical *perspicill* for Ronca to reference, but perhaps it was mimed. Pandolfo is eager to replicate the wonderful experience that he just had with the *perspicill* on his ears, "And may I see it sir? Blesse me once more" (*Alb.* I.iii).

Pandolfo's experience with the *otacousticon* is narrated by Ronca in such a way that makes it seem like this instrument is truly a figment of the imagination. Pandolfo asks to see the instrument, but, instead of showing it to him, Ronca offers Pandolfo an experience: "Tis something ceremonious; but you shall try't" (*Alb*. I.iii). Ronca instructs Pandolfo in how to arrange his body:

> Ronca: … Stand thus. What heare you?
>
> Pandolfo: Nothing.
>
> Ronca: Set your hands thus
> That th'vertex of the Organ may perpendicularly
> Point out our Zenith. What heare you now? ha, ha, ha. (*Alb.* I.iii)

At this point, Ronca has not actually shown Pandolfo anything. Pandolfo, one might imagine, has followed Ronca's instructions, which has caused Ronca (and presumably the audience) to laugh. This metatheatrical situation causes Pandolfo to exclaim:

> Pandolfo: A humming noise of laughter.
>
> Ronca: Why that's the Court
> And Universitie, that are now merry with an old gentleman in a Comedy. (*Alb.* I.iii)

Pandolfo has been prepped by his vision of the Court, so he might also be led to believe that this audience is laughing at a distance and not in the same room with him. When Pandolfo demands, "O let me see this wondrous instrument," still no stage direction is given that Ronca produces an object for Pandolfo to visually examine (*Alb.* I.iii). All that is indicated is that Ronca replies, "Sir,

this is call'd an *Otacousticon*" (*Alb.* I.iii). It is unclear whether or not there is a prop or costume of false ass ears, or if Ronca pantomimes an identical position that Pandolfo was just in, provoking Pandolfo's response: "Why tis a paire of Asses eares, and large ones" (*Alb.* I.iii). There is simply no indication in the text as to whether or these detection objects appeared on the stage or not.

More dialogic evidence suggesting the invisibility of these objects comes at the very top of the next scene with the entrance of Pandolfo's servant, Cricca. Pandolfo, excited about his new discoveries and the prospect of procuring them for himself, exclaims, "Come hither Cricca./ Wonder for me, admire, and be astonish,/ Marvaile thy selfe to Marble at these engines,/ These strange Gorgonian instruments" (*Alb.* I.iv). Cricca simply replies, "At what?" (*Alb.* I.iv). Cricca's lack of response to these items suggests that perhaps they didn't appear onstage. Ronca quickly changes the subject and begs Pandolfo to not brag about these powerful instruments and threatens that Pandolfo will know no more of astrology's secrets should Pandolfo continue to talk about them. It is possible that the instruments used in this scene were mimed, and invisible.

The fact that no props are listed is not due to the fact that Tomkis didn't ever use stage directions in which props were called for. The end of the play features a scene in which Pandolfo, upon being made the fool, takes out his frustrations on Trincalo, whom he beats with a staff:

> Pandolfo: Seeke not by humble penitence t'appease me.
>
> Nothing can satisfie.
>
> Trincalo: Fare-well humilitie.
> How I am beaten sober.
>
> (*takes away Pandolfo's staffe*) (*Alb.* V.ix)

Another stage direction appears when Pandolfo takes back his staff to continue with the (presumably comedic) beating of his servant, who laughs through the entire scene. The stage direction is written beside Trincalo's laugh lines: "*Whilst Trincalo laughes, and falls the staffe,*

Pandolfo recovers it, and beates him" (*Alb.* V.ix). Not only is the presence of a prop indicated through Tomkis's use of stage directions, but so is playwright's intended use of that prop. No such indication is made in I.iii with regard to the *perspicill* and *otacousticon*.

The possibility that Tomkis's dearth of props in stage directions in I.iii was perhaps intentional can argued by looking to his use of stage directions in other works. Tomkis published the play, *Lingua: Or, The Combat of the Tongue, and the five Senses for Superiority. A Pleasant Comoedie* in the same year that *Albumazar* was published, 1615. A sort of revival of the morality, the play was produced at Cambridge in 1607.[86] Tomkis certainly knew how to write stage directions, since he used them liberally in this earlier work.[87] This evidence is found predominantly in Tomkis's use of written specifications for entrances and exits, as well as his specific use of stage directions for interactions between characters when props are involved.

In *Lingua,* Tomkis takes great pains to describe the costumes of each character, especially upon their first entrance in the play. For instance, Lingua's first appearance is described as follows:

> LINGUA, *appareled in a Crimson Satten Gowne, a Dressing of white Roses, a little Skeane tyed in a purple Skarfe, a paire of white Buskins drawne with white Riband, Silke-garters, Gloves, &c.* (*Ling*. I.i)

Nelson and Smith's thorough research of the archives at Cambridge vouch for the use of elaborate costumes at Trinity Hall. Another entrance later in the play describes a procession involving several characters, each holding specific props:

> *A Page carrying a* ***Scuthcion argent****, charged with an Eagle displayed proper, then Visus with a* ***Fanne of Peacockes Fethers****, next Lumen with a Crowne of Bayes, and a* ***Shield with a bright Sunne in it****, apparalled in Tyssue, then a Page bearing a* ***Shield*** *before Coelum, clad in Azure Taeta, dimpled with Stars, a Crowne of Starres on his head, and a Scarfe resembling the Zodiacke everthwart the*

[86] Smith suggests that the play may have been penned and performed as early as 1602.

[87] It could be the case of a different genre of play, but since this dissertation is not predominantly a comparison of Tomkis's work, nor of diverse university performance genres of the early seventeenth century, I will limit this discussion to the stage directions as they relate to Tomkis's employment of the telescope as a stage prop in 1614.

> *shoulders; next a Page clad in greene* ***with a terrestriall Globe*** *before Terra, in a greene velvet Gowne, stuck with branches, and flowers, a Crowne of Turrets upon her head,* ***in her hand a key****; then a Herauld, leading in his hand Colour, clad in changeable Silke, with a Raine-bow out of a Cloud on her head, last a Boy: Visus marshalleth his shew about the Stage and presents it before the Bench.* (*Ling.* III.vi)[88]

That the objects should appear onstage with the characters is not necessarily an indication that these props were used as a part of the plot in the action of the play. It is likely that the kinds of props indicated by the above procession were intended to be held as symbolic of the allegorical characters that held them.

Props in *Lingua* are important to parts of the play's action, evidence of which can be found within the stage directions of other scenes in the play. As with the staff-beating scene in Act V of *Albumazar*, *Lingua,* as it is published in 1615, includes stage directions for actions, especially for comedic bits, but also to indicate specific business for certain props that are part of the plot development. A good scene that has evidence for both types of stage directions comes very early on in the play. I.v. features the character Tactus who has come across a robe and crown. In this scene, Tactus makes his first entrance (which is accompanied by a detailed costume description). Comedic actions that lead to Tactus's discovery of the robe and crown are indicated with written stage directions that accompany the dialogue:

> "Tactus: Cleere is the Sunne and blew the firmament,
> Me thinks the heavens to smile. *Tactus sneezeth*.
> ----------Mendacio: At thy mishap.
> To looke so high and stumble in a trap.
> *Tactus stumbleth at the Robe and Crowne*. (*Ling.* I.v)

[88] Objects that are props have been boldfaced by the author.

A stage direction indicates that Tactus should sneeze, and upon sneezing, discover the robe and crown. Further comedic business involving these objects as props in the scene I.vii, in which Tactus responds to the sudden entrance of Olfactus, and tries to hide the objects:[89]

> "Tactus: Ay me Olfactus comes, I cal'd too soone,
> Heele have halfe part I feare; What shall I do?
> Where shall I runne? How shall I shift him off?
>
> *Tactus wraps up the Robe and Crowne and sits upon them.* (*Ling.* I.vii)

These stage directions, and others like them that recur throughout the play, indicate how the play should have been performed in production: with props. This is much more textual evidence than appears for use of the *perspicill* and *otacousticon* in *Albumazar*. In Tomkis's 1614 production, dialogue indicates that the telescope does change hands, and did have comedic business associated with it, but the precedent of use of stage directions in earlier works and in later scenes of the same play suggest that perhaps these objects were performed in a pantomimic style, which leads to a slightly different reading of their relevance to the plot and their status in the society for which the play was produced.

If the *perspicill* and *otacousticon* in *Albumazar* were mimed, all of the praise that Ronca verbalizes raises the stakes of the joke. Already, the objects are not presented in the hands of a scientist character. They are not even indicated to be used by the astrologer character. Instead, the novel scientific instruments, *perspicill* and *otacousticon*, are staged in the hands of a thief and a fool as part of a dumb show. If the telescope is performed as an invisible and imaginary object, it deepens the message that the author might be sending to the royal audience: not only is the practice of astrology ridiculous, but the tools associated with astrology and its counterpart in the "new

[89] They could be costumes, but because they are not wearing them at the time, their presence onstage serves the function of hand props.

science," astronomy, are likewise insubstantive. Tomkis, may have staged a deep skepticism regarding the relevance of the telescope to the practice of astronomy. The dialogue surrounding the actions indicate that there was much popular knowledge of the telescope circulating around London and Cambridge at that time, but perhaps the physical objects were rare, indeed. Perhaps they were rare enough for popular and royal opinion to hold their existence (or at the very least, their use-value) in the realm of the imaginary.

2.3 RESHUFFLING DISCIPLINE: APHRA BEHN'S *EMPEROR OF THE MOON*

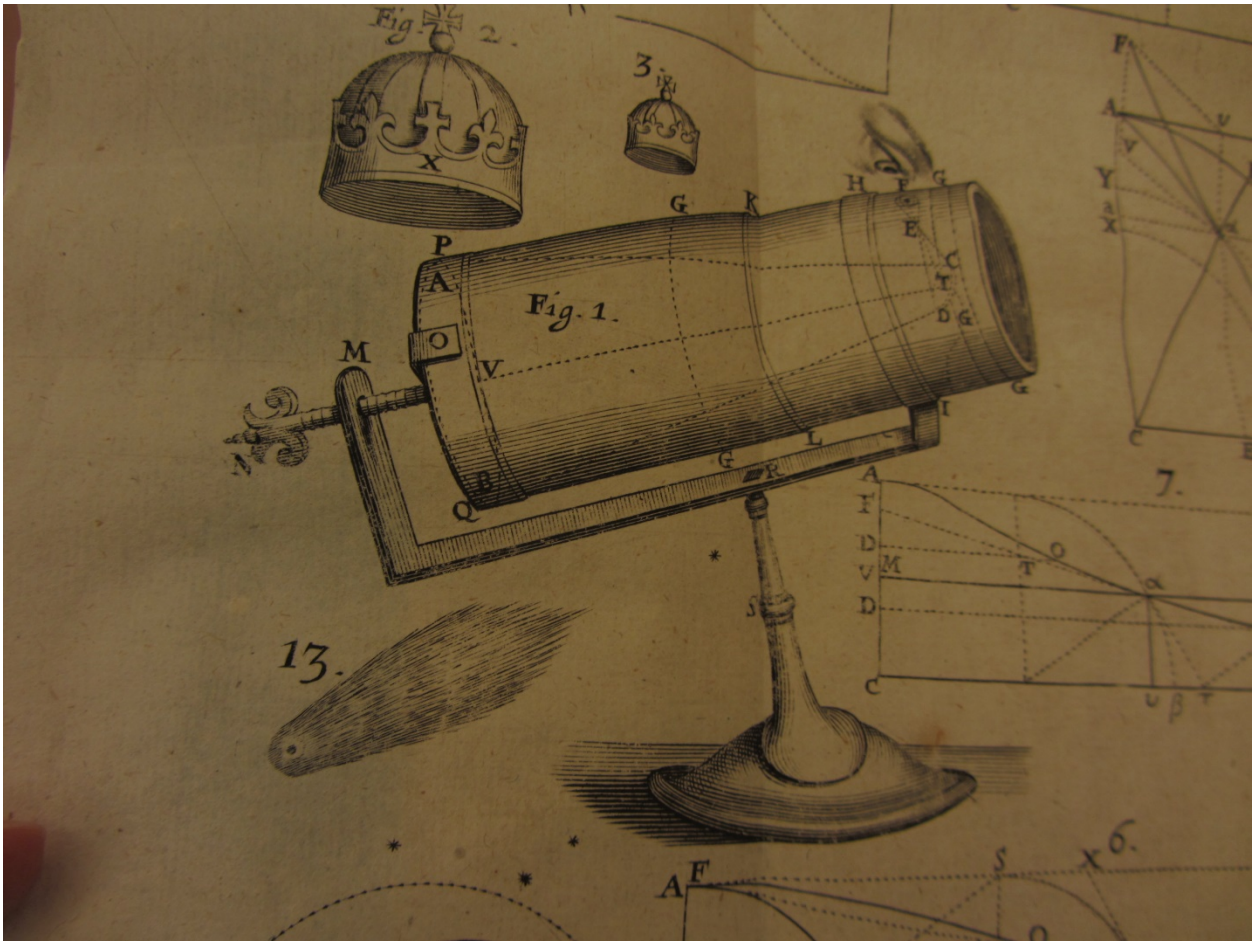

Figure 5: Schematic drawing detail of a Newtonian reflective telescope in Philosophical Transactions. 81. 25 March 1672. RB 487000:0681, The Huntington Library, San Marino, California.[90]

Aphra Behn's *The Emperor of the Moon*, opened to a very different England in 1687 than did Tomkis's *Albumazar*. England had gone through the massive political upheaval of the Cromwell period. Behn's benefactor, Charles II, had been exiled, returned to the British throne, and had

[90] This drawing represents the hybrid assemblage of objects and agents at work in astronomy: the human eye, the apparatus, the observational object, and the government. Wallis, John, "An accompt of a new catadioptrical telescope invented by Mr. Newton, Fellow of the R. Society, and Professor of the Mathematiques in the University of Cambridge," 1672, RB 487000:0681, *Philosophical Transactions*, The Huntington Library, San Marino, California.

recently died. James II had just taken the throne, and he was not as supportive of the arts, as Behn suggests in the play's dedication. Just as much had changed techno-historically, since Tomkis's staged *perspicill* lured Pandolfo and captured audiences at the beginning of the century. The Royal Society of London was established with an official Royal Charter in 1662 and developments in all aspects of experimental science, astronomy in particular, escalated in England and Europe. Notable advancements in telescope technics were accomplished by Sir Isaac Newton, who developed a telescope that worked by reflection, and Christian Huygens, who was famous for the design of some of the century's largest and most powerful telescopes. Nevertheless, the practicality of knowledge gained through artificial organs remained a suspect endeavor. This question—of what use is knowledge of the unseeable cosmos to people living on Earth—was taken up explicitly by Behn in 1687. *Emperor of the Moon* brings the practitioners of the "new science" and their machines to task in a mechanical farce inspired by Nolant de Fatouville's *Arlequin, empereur dans la lune,* originally staged at the Comédie Italienne at *l'Hôtel de Bourgogne* in 1684.[91] Performances embodied by humans and the machines that appear on Behn's stage convey a somewhat conflicted interest in/rejection of the mechanics of astronomical observation and imagination.

[91] Behn's play closely resembles the French original. It features a dotty professor, Dottore Baliardo, who is obsessed with the moon, its lore, its topography, and its culture. Both French and English versions of the play include a telescope of remarkable size. She acknowledges this influence, but plays down the similarities in her "Dedication" to the play, published in 1687: "A very barren and thin hint of the Plot I had from the Italian, and which, even as it was, was acted in *France* eight odd times without intermission. 'Tis now much alter'd, and adapted to our English Theatre and Genius, who cannot find an Entertainment at so cheap a Rate as the French will, and who are content with almost any Incoherences, howsoever shuffled together under the Name of a Farce" (Behn, "Dedication," n.p.).

2.3.1 Dorset Garden's Very Large Telescope

The Emperor of the Moon is the second most popular play to have been written by Aphra Behn. It premiered in March, 1687 at the Dorset Garden Theatre.[92] After its premiere, *Emperor* enjoyed a lengthy history in repertory at Drury Lane, a brief revival during the last gasps of Dorset Garden in 1706, a long history at Lincoln's Inn Fields, and a final run that alternated performances at Covent Garden and Drury Lane during December of 1748. In 1699, a song by Daniel Purcell was added. The fact that the play premiered at Dorset Garden is not insignificant, given the spectacular masque that is performed at the end of the play. The Jacobean masque had come back into fashion, and Behn's farce capitalized upon the spectacular resources of this short-lived but lively "spectacular amusement park" (Radice, "Purcell," 129). The play's final masque makes room for a doubled educational aspect for which its Jacobean predecessor was often put to use. However, by the late seventeenth century, it could have been a general audience that constituted any active learning within the domain of the theatre, as well as members of the aristocracy who would have participating in that audience.[93] Like *Albumazar*, Behn's *Emperor* was an adaptation of Arlequin, *empereur dans la lune* with French scenes by Nolant de Fatouville, premiered at *l'Hôtel de*

[92] *The Stationers' Register* records that it was licensed on 6 April 1687, but the "Newdigate newsletters" comments on 16 March 1687 that, "A Country man having invented a head & soe contrived it that whatever language or tune you speak in the Mouth of it it Repeated distinctly and Audibly."

[93] Harold Love, in the article, "Who Was the Restoration Article," cites numerous contemporary sources to suggest the wide range of social classes that would have been present at Restoration drama. He concludes, "The Restoration theatre, then, was in many ways an image-in-little of the Restoration city. Much as the metropolis was divided, not only between the two cities of London and Westminster and the various independent parishes of Middlesex and Surrey but among a whole host of minor liberties and precincts each with its own carefully charted boundaries and anciently derived privileges, so the auditorium seems to have been conceived as a number of distinct and independent territories within which it was possible for people from a wide range of backgrounds to find their own local sense of belonging and their own local mode of participation, with the pit presenting the opportunity for freer contact but also requiring greater caution and a watchful respect for the sensibilities of others" (Love, Harold, 43).

Bourgogne in March, 1684, just three years before Behn's adaptation.[94] Later in the eighteenth century, Joseph Haydn revived the story as the *drama giocoso*, *Il mondo della luna* (1777), which relied upon Carlo Goldoni's 1750 adaptation of Nolant de Fatouville's original.[95]

Like *Albumazar*, *Emperor* is also originally a work of the *commedia*, and its stock characters and zany plot remain primary elements of Behn's Anglicized science farce.[96] In this story, the doctor, Baliardo, is enamored of the concept of life on the moon. He is a self-identified Cabalist, and in this regard resembles the protagonist of *Albumazar* because of his interest in the occult.[97] Baliardo, despite his Italian name, is not depicted as a charlatan, but a harmless old man with a disturbing interest in the moon and its inhabitants. It is concern for the *dottore*'s well-being (and a desire to marry) that drives the *innamorati* (lovers) characters to devise a plot that will shock Baliardo out of his irrational interest in unearthly things and his reliance upon the untrustworthy telescope to procure such information. His concerned family members construct an elaborate practical joke that involves tricking Baliardo into thinking that he really can observe moon people through his telescope, and then shocking him back to reality in the play's final masque.

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[94] The French scenes were published in Evaristo Gherardi's collection of *commedia dell'arte* scenarios that were performed at the *Comédie Italienne* in the second half of the seventeenth century, *le Théâtre Italien* (1697).

[95] Goldoni's version premiered in Venice. More research is necessary to track instances of the telescope as they appeared in these operas. For more information about these productions, please refer to the article, "Haydn, Goldoni, and *Il Mondo Della Luna*," by Michael Brago. Also in 1777, a revival of Behn's *Emperor*, "As Performed at The Patagonian Theatre" was published by T. Sherlock. More research is required to document this production history.

[96] Jane Spencer's 1995 edition of *The Emperor of the Moon*, contains detailed notes that indicate which scenes Behn took from Fatouville's original performance. There is also evidence that some of the physical gags might also have derived from the original performance.

[97] Several lines in the play do reveal that the character's interest in cabalism is a thinly veiled critique of the Royal Society, which some detractors claimed was only interested in esoteric information that lacked practical applications in the real-world. While the term "Cabal" has a specific context within Judaism, the mid-late seventeenth century England experienced a fad for applying the term in a secular context to refer to a number of kinds of secret organizations, meetings, and practices.

The giant telescope featured in *The Emperor of the Moon* is a crucial piece of a theatrical assemblage of characters, objects, and plot that make the piece a witty comment on contradictory attitudes about the "new science" at the dawn of the Age of Reason. Perhaps the most memorable aspect of Behn's Restoration science comedy is Baliardo's telescope of extraordinary size. Act I scene ii is set in a garden, the location on Baliardo's property that would have afforded the best conditions for astronomical observation: an open sky and open space. Some of the most interesting information about Behn's telescope can be found in her stage directions, which indicate not only its proportions, but the assemblage of human bodies and scientific gadgets with which it should be performed: "*Enter Doctor, with all manner of Mathematical Instruments, hanging at his Girdle; Scaramouch bearing a Telescope twenty (or more) Foot long*" (*Emp.* I.ii). Behn is going for laughs, as the ensuing bawdy joke suggests, at the expense of Baliardo:

> Doctor: Set down the Telescope. — Let me see, what Hour is it?
>
> Scaramouch: About six a Clock, Sir.
>
> Doctor: Then 'tis about the Hour, that the great Monarch of the upper World enters into his Closet; Mount, mount, the Telescope.
>
> Scaramouch: What to do, Sir? (*Emp.* I.ii)

A series of phallic jokes, typical of the *commedia dell'arte*, recur throughout the scene. The structure and style of the *commedia dell'arte* plot and stock characters gives the audience an opportunity to laugh at the strangeness of a science machine of such apparently incredible dimensions.[98]

[98] A less materially impressive example of a *commedia dell'arte* telescopic phallus joke appears in the Casamarciano troupe's scenario for *Il comvitato del pietro* (The Stone Guest, 1700) in which Rosetta claims that the Dancing Master "took her to a cave and put his telescope' in her hands" (Casamarciano, "The Stone Guest," *The Commedia dell'Arte in Naples: A Bilingual Edition of the 176 Casamarciano Scenarios*, 424-428).

At first read, Behn's telescope might easily be dismissed as a deliberately exaggerated conceit of the *commedia* plot. In fact, the size of Behn's staged telescope of "twenty (or more) Foot long," paled in comparison to its real-life contemporaries in the domain of science. In the mid-seventeenth century, two continental astronomers, Johannes Hevelius of the Polish-Lithuanian Commonwealth and Christian Huygens of the Netherlands, continued to experiment with refractive telescopes.[99] Both continental optical virtuosi experimented with focal length of lenses. In 1673, Hevelius constructed the longest telescope of the seventeenth century—a one hundred and fifty foot-long refractive telescope—and arranged its lenses, without a tube, along a wooden trough in the open air. Huygens also built a long, tubeless telescope in 1686, the year before Behn's *Emperor of the Moon* was published, but his was one hundred and twenty-three feet long and used only two lenses, separated by a great distance. These telescopes built for the domain of astronomy would scarcely have fit in the entirety of the Dorset Garden theatre lengthwise, let alone on the stage. The twenty-foot length indicated by Behn would have taken up most of the width of the stage.[100] As far as theatrical metaphor goes, the twenty-foot long scope would have dominated the stage, and performed the extent to which the machine had come to occupy Baliardo's thoughts.

Behn borrowed the concept for the large telescope gag from the French. The stage directions for Fatouville's earlier *Empereur* are not as detailed as Behn's and state simply, "*Le Théâtre represente un Jardin, au fond duquel on voit une grande Lunette d'approche montée sur*

[99] Hevelius and Huygens were, perhaps, more notable for other astronomical accomplishments. Hevelius created the first true map of the topography of the moon, *Selenographia* (1647), and Christian Huygens is famous for his discovery of the rings around Saturn, now referred to as Huygens Rings.

[100] Mark A. Radice, in his article, "Theater Architecture at the Time of Purcell and Its Influence on His 'Dramatick Operas'" (1990) gives estimates of the stage space as having a width of twenty-five to thirty feet, and a depth of as much as fifty feet, if one were to include an apron of as much as twenty feet. The entire building is estimated to have been between 140-147 feet long.

son pied."[101] The French telescope should have been large, but the stage directions don't indicate how large.[102] The caricature of Fatouville's Dottore Baloardo offers another possible target of "new science" satire. It is likely that this character is a pointed impersonation of the Italian virtuoso, Giovanni Domenico Cassini (1625-1712), rather than a mash-up of absentminded Royal Society types and dabblers in the occult, as is probably the case with Behn's Baliardo.

A linguistic conceit is established at the beginning of the *Empereur* to indicate the doctor's foreignness: he speaks half in Italian and half in French. For instance, an early monologue explaining the reasons that there should be life on the moon begins in French, but Baloardo quickly slips into Italian:

> S'il y a des Crepescules dans la Lune, *bisogna ch'a vi sia una Generation, & una Corrution; e s'al ghè una corruption, & una generation, bisogna ch'a ve sasea dei Animali, e dei Vegetabili; e s'al ghe nasce dei animali, e dei vegetabili, ergo la Luna è un Mondo abitabile com'al nostro*. (139)[103]

Baloardo's Italian, like his science, is often not quite correct, which is part of the satire. The target of Fatouville's satire might have been Cassini, an Italian astronomer most known for his discovery of the gaps between the rings of Saturn (now known as the Cassini division. Cassini moved to Paris in 1669, joined the *Académie Royale des Sciences*, and became somewhat of a nemesis to

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[101] (The theatre shows a garden, at the bottom of which a large telescope is mounted on its feet.)

[102] This is typical of the texts included in Evariste Gherardi's *Le Théâtre Italien ou Le Recueil Général de toutes les Comédies et Scènes françaises jouées par les Comédiens Italiens de Roi.* Gherardi included the text for the French scenes, and left out much of the improvised *lazzi*, the physical gags, out of the textual document. No description of the telescope is included in the Gherardi's 1700 text other than that the device should be "grande." Without any other indication in the extant French scenes, it is all but impossible to know exactly what kind of telescope was on stage in Paris in 1684. Visual representations of the play feature detailed portraits of the characters and hint at the scenario but do not feature a telescope.

[103] This scene is also included in John Rudlin's *Commedia dell'Arte: An Actor's Handbook*, in an explanation of the Pierrot/Pedrolino character's development in Paris during the late seventeenth century, pp. 137-138. (If there are sunsets on the Moon, there must be procreation, and contamination(?); and if you have a contamination and procreation, there must be animals and vegetables; and if animals are born and also vegetables, then it must be stated that the Moon is a habitable World like ours.) (translation mine)

Huygens, the *Académie's* former astronomical darling. Cassini was notorious for his dramatic scientific demands, and, according to Van Helden, he, "by gesture claimed the observatory as his own.… He was the brilliant courtier who could have the water tower of Marly moved to the grounds of the observatory in order to accommodate the very long 'tubeless' telescopes with which he continued his amazing… discoveries" (Van Helden, *Huygen's Ring*, 37).[104] Cassini also made many discoveries by using a seventeen-foot-long telescope.[105] The telescope race had by no means come to an end by the time Behn's Britishized version premiered at Dorset Garden. Considering the criticism and curiosity that the Royal Society piqued in London at the time, any number of contemporary English and Continental figures could have filled in the imaginations of the *Emperor*'s audiences as a target of Behn's satire.

2.3.2 Behn's Astronomical Assemblage of Bodies: Physical, Mechanical, and Philosophical

There is more than one way to laugh. People laugh out loud when they find something truly funny. One might giggle, snort, or chuckle upon finding something surprisingly amusing. Hysterical laughter can be a sign of emotional danger—a state close to tears. Oftentimes, people laugh when they are nervous or find themselves in an uncomfortable social situation. Thus far, the plays that have been discussed in this chapter have been comedies. Given the emergent state of astronomy throughout the seventeenth century in Western Europe, I suggest that the reason so many of the

[104] For a more detailed discussion of the seventeenth century competition to make the best telescope, please read Albert Van Helden's *Huygen's Ring, Cassini's Division, and Saturn's Children,* 2004.

[105] This was a gift given to him by the Italian telescope maker Giuseppe Campani (1635-1715). Cassini and Huygens were both members of the French *Académie* and both were known for their experimentation with very long telescopes. If Cassini were using his seventeen-foot-long scope in Paris, it becomes plausible that this is about the length of the machine represented on the French stage in 1684.

plays that dealt with the "new science" and its mechanical accoutrements is because Western European society on the whole was nervous about the rapidly changing relationship of the human to the natural world. Comedies about the "new science" allowed a public venue for the collective expression of laughter as a nervous affect. In this section, I will discuss the ways in which Behn's *Emperor* is an assemblage of the collective performance of science, one in which affect, emotion, body, machine, and idea all play a part.

Behn warms her audience up with a series of jokes aimed at the easy target, Baliardo. In doing so, she accomplishes several theatrical tasks. She provides audiences with references to the play's "new science" context while also establishing herself as a credible critic of these references. She mixes in enough obvious jokes to let the audience know the playwright holds a philosophical position that tempers sensual experience with reason. The jokes themselves give the audience an opportunity to laugh outright. This is the first part of the Latourian trick. By allowing the audience to laugh with the first characters who appear onstage, Behn immediately sets up an emotional connection between the people in the audience and the actions onstage.[106] The different kinds of technology that appeared onstage in Behn's *Emperor* are particularly relevant to the way that the Latourian assemblage can work towards an embodied participation in the performance of science, perhaps against the intent of the playwright. All agents and actant objects are participating through their active presence in the metaenvironment of the theatre.

The pointedness of Behn's satiric agenda can first be seen in the characters that she includes in her version of *Emperor of the Moon*. The French version had only about six traditional

[106] In Plantinga's terms, this would be a direct emotion in which case the spectator feels something about the content of the performance and its plot. This is different than the artifact emotions, which have to do with how the spectator reacts to the *things* on stage and/or [still don't like "and/or," especially in a scholarly contex] technique involved with the production of the performance (Plantinga, 69).

commedia stock characters, but Behn includes *innamorati* of Elaria and Bellemante.[107] She also brings in an entirely new cast for the masque at the end of the play. In Behn's work, Scaramouch replaces Pierrot as the doctor's assistant.[108] Harlequin's attempts to woo Colombina remain intact.[109] Although Harlequin does engage in elements of disguise towards the end of the play—a conceit that is an oft-repeated favorite of the French audience—it is Charmante, Elaria's lover, who first appears in disguise to press the doctor for an introduction to Elaria on behalf of the fictional Emperor of the Moon.

Baliardo's reputation as a lunatic is introduced through a conversation between his daughter and his servant:

> Scaramouch: You must know, [Elaria], your Father, (my Master, the Doctor,) is a little Whimsical, Romantick or Don Quicksottish, or so, ---
>
> Elaria: Or rather Mad.
>
> Scaramouch: That were uncivil to be supposed by me; but Lunatick we may call him without breaking the Decorum of good Manners; for he is always travelling to the Moon.
>
> Elaria: And so Religiously believes there is World there, that he discourses as gravely of the People, their Government, Institutions, Laws, Manners, Religion and Constitution, as if he had been bred a *Machiavel* there. (*Emp.* I.i)[110]

Scaramouch raises the issue of travel to the moon as analogous to reading about it, suggesting that proximity to an object of study is required in order to know certain things about it.[111] We have

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[107] The daughter and niece characters that are present but mostly silent in Fatouville's French scenes.

[108] However, Pierrot is included as the character of Pedro in some scenes, a choice that would have been somewhat truer to Italian *commedia* conventions. Pierrot would grow in popularity throughout the seventeenth and eighteenth centuries.

[109] Colombina in Behn's play is Mopsophil, the governess, but their plot function and character type remain the same.

[110] [] indicate my additions. () are included in the original text.

[111] Other works that preceded *Emperor*, suggested other, imaginative means of travel to the moon. These are discussed in Ben Jonson's *News from the New World Discover'd in the Moone* (1620). Poetry, literature, and imagination had long been thought of as ways to travel to the moon. As the Herald in Jonson's masque declares, "There are in all but three ways of going thither; one is Endymions way, by rapture in sleepe or a dreame. The other Mimipus his way, by wing, which the Poete tooke. The third, old Epedocles way; who when he leapt into Aetna,

already seen in *Albumazar* the telescope's capacity to capture objects and bring them closer through the telescope's lenses.[112] Another means of gaining proximity to the moon is the power of the imagination that can be unleashed by the act of reading books:

> Scaramouch: How came he thus infected first?
>
> Elaria: With reading foolish Books, *Lucian's Dialogue of the Lofty Traveller*, who flew up to the Moon, and thence to Heaven, an Heroick business called, *The Man in the Moon*, if you'll believe a Spaniard, who was carried thether upon an Engine drawn by wild Geese; with another Philosophical Piece, *A Discourse of the World in the Moon*; with a thousand other ridiculous Volumes too hard to name.[113]
>
> Scaramouch: Ay, this reading of Books is a pernicious thing. I was like to have run Mad once, reading Sir John Mandivel…(*Emp.* I.i)[114]

Baliardo is able to travel to the moon by means of his imagination. The telescope brings the moon closer by means of magnification. Magnification and imagination come together in "The World of the Moon," a plot described to Elaria by Scaramouch to be enacted by Cinthio and Charmante, "Wherein [Baliardo] shall be so impos'd on, as shall bring matters most magnificently about" (*Emp*. I.i).

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having a drie seere bodie, and light, the smoake tooke him and whift him up into the Moone, where he lives yet waving up and downe like a feather, all soot and embers coming out of that cole-pit'; our Poet met him, and talkt with him" (42).

[112] This idea of capture and travel when the moon is involved resurfaces in a later discussion of Ben Jonson's antimasque, "News of a New World Discover'd in the Moon," in which Jonson's characters speak of traveling to the moon through the vehicle of poetry. Jonson's influence upon Behn is noted in her dedicatory epistle to *Emperor of the Moon*. The moon does appear in the masque at the end of the play; however, the moon descends to the audience on earth, not the other way around. Behn's aim is to demonstrate that the "new science" that purports to provide new ways to know the moon is as artificial as the Dorset Garden spectacle. However, I suggest that through the Latourian assemblage of actors, machines, audience members, and science ideas, productive thought about the moon, the telescope, and the processes by which humans come to better understand the natural world are accomplished within the metaenvironment of the theatre.

[113] Behn's satirical commentary on such books, particularly Godwin's *The Man in the Moone* (1638) is taken up later in the play, before the masque, in a Harlequin-in-disguise scene taken largely from Fatouville's *Empereur.*

[114] Scaramouch's reference is to John Mandeville, a medieval travel writer whose works, like others, continued to influence seventeenth century writers who chose the moon as the subject of their fantastic journeys. Elaria mentions Francis Godwin's 1638 fantasy travelogue, *The Man in The Moon,* which will become a much more actant idea later in the play.

Hiding behind the obvious laughs at the *commedia*-esque gags and the not-so-subtle digs at the virtuosi of the Royal Society, a more elaborate trick is embedded within Dorset Garden's mechanical stage scenery. It is plausible that Behn's very large telescope could have masked a magic lantern—an early image projection device. The large telescope onstage juxtaposes a mechanical curiosity on the side of the audience with an anti-mechanical prejudice on the side of the playwright.[115] Baliardo and the Royal Society are still the butts of Behn's textual gags, but the mechanics of the staged trick are shared with the audience, and this demonstrative aspect of the performance supports Bernard le Bovier de Fontenelle's natural philosophy that, "the more one learns about how nature actually works, the greater one's capacity is to enjoy its wondrous show" (Coppola, "Retraining," 485).[116] Behn might have staged a demonstration of the magic lantern within the telescope scene so that at the same theatrical moment when she dramatically proves that the telescope is easily manipulated and therefore untrustworthy, the meta-theatrical, technical demonstration enables the Dorset Garden audience to learn how a magic lantern works in an entertaining manner. This interpretation weakens the anti-empiricist rhetoric by staging and empirical learning experience for the audience.

Latour's ANT is an apt approach to considering how science was performed at the Dorset Garden premiere of Behn's *Emperor* in 1687. Dorset Garden's reputation for housing mechanically spectacular operas and plays is an example of how humans, the machinery required for special effects, audience members, and the playwright's words work together to produce new knowledge at a live theatrical event. Dorset Garden was demolished in 1709 in an act that has proven frustrating for historians of theatre technology. Latour suggests,

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[115] Spencer comes closest to my theory that the telescope on Behn's stage is neither cheap joke nor empty spectacle.
[116] Behn translated Fontenelle's *Entretiens sur la pluralité des mondes* (1686) in 1688. She is most famous for her Introduction to her translation.

> …when objects have receded into the background for good, it is always possible—but more difficult—to bring them back to light by using archives, documents, memoirs, museum collections, etc., to artificially produce, through historians' accounts, the state of crisis in which machines, devices, and implements were born.… By now, the history of technology should have forever subverted the ways in which social and cultural histories are narrated. (*Reassembling*, 81)

Although the machines themselves are not available for examination, other material can be combed for evidence regarding the performance of those machines as assembled with actors on the stage in the presence of the participant collective of the audience.

Emperor's machines worked in ways that sometimes opposed Behn's textual rejection of the "new science." Latour's ANT project, "is simply to extend the list and modify the shapes and figures of those assembled as participants and to design a way to make them act as a durable whole" (*Reassembling*, 71). I suggest that the placement of Behn's very large telescope in a triangular relationship with the entertainment tradition of the magic lantern as well as in relationship with telescopes used for the performance of astronomy reveals a narrative that does not reject science technologies out of hand, but rather would possibly have yielded a very invested attention on the part of the audience because this stage technology's capacity to capture curiosity and produce images. This second narrative would still not have produced a rapturous acceptance of the telescope in public opinion. If my proof-of-plausibility argument regarding the magic lantern connection is correct, then the technology presented on stage, by means of its parts that would have been similar to the technology at work in Newton's reflecting telescopes, is itself an adoption and acknowledgment of the social use-value of telescope technologies at the time. The connection is subtle, but Latour's provocation to "extend the list and modify the shapes and figures of those assembled as participants," also extends a notion of what would have been readable in the embodied narrative of Behn's 1687 production of *Emperor of the Moon* at Dorset Garden.

In Act I, scene ii, Don Charmante, the *innamorato* in love with Baliardo's daughter, visits the doctor disguised as an ambassador from the moon. Charmante's telescope demonstration reveals how easily the senses may be deceived. It also satisfies an audience curious about machines and technological innovation. In the scene, Don Charmante, "*drest in a strange Fantastical Habit,*" as a farcical ambassador from the moon, visits Baliardo and greets him: "Doctor Baliardo, most learned Sir, all Hail; Hail from the great Caballa — of Eutopia" (*Emp.* I.ii).[117] Baliardo, given his lifelong pursuit of making contact with lunar intelligence, doesn't hesitate to welcome Charmante into his observatory.

The trick/demonstration proceeds with Charmante's instructions to Baliardo to position himself at the viewing end of the telescope, leaving Charmante to take an aside to the audience. Behn describes very specific stage directions:

> [*He [Baliardo] looks in the Telescope.*
>
> [*While he is looking, Charmante goes to the Door to Scaramouch, who waited on purpose without, and* ***takes a Glass with a Picture of a Nymph on it, and a light behind it; that as he brings it, it shows to the Audience. Goes to the end of the Telescope***. (*Emp.* I.ii)[118]

Charmante asks if Baliardo has seen anything, and Baliardo gives a response typical of an amateur astronomer trying to get *something* to come into focus; essentially, a hopeful, imaginative, "maybe?" or, in Baliardo's case, "Methinks I see a kind of Glorious Cloud drawn up – and now — 'tis gone again" (*Emp.* I.ii). Charmante appeals to Baliardo's spiritual side and instructs him to return to the viewing lens in an attitude of supplication. While Baliardo is distracted by the act of

[117] Utopia, translating to "no place," informs the audience that this is a hoax.
[118] In the 1687 publication of *Emperor,* [… followed by italicized text is the original format in which stage directions appear. Bold is my own emphasis. Bold added for emphasis by the author.

prayer, "***Charmante puts the Glass into the Mouth of the Telescope" Emp.* I.ii).** Baliardo finally sees a Charmante's moon nymph, "a Beauty young and Angel like, leaning upon a Cloud" (*Emp.* I.ii). Because repetition has always been a successful comic device, Charmante repeats the same ritual: he instructs Baliardo to pray and, "*Char[mante] claps the Glass with the Emperour on it, [Baliardo] looks in and sees it*" (*Emp.* I.ii). Baliardo sees Iredonozar, the Emperor of the Moon, "seeted on a Throne… most sad and pensive" (*Emp.* I.ii). Behn's moral lesson expressed through Charmante's interaction with Baliardo is simply that science machines intended to improve one's vision cannot be trusted because they are too easily manipulated.

The possibility that the Dorset Garden performance could have contained a magic lantern demonstration complicates Behn's intent to admonish gullible believers in the knowledge-productive capacity of the telescope.[119] Like the illustrated illusion instruction manuals of della Porta and Fontana, the magic lantern demonstration embedded in the action of *Emperor of the Moon* performs the instructions for practical jokes by using the same materials as were used in contemporary telescopes. This demonstration would not have encouraged the audience to believe in the scientific usefulness of the telescope, but the technical nature of the demonstration—Charmante's deliberate reveal of the glass and its backlight—teaches the audience about an instrument that would have used lens technology similar to that of contemporary reflective telescopes. The mechanical demonstration acknowledges a popular delight in theatrical technology, thereby engaging audience emotion. A magic lantern demonstration would have

[119] The origins of its invention are murky—shadows and light have been used to entertain humans for millennia—but the magic lantern as a projection device came into popular use in in Europe sometime during the middle of the seventeenth century. Before that, devices such as the *camera obscura* and its many variations had been in use at least since Fontana mechanical illusions of the fifteenth century.

triggered audience artifact emotion (engagement with the mechanical elements of the production) while also experiencing the direct emotion elicited by the comedic play between Baliardo, Charmante, and the very large telescope. Audience attention would have been doubly engaged by the educational, perhaps even Baconian, treatment of audience curiosity about contemporary lens technologies. The knowledge production performed by the staged telescope would not have negated the anti-mechanical prejudice delivered by the dialogue. The mechanical element of *Emperor of the Moon* allowed audiences to entertain conflicting opinions about the role of lens technologies in their lives in a simultaneous manner.[120]

The techno-historical relationship between the magic lantern and the telescope is yet another example of the blurry boundaries between science and performance, wonder and imagination, trust of mediated images and disdain for them. By the time Behn's *Emperor* premiered, magic lantern technology was no longer cutting edge. The magic lantern incorporates two convex lenses plus a candle, a glass slide upon which the projected image is drawn, and a concave mirror to clarify the image (Vermeir, 128).[121] This assemblage contains many of the same pieces as Newton's refractor telescope, but arranged in a different order.[122] If the telescope represented on stage were an enclosed tube telescope, the reflector and the setting for the candle-slide apparatus could have been pre-set inside Charmante's end of the telescope, which would have been pointed upstage in order for a clear projection onto a backdrop to be viewed by the

[120] The capacity to be of two minds about one thing, especially where science and technology are concerned, is touched on again in Chapter 4 of this dissertation.

[121] Koen Vermeir's article, "The Magic of the Magic Lantern," discusses the seventeenth century technology of the magic lantern in great detail.

[122] The people who were invested in telescope design were also often involved in projection technology. Huygens, who, as noted above, engineered some of the largest telescopes of the seventeenth century, also dabbled in magic lanterns. The reflective technology that Huygens et al incorporated for the projector preceded Newton's application of the mirror to telescope technology in 1668.

audience.[123] The smaller tube with the two convex lenses could have already been part of the apparatus displayed to the audience, but not indicated by Behn's otherwise precise stage directions. While the audience would have been captivated by the magic lantern demonstration, Baliardo's actions duplicated the audience's sensation of captivated curiosity. Staged technology, not real astronomy, would have been the cause of representation and receptive states of captivation alike. The difference is that while Baliardo's character believes that he is seeing moon people through his telescope, the audience knows that they are seeing a technical demonstration.[124]

2.3.2.1 Bernard le Bovier de Fontenelle: a Philosophical Interlude[125]

Behn's "Translator's Preface" to her translation of Fontenelle's *Entretiens sur la pluralité des mondes*, when read in tandem with the "Dedication" to *Emperor of the Moon* gives important clues regarding Behn's the social and religious attitudes regarding experimental science that are voiced by the characters in her play.[126] Her political position as a royalist provides an interesting counterpart to the Dorset Garden context of the original production of her English farce. On the one hand, the play was intended to appeal to a noble audience, but its original situation at Dorset

[123] This is also possible, especially if the telescope were set on the apron, which, at Dorset Garden, would have been about twenty feet deep.

[124] The reasons for this kind of demonstration can be read into the Jesuit influence on Behn during the time that she was writing *Emperor*. Jesuits, a conservative branch of Catholicism, were engaged in a practice of revealing the truth behind false images. It was part of the tradition of magic lantern demonstrations to project images of fictional or monstrous things such as demons and fairies. This allowed those who wished to experiment with projection technology to do so without the heretical action of projecting an idolatrous image of God, or, the image of God in human form. For more on the Jesuit practice of projection, please refer to Vermeir's article.

[125] Fontenelle is another interesting figure who worked at the intersection of theatre and astronomy during the seventeenth century. In addition to his contributions to the discipline of natural philosophy, he also wrote several plays including, *La Comète* (1681).

[126] Many histories attest to her murky past, her work as a spy for Charles II, and the time that she spent in debtors' prison as the result of not having been paid for her political efforts. Much has been written about the likelihood of her history of travel in this position that would have influenced themes of conquest and the New World as they appear in many of her dramatic and literary works .The lengthy conversations about contemporary treatises on exploration and travel that appear in *Emperor of the Moon* are not discussed in this dissertation.

Garden suggests that the play's spectacle would draw more popular crowds as well.[127] She discusses her desire to appeal both refined and general audiences in the "Dedication:"

> I am secure from this Censure, when your Lordship shall be its Judge, whose refin'd Sence and Delicacy of Judgment, will, thro all the humble Actions and trivialness of Business, find Nature there, and that diversion which was not meant for the Numbers, who comprehend nothing beyond the Show and Buffoonery. (Behn, "Dedication," n.p.)

Her expertise in writing the bawdy, physical humor typical of the *commedia dell'arte* and English farce has been discussed above. It almost goes without saying that her second-most-popular play should be written in that style. What is interesting about the above "Dedication" is the intentionally scientific nature of the piece, an element to which she directs her noble benefactor's attention. However, where she suggests that the science content is "not meant for the Numbers, who comprehend nothing beyond the Show and Buffoonery," I find room for conversation. Behn might not have intended the science content for a general audience, but that same general audience got an ample helping of it, and would have been a part of it by the fact of their participation at the theatrical event. All members of the audience able to see the action would have been engaged on some level as participants in the performance of science. Whether or not they agreed with the playwright's position about the "new science" is beside the point; all spectators would have been party to the experiment.

A Jesuit anti-illusory, anti-idolatrous prejudice may have inspired Behn's inclusion of the magic lantern demonstration that performatically comments on the illusion it creates. Koen

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[127] After the first few documented performances, *Emperor* moved to Drury Lane. More research is necessary to determine how the mechanical elements of the performance might have changed with the house. Dorset Garden fell into decline about midway through the 1690s, during which time plays and operas were no longer performed there. A brief attempt at a revival of the theatre was attempted in the 1706 and 1707, and *Emperor of the Moon* was one of the Drury Lane repertory shows that were produced during that short Dorset Garden resurgence before it was torn down in 1709.

Vermeir cites the Jesuits as a likely reason for many such continental magic demonstrations: "As the defenders of a Catholic absolute truth, the Jesuits tried to counter the contemporary sense of illusion by staging their own plays… the world did not delude, and all knowledge, even the knowledge of God, was only attainable by means of the senses" (Vermeir, 131). Secular, experiential knowledge, including knowledge acquired through sight, was inseparable from knowledge of the divine, and, their plays reflected this notion. Vermeir continues, "For the Jesuits, a stage play is not an illusionist entertainment but a place where truth is shown, where the invisible is made visible and explicit. They made a strict distinction between *imago* (true image) and *idola* (false images, showing something that is not there; an aberration or deformity)" (131-2). Given Behn's 1688 Jesuit-influenced "Translator's Preface" to Fontenelle's *Entretiens sur la pluralité des mondes* (1686), it is likely that the same source could have inspired her to include a demonstration of illusory spectacle in the *Emperor*'s telescope scene.

Behn's views on astronomy, as expressed in her "Translator's Preface," are based primarily on interpretation of the Bible, some personal experience, and an expression of her own reason.[128] While she does not place much trust in the telescope as a useful tool for the performance of astronomy, she does adhere to a Copernican model of the universe. At the beginning of her introduction to Fontenelle's *Entretiens*, she excuses Fontenelle's Copernican argument, for she believes the French philosopher to be too reliant upon the telescope for his findings:

> … he gives a magnificent *Idea* of the vastness of the Universe.… This he proves judiciously, by the Appearances and Distances of the Planets and fixed Stars; and if he had let alone his learned Men, Philosophical Transactions, and Telescopes in the Planet *Jupiter*, and his Inhabitants not only there, but in all the fixed Stars, and even in the *Milky Way*, and only stuck to the greatness of the Universe, he had deserved much more Praise. (Behn, "Translator's Preface," n.p.)

[128] For a thorough discussion of Behn's "Translator's Preface," especially with regard to proto-feminist themes that emerge in it, please refer to Susan Goodfellow's article, "Masculine Strokes": Aphra Behn as Translator of 'A Discovery of New Worlds.'"

She prefers the "idea" of the universe to the notion that a telescope could usefully augment human vision in order to better understand it. She finds fault with the telescope, and also with the Royal Society (as well its French counterpart, *l'Académie des Sciences*), to which she refers as the "Philosophical Transactions" and "learned Men."[129] As with the masque in *Emperor*, which shall be discussed in the following section, Behn lumps the telescope into a category she reserves for fiction and myth. She criticizes Fontenelle for his inability to temper his "wild fancy" with reason ("Translator's Preface, n.p.).

Behn assesses the state of astronomy according to a Jesuit-influenced biblical interpretation. She offers a lengthy scriptural defense of Copernicanism following Father Tacquit, a Jesuit who, she claims, "cites several Texts of Scripture; and particularly the 19th Psalm, And the Sun standing still at the Command of Joshua" ("Translator's Preface, n.p.). Without going into a lengthy discussion of this interesting preface, the two points to which Behn repeatedly returns are 1) that the Bible can be interpreted as supportive of either a Ptolemic model of the universe or a Copernican, and, 2) that "the Bible was not to instruct Mankind in Astronomy, Geometry, or Chronology, but in the Law of God to lead us to Eternal life" ("Translator's Preface, n.p.).[130] She cedes the authority of astronomy to astronomers, but with an aside that it is, "for the School-men [to] agitate … many things of a higher Nature…" ("Translator's Preface, n.p.). She doesn't cite Newton, who published his *Prinicipia* the year before Behn's translation of *Entretiens* appeared, but she does refer to the contemporary natural philosophy of René DesCartes and Jacques Rohault

[129] Since 1665, the Royal Society has published under the heading, *Philosophical Transactions.* It should also be noted that Isaac Newton's *Principia* was published in 1687, the same year as *Emperor*'s premiere. However, Behn makes no direct reference to Newton, his publications, or his telescope in either the "Translator's Preface" or her "Dedication" to *Emperor of the Moon*.

[130] This is also a point which Galileo made in his several letters written in his own defense during his trial with the Roman Inquisition.

in defense of some adjustments that she made to Fontenelle's text.[131] This reference to DesCartes provides some evidence for Behn's point of view that tempers experience with reason, as it is expressed in *Emperor of the Moon*.

Behn doesn't believe the telescope to be a useful detection device for the performance of science, but she contradicts this point of view somewhat at the very end of the "Translator's Preface" when she uses her own experience of looking through one as a reason for changing the setting of Fontenelle's original *Entretiens*:

> I have laid the Scene at *Paris*, where the Original was writ… I thought *Paris* and St. *Denis* fitter to be made use of as Examples, to compare the Earth and the Moon to, than *London* and *Greenwich*; because St. *Denis* having several Steeples and Walls, is more like *Paris*, than *Greenwich* is to *London. Greenwich* has no Walls, and but one very low Steeple, not to be seen from the Monument without a Prospective Glass. ("Translator's Preface, n.p.)[132]

The resulting natural philosophy reflects that which Behn dramatizes in *Emperor*: telescopes are fallible devices when applied to the study of the universe, but perfectly acceptable technologies to be put to use in other ways—either for earthbound exploration as the *Discovery* preface indicates, or for entertainment as in *The Emperor of the Moon.* Her point of view that people may come to their own conclusions about religion, reason, and nature is stated clearly in the "Translator's Preface" and is performed through her inclusion of a variety machines onstage in *The Emperor of the Moon*.

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[131] "I have made bold to correct a Fault of the French Copy, as to the heighth of our Air or Sphere of Activity of the Earth, which the French Copy makes twenty or thirty Leagues, I call it two or three, because sure this was a Fault of the Printer, and not a mistake of the Author. For Monsieur DesCartes, and Mosieur Rohalt, both assert it to be but two or three Leagues" ("Translator's Preface, n.p.).

[132] The term "prospective glass" could mean magnifying glass or spyglass, she must be using the term to mean spyglass here, because a magnifying glass would not function to bring distant objects into clearer focus.

2.3.3 Science and Myth in *Emperor*'s Masque

Behn transforms the stage of Dorset Garden into a telescope of sorts in the play's final masque. In *Albumazar*, Ronca's performance of the truthful qualities of the telescope captured Pandolfo's attention in order to trick him, but the spectacle at the end of *Emperor* captures the audience's attention (both the audience in the theatre and the characters in the play who were also audience to the events that transpired during the masque) by bringing the moon closer to them. This performance differs from that of *Albumazar* because, unlike Ronca's attempt to con Pandolfo through grains of truth, Behn uses the masque to dissuade the audience of any delusion that the telescope can work to make distant celestial objects appear more closely and clearly than as seen with the naked eye. Dorset Garden's proscenium becomes a lens through which the audience sees the moon grow ever larger as it descends, although this action makes the moon more like a spaceship than the theatre like a telescope.[133] The masque, like the telescope scene, complicates the protagonist's experience of wonder with audience response to staged, mechanical wonders. The text conveys the moral that to fall prey to wonderment is an act of foolish naïveté, but the presence of mechanical wonders is nevertheless captivating to those witnessing the spectacle.[134] Reason tempers the senses, but the masque, like the telescope scene, finds that entertainment that incorporates technology is a part of the very human experience of knowing the natural world because mechanical human inventions are a part of that world. The audience might caught up in

[133] There is a long sequence of actions that also deal with space travel monographs that were published in the years leading up to *Emperor*'s premiere. I have not discussed those at length because, while very amusing, they do not feature telescopes at all. Also, it is likely that Dorset Garden's capacity for "the much-loved flying machines," would have played a part in the staging of this masque (Radice, 129).

[134] Al Coppola makes the argument that, "even as *Emperor* appropriates vapid, crowd-pleasing entertainments to ensure its own commercial viability, the play critiques… above all, Dorset Garden machine operas that it cannibalizes for cultivating a dangerously passive habit of mind" (Coppola, "Retraining," 483). While this is textually true, I argue that there is something more compelling in the use of mechanical spectacle than a simple rejection of it.

the “Show and Buffonery” that Behn mentions in her “Dedication” to the play, but as she notes in the “Translator’s Preface” to Fontenelle’s *Entretiens*, each person is entitled to their own opinion. Although Behn might have drawn distinctions between content that was appropriate for a noble audience and actions more appropriate for “the Numbers,” she asserts that “Nature” is there to be found. All participants at the event would have had access to the themes of “Nature” represented in the production—in the form of props in the form of scientific devices and in the presence of machines that enacted contemporary lens technologies.

The theme of wonder is discussed at length as Baliardo, in the company of his wards, approaches the grounds where the masque shall be performed. Behn’s stage directions indicate, “*The Gallery [should be] richly adorn’d with Scenes and Lights*” (*Emp.* III.iii). Upon seeing the elaborately dressed stage, Baliardo struggles to contain his experience of wonder, for fear of being thought a rube:

> Let not thy Female Ignorance Prophane the highest Mysteries of Natural Philosophy; To Fools it seems Inchantment --- but I’ve a Sense can reach it, --- sit and expect the Event. --- Hark --- I am amaz’d but must conceal my Wonder --- the Joy of Fools --- and appear wise in Gravity. (*Emp.* III.iii)

Baliardo verbally checks himself for the sake of his appearance in front of the characters in the play, but his asides directly invite the audience the join him in his active thought process and to participate in his state of wonder. Baliardo’s word choice to describe his own, shared emotional state as wonder alters the emergent scientific language of natural philosophy. When he declares his own emotion to be wonderment, he changes the experience of the observation of a wondrous object to an embodied process by blending the boundaries of self and science experiment. A Latourian perspective might suggest that Baliardo’s direct address created new social ties, as theatrical prop and science object merge and protagonist and audience also become a collective witness to events on the stage. “It is an association between entities which are in no way

recognizable as being social in the ordinary manner, *except* during the brief moment when they are reshuffled together" (*Reassembling*, 65). In this case, the physical space of the theatre shakes up social strata (different classes of people in different areas of the theatre—onstage, in the orchestra, in the gods—are all engaged with the same dramatic performance). The physical space of the theatre also reassembles disciplinary distinctions as technological advancements are applied to theatrical special effects and the telescope, with all of its contemporary modifications and improvements, is lowered in tone so that it can be the subject of productive curiosity for the collective assembled for the Dorset Garden production. The theatrical context in which this experience transpires makes the performance itself an experimental medium for the experience of outer space.

Behn's performance brings the moon to her Dorset Garden audience in the masque at the end of the play, which is the final step in the process of ridding Baliardo of his misplaced trust in the telescope.[135] The audience's expectations for a spectacular masque performance would also have influenced their reception of the science, and history of science, content contained in the *Emperor*'s final scene. Seventeenth century audiences expected a masque to be populated by characters from classical myth, fantastical legend, or the mists of England's ancient Britons, often in support of a political or instructive comment. At Dorset Garden, audiences would also have expected to be entertained by elaborate mechanical spectacles. In Behn's play, the placement of the historical figures of Galileo and Kepler—who descend in chariots, each with his own *perspicill*—as prominent features of the closing masque drives home Behn's point that reliance on

[135] The use of the masque as a final educational tool fits with masque tradition. Masques, particularly under the reign of James I, but also throughout Charles II's reign, were used as a sort of edutainment for the aristocracy. Playwrights would embed science concepts and current events into the song, dance, and mechanical spectacle of the court masque. Behn deliberately drew upon this tradition in the final step in the re-education of Dottore Baliardo, placing him in the royal seat of honor as the anti-Telescopic performance transpired around him.

telescopes for generating knowledge about astronomy is akin to studying myth as history or asking an astrologer to read one's horoscope in order to know the future.

The masque mythologizes Galileo and Kepler by situating them in a context that is at once astrological, exotic, and extraterrestrial. She acknowledges the scientists' importance to the past as well as their distant relationship to the present moment. This double context plays both sides of the empiricism-reason debate and keeps Behn safe from censure. Even so, the presence of the *perspicills* artifactually locates Galileo and Kepler on a scientific and philosophical continuum of which Behn and her audience were a part. The opening sequence of the masque is a spectacular patchwork of astronomy, astrology, and conquest:

> *The Scene in Front draws off, and shews the Hill of Parnassus; a noble large Walk of Trees leading to it, with eight or ten Negroes upon Pedestals, rang'd on each side of the Walks. Next Keplair and Galileus descend on each side, opposite to each other, in Chariots, with Perspectives in their Hands, as viewing the Machine of the Zodiack. Soft Musick plays still.* (*Emp.* III.iii)

The tableau is an assemblage of bodies, environments, and machines signifying each part of Behn's argument. The Hill of Parnassus indicates a mythological locale but also a desire to know about distant things. The chorus of "Negroes" likewise conjures a context of exploration, conquest, and otherness, and equates a desire to know about the depths of outer space with the early modern European rage for conquering other continents and their peoples.[136] Kepler and Galileo appear within the same context of the far away, and so are their telescopes.[137] Kepler introduces himself

[136] Behn is perhaps best known for her examination of this subject in her novel, *Oroonoko* (1688). While the chorus of "Negroes" can be read as a common physical trope of the early modern masque, their presence in this assemblage of Zodiac, historical scientist, Mt. Parnassus, and moon people suggests that the Restoration stage not only attempted to mythologize empirical science practice and its findings about outer space, but also people living on planet Earth.

[137] Handheld telescopes must be "Galilean' style, a miniature echo of the monstrous machine that appeared in the first act.

and Galileo to Baliardo: "Most reverend sir, we from the upper world thus low salute you. Kepler and Galileus we are called, sent as interpreters to great Iredonozar, the emperor of the moon, who is descending" (*Emp.* III.iii). Although Baliardo responds to these scientists of recent history as "reverend bards, profound philosophers," their presence in the masque communicates Behn's opinion, as articulated in the "Translator's Preface" to Fontenelle's *Entretiens*, that their contributions to astronomy are, perhaps, as insubstantial as the predictions of the Delphic oracle (*Emp.* III.iii).[138] Contemporary telescope makers such as Huygens, Newton, and Hevelius, of whose work Behn would likely have been aware, are not named.

The final spectacular metaphor is performed through the descent of the moon onto the Covent Garden stage, and the masque becomes the machine that captures the moon and brings it closer to the audience.[139] After Kepler's introduction, the mechanical spectacle continues:

> … *the globe of the moon appears, first like a new moon; as it moves forward it increases, till it comes to the full. When it is descended, it opens, and shows the emperor and the prince. They come forth with all their train, the flutes playing a symphony before [the emperor], which prepares the song; which ended, the dancers mingle as before*. (*Emp.* III.iii)

The Emperor of the Moon travels on the moon as a vehicle by which he might come to know more about the Earth, or so it seems. Just as Albumazar's telescope functions as "an engine to catch starres," so Behn's play works to bring the moon and audience closer to one another, and there to proceed with a rational contemplation of it. Baliardo is not castigated as a fraud, but cured from the telescopic fog which has been clouding his reason. Baliardo concedes that he, "see[s] ther's nothing in philosophy," but leaves one to wonder if it is all philosophy that Behn considers bunk

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[138] The context of the two historical scientists' arrival within the masque makes a number of meanings possible. Behn's position on astronomy and astronomers is not entirely dismissive. In the "Translator's Preface," she acknkowledges, "eclipses: "…the Eclipses of the Sun and Moon, which are now so regular, that an Astronomer could tell you in to a Minute, what Eclipses will be for thousands of Years to come," (Behn, "Translator's Preface," n.p.).
[139] See Coppola's and Butler's dissertations on the metaphoric image of the telescope applied to Britain's politics.

or just natural philosophy based on experiential observation (*Emp.* III.iii). The play is a farce, and so Baliardo gives up his telescopes and pursuits of natural philosophy without much protest.[140]

Both *Albumazar* and *Emperor of the Moon*, when examined through their respective staged telescopes, can be seen as points on a continuum in the cultural process of accepting machines as tools for extended and enhanced human perception. Behn's staged telescopes mock astronomical devices even as they deploy related technologies. Tomkis's mistrust of the Galilean telescope of his play is perhaps evidenced by its complete lack of physical manifestation in the action that it provokes. Nevertheless, the presence of representational telescopes on the stage leaves some room for multiple points of entry by which curious audience members might participate in a culture that increasingly relies upon the telescope and its capacity to augment human vision. Each playwright mouths dissent through their respective characters, but the choice to include telescopes as essential to these farces indicates that the process of accepting machines as a part of extended and enhanced human perception was taking place on London's hybrid stages throughout the seventeenth century.

[140] Shadwell's Gimcrack professes as much, but then resolves to pursue even more esoteric knowledge – the Philosopher's Stone.

3.0 CRITICISM: TRUST AND AUTHORITY IN THE PERFORMANCE OF CREDIBLE SCIENCE

Figure 6: Saturn. Adult Astronomy Camp. May, 2014.

The first time I observed Saturn was through an eight-inch telescope at an amateur astronomy star party, when I exclaimed, "That's not real!" The image looked so much like an icon—too bright, too clear, too perfectly like Saturn—to be so distant an object visible through such a small machine. I thought it must be a joke. Someone had tricked the lens and was pulling my leg. It wasn't until I looked through the scope again and saw clouds moving across my field of vision to obscure the image and cause Saturn to disappear that I was able to begin to believe that I was not the victim of a practical joke. My experience was perhaps similar to that of Galileo's detractors who, in the early seventeenth century, refused to look through his controversial telescope because they believed more in the distortive properties of glass lenses than in their potential to transmit a truthful image of an observed celestial object.[141]

[141] Among Galileo's detractors are included Cesare Cremonini and Giulio Libri, both of whom refused to look through the telescope. In his biography of Galileo, Stillman Drake writes, "The chief philosopher at Padua (Cremonini) had always refused to look, though Galileo had repeatedly offered to show him the new discoveries. The chief philosopher at Pisa (Giulio Libri) tried to argue the satellites out of the sky; these men seemed to think that philosophy was to be found in books, not in nature" (Drake, Stillman, *Galileo at Work*, 162).

The theatrical performances discussed in this chapter demonstrate the evolution of a late modern de-valuing of human perceptual and communicative capacities in favor of mechanical forms of observational data generation, collection, and analysis. Lauren Gunderson, in her 2003 play, *Background*, deals with trust among scientists and ethical research praxis by crafting a text that itself acts as a telescopic mechanism by which the audience might see across time and to the truthful discovery of Cosmic Microwave Background Radiation (CMBR).[142] The film, *Contact* (1997), based on Carl Sagan's 1985 novel of the same title, raises the issue of trust when empirical observations come into doubt due to a lack of material, mechanically derived, evidence available to mediate and corroborate one scientist's story. Both *Background* and *Contact* critique the status of twentieth-century science practice by dramatizing inequalities of access that were pervasive to twentieth century performances of science in the domain of science. While the historical telescopes represented on stage and screen revolutionized what astronomers were able to detect about hidden aspects of the universe, the embodied performances reveal the invisible system of oppression at work in physics disciplines against which present-day professionals are still working.

[142] Cosmic Microwave Background Radiation (CMBR) is essentially traces of the origins of the universe still detectable in our environment. It is the fuzz on a transmissionless television screen, the static between stations on the radio. Its temperature is uniform throughout space, and this constant temperature is the clue that it is leftover from a giant explosion that, according to the big bang theory, occurred just before the beginning of the universe. Popular physics writer Brian Greene explains, "[t]he uniformity of radiation is thus a fossilized testament to the uniformity of both laws of physics and the details of the environment across the cosmos" (Greene, *Fabric of the Cosmos*, 222). Michio Kaku offers a concise story that summarizes the big bang theory and CMBR's relationship to it: "For years after the big bang, the temperature of the universe was so hot that anytime an atom formed, it would be ripped apart; hence there were many free electrons that could scatter light. Thus, the universe was opaque, not transparent. Any light beam moving in this super-hot universe would be absorbed after traveling a short distance, so the universe looked cloudy. After 380,000 years, however, the temperature dropped to 3,000 degrees. Below that temperature, atoms were no longer ripped apart by collisions. As a result, stable atoms could form, and light beams could now travel for light-years without being absorbed. Thus, for the first time, empty space became transparent. This radiation, which was no longer instantly absorbed as soon as it was created, is circulating around the universe today" (Kaku, *Parallel Worlds*, loc. 990-1006).

3.1 ESTABLISHING CREDIBILITY AND TRUST ACROSS DOMAINS

In this chapter, I look at performances that investigate how adherence to either unaided human experience or pure mechanical data leads to incomplete perception of the unknown. This performance studies perspective blends the domains of science and arts in order to critique pure empiricist practices that have dominated credible astronomy since the late seventeenth century. As philosophers of science Kyle Pawys White and Robert P. Crease suggest, such scientist/non-scientist exchange of knowledge involves a considerable amount of trust, particularly on the part of the non-scientist (Whyte & Crease, 412). The rift in this trust, argues Mary Crane, has its roots in the "the new science of the seventeenth-century," because it, "contradicted basic sensorimotor experience, [and] it opened up a gap between nonscientists and nature that has never been closed" (Crane, "Analogy," 107). The simultaneous presence of telescopes and humans on stage and screen performs a debate over the best way to know space: through mechanical data collection or embodied experience that may seem more subjective and intuitive. The examples of *Background* and *Contact* are critiques created in the domain of the arts that index the incomplete picture that purely data-driven approaches to the performance of science in the domain of the laboratory produce. A performance studies perspective blends the domains of science and the arts towards the end of empowering all interested agents to participate in acts of knowing space.

The disembodied scientist as moral authority becomes the subject of performatic critique in the plays and performances discussed in this chapter.[143] A performance studies approach makes

[143] The example of Boucicault's *The Octaroon* dramatizes the shift from religious moral authority to scientific moral authority through the performance of the "telescope" (really a camera) that melds with immanent religious authority in a murder trial.

apparent the cultural continuum between scientists and other community members. Performance highlights what Steven Shapin argues can also be the role of the philosopher of science:

> If we ask ourselves how it is that we came to believe a whole range of expert scientific and technical claims—probably the majority of those whose truth we now accept—we will discover that we were told these things by familiar others, often in a setting of face-to-face interaction: by people whose names we know (or knew) and whose characteristics we know (or knew)—teachers, professors, physicians, nurses, plumbers, mechanics, colleagues. And it is well to remember that experts commonly stand in something like the position of lay members with respect to claims of *different* expert groups. (Shapin, *Never Pure*, 30-31)

By examining both the contexts in which science is performed and instances in which science (and its machines) are represented in performance, the spectrum of credible agents performing science becomes detectable in a culture that is increasingly divided by technology and access to it. *Background* and *Contact* dramatize situations in which individual scientists' embodied experience is challenged by institutionalized systems of empirical authority. In *Background,* social hierarchies at work in academic scientific communities are brought to light through Ralph Alpher's (1921-2007) historic struggle for credit regarding his claim to the prediction of CMBR. The inability of data-oriented technologies to accurately vet all aspects embodied astronomical observation is critiqued in the fictional *Contact.*

In his book, *How to Write the History of the New World*, Jorge Cañizares-Esguerra outlines a shift from an early seventeenth century regard for embodied experience towards an eighteenth century skepticism of embodiment that persists in twenty-first century performance of observational science. Cañizares-Esguerra's historiography is useful in articulating the reasons why Alpher's historical snub matters to the history of science. It also gives historiographical credibility to a claim that embodied experience matters, as is performed in *Contact*. As Cañizares-Esguerra demonstrates, the performance of science hasn't always been data-driven. The age of Reason marked the beginnings of testable experiment and comparison of evidence as a means of

scientific and historical inquiry that superseded the individual's witness to novel events in previously unexplored spaces. Cañizares-Esguerra's historiography indicates a development of trust in embodied experience to an incorporation of science machines like telescopes into that experience and finally to a prioritization of accounts of novel phenomena vetted by an elite social group of credible experts. Cañizeres-Esguerra suggests that the telescope becomes a ridiculous object not just because what is seen through it cannot be trusted (as is dramatized in Behn's *Emperor*) but also because the use of tools for socially credible scientific observation ran counter to rationalist threads of philosophy during the close of the seventeenth century.

As we saw with Behn's *Emperor*, terrestrial explorers' first-person accounts had become as much of a topic for ridicule as fictional accounts of extraterrestrial exploration by 1687. Both seemed like topics that did not relate to the everyday experience of the average English (or, French) citizen, and these stories were mocked by a public that did not want to engage with the playthings of the wealthy as meaningful entities in their everyday experience of nature. The telescope was at the heart of this debate.

Crane's analysis of the "new science" as it emerged over the course of the seventeenth century helps us to understand the crucial gap between embodied, intuitive ways of knowing—as they are dramatically argued for in *Emperor of the Moon*—and deductions about the natural world drawn from experiments performed in the domain of the laboratory. In the chapter, "Analogy, Metaphor, and the New Science: Cognitive Science and Early Modern Epistemology," Crane highlights the shifts in cognition required in the process of disengaging the body from empirical science practice during the late seventeenth and early eighteenth centuries. Crane's exploration of analogy in seventeenth century scientific and science-inspired literature pertains to this analysis of contemporary performances and films that also deal with science because dramatic, theatrical, and

filmic performance genres are inherently analogic. Drawing on Lakoff and Johnson's theories regarding embodied metaphor in language, Crane suggests that one of the most important aspects of the "new science" as it emerged as a part of seventeenth century culture, is that it is not based on analogic thought having to do with intuitive sensorimotor experience (such as assuming that the earth is the center of the universe because, from an embodied, earthbound perspective, the sun can be seen to move across the sky).[144] The "new science" has to do with experience and experiment that is removed from the everyday. Information gained from data collected under laboratory conditions often contradicts embodied sense perception. Crane argues, "To the extent that the new science of the seventeenth-century contradicted basic sensorimotor experience, it opened up a gap between nonscientists and nature that has never been closed" (Crane, "Analogy," 106). Whereas in Behn's *Emperor* and Tomkis's *Albumazar*, much of the dramatic analogy works to persuade audiences that the "new science" is as far-fetched as the thought of aliens visiting Earth or as superstitious as belief in astrology, the plays and performances in this chapter use embodied analogy in order to invite nonscientist audiences into the domain of astronomy. The plays and films discussed in this chapter help to bridge the (false) gap between science and society through staged interactions between humans and machines.

The "new science" was caught up with trends in other contemporary philosophies; use of machines such as the telescope in domains of science, performance, and exploration provides some connective tissue for the reasons why embodied experience came to fall under such scrutiny by the end of the seventeenth century. Louis Feuillée (1660-1732) is a perfect example of a scientist

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[144] Crane describes Aristotelian teleology as intuitive and based on embodied analogy. Aristotelian science considered causes of natural phenomena, and these causes were sensed as well as observed. Then, according to Crane, analogy played a part in determining these causes. She explains using the example of earth: "… if matter appeared to be dry, dryness must be its essential property, so it must therefore be largely composed of 'earth'" (Crane, "Analogy," 106).

who operated at a key moment of transition from the empirical-yet-embodied style introduced by Galileo and the Rationalist scientific method that involves testable results and still defines most modes of scientific inquiry in the twenty-first century.[145] Cañizares-Esguerra points out that Feuillée's method involved a combination of "reason and instruments" as well as, "the right observational procedures," to accompany pure observation and matter-of-fact reasoning (Cañizares-Esguerra, 16). Cartographers at the turn of the eighteenth century had to be properly trained in the use of perception-enhancing instruments and the interpretation of findings made through their use. This sequence of actions involved detailed records of procedure, illustrations of instruments and observations, and the eventual consensus of the observer's findings obtained through "polite conversation and through collective witnessing of experimental displays, both carried out in semi-public settings such as academies and salons" (Cañizares-Esguerra, 16). Feuillée doesn't reject embodied observations, but neither does he expect his own word to stand on its own. He relies on credibility gained through his stature as a scientist working for the royal court; testing social status was as important as testing his science.

Social status as a Northern European male came to be an important factor for the determination of credible scientific claims during the eighteenth century. White, Christian, European maleness will come to be a determining factor in professional credibility in the performances discussed in this chapter; in particular, Ralph Alpher, working in the early part of the twentieth century faced discrimination due to the fact that he was Jewish, and *Contact*'s

[145] Feuillée was sent to the Americas in the early eighteenth century by Louis XIV. Feuillée relied upon first-hand experience as he mapped the New World, but he also incorporated the telescope, the pendulum, and other cartography tools as necessary extensions of his own senses for accurate perception of novel natural phenomena presented by the coasts that he mapped. Please refer to Cañizares-Esguerra for a detailed discussion of his use of the telescope and of his debate over its usefulness with his nemesis, François Frézier.

Eleanor Arroway's status as a woman at times works against her.[146] The intentional agent's social standing, not necessarily that agent's skill, often established which scientific observations fell into the categories of "real" and "not real."[147] The experience of the body itself in scientific observations became a less important factor in determining the trustworthiness of reports coming from distant locales and epochs that described novel objects and curious phenomena. As the Northern European male body came to be established as the standard against which all other observational accounts were held, so those same bodies began to disappear from disputes over trustworthy science practice, because those bodies were socially credible. Although he does not argue for the replacement of human analysis by machines, Cañizares-Esguerra suggests that data—documents that had been vetted by other socially authoritative philosophers—had come to determine accuracy and credit for scientific claims about the unknown. Observations that fell out of the new norm were not considered to be the result of trustworthy science practice, and therefore deemed improbable at the least, or, just plain not real.[148] Thus began the liberal "rhetoric of objectivity," which privileged Northern European, male perception over the witness testimonies representative of other, disempowered groups such as women, the Spanish, and people of the

[146] This is an implicit and embodied plot element that is not emphasized through the film's dialogue. I discuss this aspect of the film in more depth later in this chapter.

[147] Arroway's testimony will be challenged at the end of the film because of its relationship to the reality of events as perceived and documented by other witnesses and detection devices. It is not my aim in the writing of this dissertation to establish what is real or not about human perception and the experience of life on earth. But, the term *real* is used quite frequently in popular writing about scientific phenomena as well as theatrical and filmic genres that enact scientifically-oriented narratives. So, I use this term because I think it addresses the skepticism that non-scientists hold and have held about findings that scientists publish when they publish news of extraordinary discoveries of objects and events that transpire outside the realm of unaided human perception.

[148] Cañizares-Esguerra introduces Garcilaso de la Vega as a chief figure of contention from the seventeenth into the re-interpretative eighteenth centuries. As the son of a Peruvian woman and a Spanish conquistador, his reports of Incan life were controversial because on the one hand, his personal knowledge of Incan royal life was not a repeatable act for other, subsequent, European explorers. On the other hand, Garcilaso's reports were dubious because of his sympathetic relationship to Incan life, and, later, his identification as a Spaniard. To Northern European philosophical travelers of the late eighteenth century, Garcilaso's reports were met with severe scrutiny over the credibility of his eye-witness. To those historians, Garcilaso might as well have been writing about the moon.

Americas (or any population indigenous to a region conquered by Europeans) (Cañizares-Esguerra, 53).

The productions discussed here critique the liberal science legacy by dramatizing its failure to account for the perceptual benefits of subjective experience as important to the performance of scientific inquiry. One late twentieth century example of the gap between embodied experience of the scientific exploration of space and the quantification of perceptual experience thereof is dramatized in Paul Godfrey's play, *The Blue Ball* (1995). In scene 20 of Godfrey's play, the protagonist, Paul, is interviewing a fictional astronaut, Sylvie, who confides a little-known secret about the experience of space travel. Apparently, many astronauts experience, "flicker flashes, the micro-meteorites that pass through the brain in space… small enough to enter and exit through the walls of/ the craft and we only know they exist because they create a sensation of light when they pass through the retina" (*Blue.* 20). This dramatized account of embodied experience of scientific exploration highlights the flaws of a common-sense approach to science practice because it marks a point of intersection between human-invented technology and human performance endurance; the confines of a strictly data-driven science practice is often insufficient to account for embodied experience, even within laboratory environments.[149] Sylvie relays that for a long time astronauts did not report this phenomenon because it "seemed too strange" (*Blue*, 20). The flicker flash was discounted because it was an embodied phenomenon that caused astronauts to see flashes of light that weren't hypothesized to be there. Astronauts often didn't report this experience because of a

[149] Godfrey's play is a work of fiction, but it is the result of his research into the space race. Characters like Sophie are not representations of historical astronauts, but composite characters created after interviews with many different astronauts and cosmonauts. For more information on Godfrey's research process, please refer to the fascinating introduction to his play.

fear that it would damage their credibility as objective scientists.[150] Lack of falsifiable evidence, for quite some time, meant that the experience of flicker flashes could not be documented as real.

Discrepancies between aided and unaided perception of outer space phenomena often result in confusion between the domains of science and the arts with regard to the question *what is real?* This cultural anxiety is endemic of the "two-cultures" divide and Godfrey's characters frequently voice their concern in the dialogue of Godfrey's play. Paul, in his interview with Sylvie, asks, "How can I grasp the experience you've had?/ It's a wonder to me/ Talking about it here now, it seems unreal" (*Blue*, 2). Later in the play, Godfrey dramatizes a conversation between his mythologized first astronaut, Alex, and his wife, Anna. Alex informs Anna that the sun is not yellow from space, but blue. The stars don't sparkle due to the lack of a light-diffusive atmosphere. Anna is incredulous: "It's not real then?" she asks. Alex responds with another question: "Does it matter?" (*Blue*, 5) We'll see a similar clash of unaided embodied experience and experimental practice and its relevance to a cultural understanding of reality in a discussion of the film *Contact*, later in this chapter.[151] In this dissertation, it is not the question, "what is real?" but Alex's response, "Does it matter?" that is pertinent. The dramatized critiques in this chapter suggest that how we conceptualize our embodied experience of the world matters to what we are able to perceive of it. It's not reality or non-reality that is at stake, but the processes by which people access the domains of science and the arts—and thus come to determine their own interpretations of reality or non-reality—that matter to an accessible performance of science.

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[150] Trustworthy performance and NASA is explored in great detail in Jon McKenzie's *Perform! Or Else…*

[151] In *Background,* the question of what is real has more to do with the historical record—how the archive of Alpher's theory came to be ignored in the subsequent performance of theoretical cosmology over the course of the twentieth century.

Staged telescopes mediate science praxis to a general audience of people who are not necessarily science experts. Mechanical and embodied media are the performatic channels of trust (or distrust) that run between scientists and non-scientists. Trust is an important component of performances of and about science because performance has the potential to disrupt a modernist notion that scientists, the machines that they use, and the data generated by them constitute a cultural authority. Trust between non-scientists and scientists (artists and non-artists) is essential to the realization of an equitable society in which all are empowered to be critics of, and participants in the socio-scientific issues that impact the whole group of people living in the same culture. Following this vein, Shapin makes a "heretical" suggestion:

> You could say that the making and warranting of scientific knowledge are *performances*, that those producing scientific knowledge can and do use a full range of cultural resources to produce these performances, and that these include displaying the marks of integrity and entitlement: expertise, to be sure, but also the signs of dedication of selflessness. The very idea of disembodied knowledge thus becomes a bodily performance… (*Never Pure*, 5)

In the following examples, I consider the impact of shifting the telescope's domain from that of the laboratory to that of performance has on the trust and informed skepticism that must exist among all people living within the hybrid culture of science and society.

3.2 MAKING *CONTACT*

Raymond J. Gibbs reminds readers that perception is a subjective experience, "a kinesthetic activity that includes all aspects of the body in action."[152] One aspect of "the body in action"

[152] Gibbs, Raymond W., *Embodiment and Cognitive Science*, 12.

relevant to this discussion is the identification of whose bodies are performing acts of astronomical inquiry. Rational approaches to laboratory science paid a lot of lip service to absenting the body from the scientific process, but the result of that so-called data-oriented shift in the experimental process was the erasure of visible bodies other than the Northern European, male from the domain of laboratory science.[153] Performance can function to affect the diversity of bodies participating in the performance of science by making the invisible, embodied, aspects of the lives of the people who practice it visible to a wide audience. One problem with ascribing cultural authority to a particular group of humans—scientists, as Shapin suggests—is that the practices of this empowered group of humans can become hidden from public view, removed from public participation. Representational performances of private socioscientific acts makes the domain of the laboratory more transparent to a general audience. Visibility of diverse bodies in positions of cultural authority reflects the state of the domain of science as it is and not a stereotypical projection of a field that is still entirely a monoculture. If people other than those from a hegemonically empowered group can perceive bodies like themselves acting in the domain of science, then perhaps these people might feel encouraged to also pursue science careers if they so desire. If more—and more diverse—people gain access to the domain of science, then not only might that improve the democratic access to opportunity in which these people live, but it may

[153] In observatories and other laboratory environments, people who analyzed data and crunched the numbers that supported lead astronomers' observations were referred to as "computers." The *OED* first defines the term, computer, as, "[a] person who makes calculations or computations; a calculator, a reckoner; *spec.* a person employed to make calculations in an observatory, in surveying, etc. Now chiefly *hist*." During the nineteenth and well into the mid-twentieth centuries, if a woman were working at an observatory, she was working as a computer. A similar situation arises in locations where new observatories are built, such as Chile, where local workers are often employed at a higher rate as technicians and data processors and less as astronomers. Some steps are being taken at places such as the A.L.M.A (Atacama Large Millimeter Array) in Chile, in which Chilean astronomers are guaranteed a fair percentage of telescope time is part of the enaction of a feminist performance of science, as discussed in the following chapter. The writing of histories that acknowledge the invisible labor (dark energy) that makes state-of-the-art astronomical performances possible would be worthwhile work towards a feminist performance of science.

also change the way that science is performed due to the many subjective ways that different people are able to perceive scientific phenomena. If the performance of science changes, then scientists' ability to detect previously unknowable things in and about space might also transform.

Contact can be read as a feminist critique of contemporary astronomy practice. *Contact*, co-produced and co-conceived by Carl Sagan (1934-1996) and Anne Druyan (b. 1949) and directed by Robert Zemeckis, depicts fictional characters who are employed at the real-life observatories. The telescopes in *Contact* loom in nearly every shot of the film and can be interpreted as a visual comment on the hybrid nature of astronomy practice.[154] The action progresses through three distinct environments, each with its own kind of telescope: the Arecibo Observatory in Puerto Rico with its 350-m radio telescope; the Very Large Array (VLA) on the Plains of San Agustin, New Mexico; and a fictional machine engineered by aliens but constructed by humans in Cape Canaveral, FL and Hokkaido, Japan. In the pursuit of the discovery of alien intelligence, the protagonist Eleanor Arroway (Jodie Foster) balances her embodied perceptions against mechanically generated data and institutional constraints of the corporate, government, and scientific networks in which she performs her research.

Eleanor Arroway is a SETI (Search for ExtraTerrestrial Intelligence) astronomer, an underdog of the astronomical community.[155] A quasi-outsider in the discipline of astronomy due to the unpopularity and implausibility of her research interests, Arroway struggles to convince her colleagues that her research is trustworthy, capable of producing empirically falsifiable results. Arroway is also somewhat outside the norm of the community of astronomers depicted in the film

[154]For more information about radio astronomy, please visit the National Radio Astronomy Observatory's website at www.nrao.edu.

[155] http://www.seti.org. SETI is "an exploratory science that seeks evidence of life in the universe by looking for some signature of its technology."

due to her gender; this point is not explicitly argued in the film, though it is implied through the cast of other characters that fill the screen most of the time.[156] Arroway's antagonist is the head of the National Science Foundation, David Drumlin (Tom Skerritt), who cancels the research program at Arecibo, only to take credit for Arroway's research when she finally finds something interesting at the VLA in New Mexico. Arroway's staunchest supporters are her love interest/philosophical dueling partner, Palmer Joss (Matthew McConaughey), and her colleague Kent (William Fichtner), a blind observational astronomer.[157]

One of the most important aspects of *Contact* is the consistent depiction of Arroway's deft interactions with telescopes and other detection devices throughout the film. *Contact* introduces the viewer to the physical space of the radio-observatory in action. A combination of agents and actant machines enact the process of astronomy before the filmgoer's eyes. As we shall see in *Background*, it is important for Gunderson to communicate Alpher's unsung story, but the process of the performance of theoretical cosmology remains somewhat of a mystery. In *Contact*, Arroway and other astronomers are represented onsite at massive, real-life telescopes *doing* astronomy. Yet, the film is not an educational documentary. Foster's performance of Eleanor Arroway's story invites *Contact*'s viewers to imagine themselves in the astronomer's shoes, behind the telescopes, and inside the lab itself. This educational aspect of the film works in a manner similar to Behn's very large telescope in *Emperor of the Moon*: the audience is lured into a plot that critiques an

[156] The participation of women and minorities in the domain of science is audited by the National Science Foundation. In their 2015 Digest, they found that for physics (the umbrella discipline under which astronomy and cosmology fall), "[d]espite increases in the number of women earning degrees in physics, the proportion of women in this field, averaging about 20% across all degree levels, is the lowest of all the physical sciences. In the past 20 years, the proportion of women earning degrees in physics increased more at the doctoral level than at the bachelor's and master's levels, but the numbers of women in this field remain very small" (www.nsf.gov/statistics/2015/nsf15311/digest/theme2.cfm).

[157] As part of its narrative arc, *Contact* engages with a dualistic science versus religion dialogue. While this is an important part of the history of human's quest to know the unknowable, I will not discuss it at length here because that argument falls outside of my line of argumentation that has to do with detection devices.

aspect of science by means of their curiosity about the machines represented in the film. Instead of cloaking the science in farce, as was Behn's technique, Sagan enmeshes his feminist critique of the culture of astronomy in the observatory while also entertaining the audience with a science-fiction romance.

3.2.1 Empathy, Analogy, and Event in Science-Oriented Performance

Several factors combine to encourage *Contact*'s audiences to share Arroway's experiential exploration of the unknown depths of the universe. [158] These factors are empathetic, analogic, and event-driven, and they help the audience to participate in a thoughtful, ground-up critique of the status quo of the late-1990s observatory environment in the United States. Human experience of the natural world is caught up with social factors. Critique of social systems is a part of the performance of science.

[158] *Contact* is a film of epic length, proportions, and scope. A quick summary of the plot will help to transition from Arroway's successful discovery of alien intelligence to the trial at the end of the film where her findings and her credibility are brought under scrutiny. In short, the government intervenes soon after her discovery, and it becomes an international news sensation. The U.S. government financially backs a project intended to build an alien device that was engineered by aliens (the code detected by Arroway led to the discovery of elaborate plans for what experts thought was going to be a travel device of some sort—the only clue that it was a device intended for travel was a sketch of a human being at the center of the thing). Now that the project has gained international attention (and ranked high status), Drumlin, Arroway's former supervisor and professional detractor, steps in to take control of the project, and become the person to drive the alien machine, so to speak. Arroway is deeply disappointed by this decision, made by a panel of judges who were not entirely impartial. As it turns out, the experiment to send a human being into the unknown inside of an alien machine does not meet with popular approval, and a zealot protestor/terrorist (Jake Busey) blows the entire project to smithereens, killing Drumlin in the process. All hope is lost, until Arroway's silent and mysterious backer, S.R. Hadden (John Hurt) of Hadden Industries, reveals that a second device was constructed just in case the first trial went awry. Arroway proceeds to Hokkaido and proceeds with the second experiment. It is during this experiment that Arroway travels through a wormhole to view the Vegan civilization and has a conversation about the future of intergalactic communication with an alien intelligence who has taken the physical form of her father. It is Arroway's testimony of this incredible story that comes into question during her grand jury trial.

3.2.1.1 How to make abstract science concepts that appear in representational drama empathetic to general audiences

Dramatic representations of scientific objects, ideas, and figures help audiences to efficiently relate to complex science concepts that drive the plots of these science-oriented productions. In order for the non-scientist audience to care about science-oriented plots, the tone must be lowered, to use Shapin's terms. This tone-lowering effect is achieved by empathetic representations of scientific concepts in history and fiction.[159] Analogy, as Crane discusses it, works within the empathetic reception of dramatic performance genres to enact a more generally accessible entertainment medium that deals with science content in the domain of the arts. Sometimes, a certain amount of audience education is required in order to understand why a certain plot point matters to the characters in the production. If an audience member can come to care about the figures onstage, then they will be more likely to care about the science content, with the characters in the drama.

In the theatre, it is not necessarily the viewer's capacity to empathize with the characters on stage and screen that matters, but the viewer's active empathy with the blend of character/performing agent that matters. McConachie explains:

> A spectator who has read a play before coming to the theatre to watch it might imagine what a character looks and sounds like in his 'mind's eye' (and mind's ear) and empathize with that imagined body, but once inside the playhouse the former

[159]Cognitive theorists have defined the term empathy in a number of ways, but for the sake of this argument, empathy may simply be defined as the act of feeling with another feeling agent. McConachie defines empathy as "perspective-taking," or, "a kind of mind-reading that allows one person to step into the shoes of another and experience that person's world from her or his point of view" (McConachie, *Theatre & Mind*, 15). Maiese defines empathy as a critical element of enactive social cognition: "Just as the enactive approach suggests that I perceive a car not as some object among others, but as something I can use, it also suggests that I see others as beings with whom I can communicate, who can either help me achieve my goals or thwart them, and who can be the targets of my love, trust, or empathy" (Maiese, 161). Gibbs defines empathy in terms of emotional interactions that transpire when one observing agent recognizes a sameness of experience in an other: "Empathy is not just understanding another person's particular experiences (sadness, joy, and so on), but is the experience of another as an embodied subject of experience like oneself" (Gibbs, 35). Each theorist applies a particular twist on the term to suit her or his theoretical argument. In most cases, however, empathy is theorized as a shared emotion—feeling with—rather than an individual experience of feeling sympathy for another person.

> reader becomes an active spectator and the blend of a flesh-and-blood actor with the author's character always takes the place of the imagined figure in the reader's mind. (McConachie, *Theatre & Mind*, 55)

In the movie theatre, live actors are replaced by projected images of actors (or other kinds of animation) onscreen. Plantinga asserts, "The very possibility of the audience's engagement with fictional characters rests in part on the human tendency to personify and respond to abstract, nonhuman entities, especially in the context of visual representations" (Plantinga, 97). If audiences can empathize with abstract shapes, then the extension of empathy from live actors on stage to filmed actors on screen is not a great leap. The same cognitive relationship between viewers and abstract scientific objects and ideas can be applied to the reception of plays that encounter science concepts.

3.2.1.2 A brief example of analogic empathy in Brecht's *The Life of Galileo*

Before diving into *Contact* it will be helpful to consider a rather straightforward example of the relationship between empathy and analogy as it can be embodied in dramatic performance genres. The following short example from Brecht's *The Life of Galileo* should clarify the connections between the personification of objects too large or distant for the unaided human to detect (like the planet on which a person lives or a distant galaxy), empathy, and analogic performance techniques. I will take up Crane's thoughts on analogy and the performance of science directly following this brief discussion.

Like laboratory science, performance participates in the process of analogic inquiry into the natural world. Science-oriented performance's first analogic mode entails the audience's empathetic identification with representational characters in order for learning about a science concept to transpire. Audience members can learn with dramatic characters that are engaged in an educational act within the drama. Embodied educational bits, embedded in dramatic narrative, can

help to bridge what Crane refers to as, "the widening gap between everyday observation of the world and scientific explanations of its workings" (Crane, "Analogy," 108). She surmises that, "If the causes of natural phenomena are no longer directly linked to their visible or sensible qualities, those causes can only be conceptualized by analogy with phenomena that can be seen or felt" (Crane, "Analogy, 108). The very first scene of Brecht's *The Life of Galileo* presents a "perceptually grounded mental model," an efficient, embodied explanation for a theory of the cosmos (Copernican) that is counterintuitive to everyday lived experience.[160] In the following scene, Galileo introduces his young student, Andrea, to the concept of heliocentrism via an embodied shift in perspective:

> Andrea: But I can see with my own eyes that the sun goes down in a different place from where it rises. So how can it stay still? Of course it can't.
>
> Galileo: You can see, indeed! What can you see? Nothing at all. You just gawp. Gawping isn't seeing. *He puts the iron washstand in the middle of the room.* Right: this is the sun. Sit down. *Andrea sits on one of the chairs, Galileo stands behind him.* Where's the sun, right or left of you?
>
> Andrea: Left.
>
> Galileo: And how does it get to be on your right?
>
> Andrea: By you carrying it to my right, of course.
>
> Galileo: Isn't there any other way? *He picks him up along with the chair and makes an about-turn.* Now where's the sun?
>
> Andrea: On my right.
>
> Galileo: Did it move?
>
> Andrea: Not really.

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[160] Crane fleshes out her argument through Lakoff and Johnson's cognitive theory: "Lakoff and Johnson's insights about the centrality of concrete bodily experience to all human thought raise the stakes: if new theories explaining the structure of the cosmos, matter, and motion were at odds with ordinary embodied experience of these phenomena, then the scientific revolution marked an unprecedented separation between the very bases of cognition and specialized technologies of scientific thought" (107).

Galileo: So what did move?

Andrea: Me.

Galileo *bellows*: Wrong! You idiot! The chair!

Andrea: But me with it!

Galileo: Of course. The chair's the earth. You're sitting on it.

Mrs. Sarti *has entered in order to make the bed. She has been watching*: Just what are you up to with my boy, Mr. Galilei?

Galileo: Teaching him to see, Mrs. Sarti. (*Life of Galileo*, 1)

Brecht's Galileo teaches Andrea by changing Andrea's perspective through embodied analogy. Andrea's body is placed in a physical situation in which the chair is compared to the earth and the washstand is compared to the sun. Andrea's situation in relationship with analogic objects, allows him to understand the alternative point of view that Galileo was in the process of trying to prove to his peers by other means of observational astronomy. In this case, a telescope was not needed to perform a theory of the cosmos. Brecht's audience, empathizing with Andrea via his staged analogy, is re-educated along with Andrea.[161]

3.2.1.3 How analogy works to help non-scientists engage with science content in the domain of the laboratory and the domain of the stage.

Analogy, in essence, is the comparison of one thing to another, and it is through empathetic viewership that the audience member is able to compare her or his experiences with that of the character represented on stage or on screen. In *Contact*, analogy works with empathy to engage

[161] For a more detailed discussion of a spectator's capacity to empathize with multiple characters, please see McConachie's *Theatre & Mind*: "…spectators normally empathize with several different people—some physically present, others imagined—during the course of a performance" (54).

audiences with the protagonist Eleanor Arroway's experience in two ways. Analogy first functions to establish an emotional connection between individual audience members and the character of Arroway, embodied by Foster onscreen. Once that emotional connection has been established, the second analogic function becomes possible: that of the introduction of the audience to the process of astronomy, thereby engaging that audience in a feminist critique of it.

Contact's embodied, empathetic performance of science is the product of a long history of analogic scientific inquiry that began with Aristotle. Crane articulates laboratory science as an analogic process that evolved over the course of the seventeenth century.[162] With the new science came new analogies, according to Crane. These new analogies were neither causal nor related to perceived qualities of objects and phenomena, but the analogy had to do with a substitution of experience in the laboratory for experience in the real world. She suggests that the introduction of laboratory science exemplified,

> The widening gap between everyday observation of the world and scientific explanations of its workings made metaphor and analogy important in new ways.… If the causes of natural phenomena are no longer directly linked to their visible or sensible qualities, those causes can only be conceptualized by analogy with phenomena that can be seen or felt. (Crane, "Analogy," 107).

An analogic, mechanical model of the universe supports Boyle's atomic theory, and, a later map of the solar system used to describe Rutherford's model for the structure of the hydrogen atom. Both examples of scientific discoveries made in the domain of the laboratory rely on "relationships from a visible domain to an invisible one" (Crane, "Analogy," 111).

[162] She identifies analogy as the mode of Aristotelian scientific analysis that was popular until the experimental model took hold after the slow dawn of the New Science over the course of the seventeenth century. She argues that analogy did not recede as a way of learning about natural phenomena, but the kinds of analogic thinking that applied to scientific analysis changed.

Performance's function in the exploration of science is more than that of an educational tool for non-science audiences. The presentation of diverse agents performing science in representational performance genres allows a wider range of audience members to conduct a self-self analogy as they imagine themselves to be performing science in place of the characters on stage and screen. Embodied analogy allows audience members to participate in the process of scientific inquiry through empathetic engagement with protagonists such as Eleanor Arroway. This is important if an audience comprised of non-science experts is to fully participate in a culture in which science is held in high esteem and scientists are respected as cultural authority figures. If science is perceived to be part of culture, then it should also be conceived of as a practice in which everyone might participate. This approach to science and performance opens up the possibility that ethnic, racial, and gendered make-up of the laboratory, specifically the astronomical observatory, might change as an increasingly diverse range of people embark upon careers in the domain of science. This is one of the critiques central to *Contact*.

3.2.1.4 Trustworthy science practice assists audience empathy towards event-driven science situations in representational performance.

Late twentieth and early twenty-first century representational performance genres renew a pre-modern invitation for non-scientists to authoritatively and actively engage with the investigation of the natural world. *Contact* does this through empathetic engagement with the protagonist and through education about insider science practices, without which it would be difficult to empathize with—and therefore trust—the protagonist's experiences. Trustworthiness carries a different weight for audience members watching a film filled with scientific content than it does for science-trained peers who function within an in-group of astronomers who possess a comparable amount of specialized skill. In order for Arroway to be perceived as trustworthy to a non-scientist audience,

the makers of the film needed to lower the tone of the way that she enacted her science practice onscreen. This was accomplished, in part, by playing up the embodied aspects of observational astronomy—the exciting, task-oriented, moments of discovery. Without a basic education in certain aspects of astronomy it would be difficult for non-science expert audiences to care about the story, and by extension, care about the socio-scientific issues central to the film's themes. *Contact* invites the audience to experience the performance of astronomy from Eleanor Arroway's perspective, which is situated at the fringes of institutional astronomy practice. Arroway's process is presented as a combination of empirical practice and embodied experience. It is her willingness to trust the accuracy of her own, subjective, often unrepeatable, encounters with new astronomical phenomena that makes her character appeal to an audience full of people whose experiences of the natural world are generally not based on mechanically derived and empirically testable data.

Edwin Hutchins describes certain cognitive activities as "event-driven" (Hutchins, 21). When an event occurs within a particular, task-oriented environment and it becomes an emergency, a natural occasion for situated learning arises: "the conditions under which the task is most difficult are usually the conditions under which its correct and timely performance is most important" (21). Hutchins's concept of event-driven performances in real-life situations can be adapted to meet epistemological ends in science-oriented representational performance. The same can be said of staged emergencies—emergencies represented within the metaenvironmental domain of the theatre, film, or otherwise mimetic contexts—because they educate the audience in the performance protocol of disciplinarily specific operations. Event-driven situations are significant to the processes of empathy and analogy in representational drama. When an audience member witnesses an actor's performance of a sequence of actions in an emergency represented onstage or onscreen, that audience member will, in theory, be able to empathetically respond to the situation

that the actor performs, and analogically engage with the science content by the mechanisms outlined above.[163] Event-driven, task oriented scenarios allow agents to perform their expertise in an embodied manner. This runs counter to the data-oriented notions of authority that have carried over from the seventeenth and eighteenth centuries. This conflict is dramatized in *Contact*, wherein Eleanor Arroway is depicted as a scientist who is capable of performing trustworthy science but in an empathetic, embodied, and tone-lowered manner. She proves her trustworthiness to the other fictional characters involved in the plot while also creating cognitive space for non-science expert audience members to emotionally engage with the her science-oriented stakes during the event-driven scene at Arecibo.

Contact's first event-driven, task-based situation arises during the scene in which Arroway and Kent meet in Arecibo, Puerto Rico. In this scene, Arroway performs her expert status in the presence of another scientist as witness to her reliance on what we soon learn is an old-fashioned observational technique: listening. Arroway, alone in the control room of the observatory, is listening to the radio static detected through the 350-meter antenna on a set of headphones. She hears something and she takes off her headphones and turns on the speakers in order to better hear the subject of her observation. The audience is abruptly engulfed with the diegetic sound of radio static that caught Arroway's attention. Arroway and the audience are surprised by Kent's voice when he interrupts her work and asks that she rewind the recording so that they can listen again, together. They do, and they both hear the same unusual blip in the static. Arroway purposefully begins to switch the computer monitor's visual representation mode from static to star map before she types search criteria into the keyboard. Then, one of the computers visually locates the source

[163] The event-driven performance will also be a useful concept to keep in mind in the next chapter in which data performs in a number of ways. The closer data about undetectable science objects and events comes to embodying a familiar situation, so the theory goes, the more likely the non-science expert might be to engage with that content.

of the disturbance on the screen: Pulsar J1741+2748, a known entity. The audience shares a brief moment of disappointment with the characters onscreen because no new astronomical event has been discovered. Even though they have failed to discover something new, Kent praises Arroway's technique: "I think it's great that you listen. Most people don't do that anymore." Arroway replies, "It's just an old habit. Makes it feel more real." For Arroway, the embodied experience of hearing radio waves is a real way of knowing space. The "realness" of Arroway's perception of the static has to do with the way that the audience shares, and therefore empathizes with, Arroway's expert technique of auditory observation.

This kind of event-driven performance repeats later in the film, during the second telescope scenario at the VLA in which Arroway discovers the first observable evidence for extra-terrestrial intelligence. The emergency situation is readily recognizable to the audience through Arroway's repeated sequence of actions because they have already been instructed in the trustworthy practice of a trained astronomer in the event-driven scenario at Arecibo. Arroway and Kent have been working there since Arroway lost her NSF funding at Arecibo, and financial collapse is threatening again. Arroway removes herself to the array of satellite dishes and we see her, apparently dozing on top of her car. She wears a pair of headphones that are connected to her laptop, which is linked to the VLA's radio-satellite system, which is tuned to the sounds of the universe. The environment is a combination of the sublime and the technological: the laboratory (human/machine hybrid) microenvironment represented by Arroway's interaction with her computer and the natural macroenvironment of the New Mexico desert.[164] She hears something, opens her eyes, listens. The camera angle widens to include the enormous satellite just behind her, turning as if to tune in

[164] https://nrao.edu. Previously, the film has depicted Arroway sitting at the edge of a canyon, the sun is setting on the indescribably beautiful red rocks, with the entire Y-shaped array - 28 satellite antennas each 25 meters wide weighing 230 tons and 22.62 miles at its widest point – spreading out in the distance behind her.

on the sound. One more moment, and the scene immediately shifts into task-performance mode. The stakes of Arroway's research are much higher this time, an intense state represented by the sheer amount of technology represented on screen compared to the flow of action at Arecibo, which was limited to an assemblage consisting of one desk, a speaker, a set of headphones, a couple of computer screens, and two people. Now, the control room is filled with rows of computers, some showing star maps, some sine curves, some static (the ever-present CMBR in visual form). People are communicating via cell phones, land lines, and computer systems. The audience can ascertain that the intelligence from Vega is communicating through audible pulses, detectable in the radio static, that occur as a sequence of quantifiable prime numbers which are transduced through the assemblage of computers, telescopes, and humans in this astronomy research environment. In very little time, the VLA is overrun with people and objects from all walks of the so-called science-society spectrum.

I argue that Zemeckis deliberately situates the figure of Arroway in as natural a macroenvironment as possible as she conducts her observations of the sky in order to increase the potential for empathy between non-scientist audience member and expert scientist fictional character.[165] According to Crane, a rift between the non-scientist and the right to observe nature began in the seventeenth century, "as everyday experience of the natural world was severed from scientific explanations of it, and ordinary people could no longer trust their experience of the world to reveal the truth about its nature" (Crane, "Analogy," 105).[166] Arroway's dramatic position as an outsider due to her gender, her area of expertise, and her situation outside the laboratory, makes

[165] It is a conveniently aesthetic arrangement, since most earthbound observatories are situated in remote, arid, unpopulated areas.

[166] Shadwell's *The Virtuoso* is the penultimate example of the scientist cut off from the everyday because of the false conditions created in his laboratory. This satire is discussed briefly in the conclusion of this dissertation.

her experience of nature/astronomy more accessible to a non-expert film audience. Spectator-participants in the movie theatre metaenvironment might empathize with Arroway because they are not closed off from her experience in the way that outsiders are in the context of the film's narrative. Arroway's eyes may be closed, but movie viewing audiences' are not. Film audiences hear with Arroway as she listens to the rhythmic counting system sent via CMBR to Arroway's extended ears. The prospect of making contact with extra-terrestrial life becomes plausible to the non-scientist audience member as she shares Arroway's embodied experience. By situating Arroway's expert practice in a natural location (the desert and open sky), Zemeckis filmically builds a bridge between astronomy and the non-scientist's experience of it. Arroway's process is not "naïve" or "intuitive," as Crane describes pre-seventeenth century natural philosophy, but it might appear so to an outside observer, since Arroway performs her observations in the same position from which most non-scientists observe the cosmos: outside, sky above, earth below. The appearance of Arroway's practice during this scene obscures the highly technological aspects of her job.

The film narrates a story in which Arroway's professional reputation as a credible astronomer is damaged because of her trust in her own embodied sense of what is real. This is the story that is presented during the hearing scenario at the end of the film, and in this way the neoliberal practice of astronomy is critiqued; just as credible scientists at the turn of the eighteenth century could not entertain data that fell outside the norm, so the neoliberal science outfit—backed by the US government—in *Contact*'s fictional scenario cannot entertain the subjective experience of one individual when that information is not corroborated by the many data counting devices intended to support (or refute) Arroway's observations. Whereas eighteenth-century scientists relied upon the corroboration of their peers for social and scientific credit, at the turn of the twenty-

first century the approval by a group of credible peers has been replaced by evidence falsifiable against mechanically mediated information. It is the inability of the government to get inside of Arroway's head that leads to the hearing at the end of the film. No matter how many times Arroway has proven herself as a trustworthy scientist, her research methods are not repeatable due to cost and institutional disinterest in SETI's mission. Arroway's credible reputation has been damaged and therefore her experience is not considered worth the effort or the cost of further tests.

Whatever credibility Arroway had gained through her actions during event-driven astronomy emergencies vanishes during the hearing. Failure of alien technology and earth-bound communication media systems results in a globally televised fiasco in which her embodied experience is proven to be insufficiently credible. She is accused of having fallen prey to a hoax, if not of having invented one, in order to convince the world of her hypothesis that aliens exist. Her report—that while inside the alien device in Hokkaido she traveled through wormholes to see an alien civilization and that she had a conversation with an alien intelligence about the future of the human race—is greeted with incredulity and skepticism. She cannot verify her experience because she lacks a body of evidence other than the subjective memory of her sensory experience. Arroway's testimony is challenged because she is tried by people who are unable to share in her experience. The court is not a laboratory, yet, in the case of Arroway's hearing, it brings pre-seventeenth century concepts of causes to bear on Arroway's testimony. Crane argues, "If the causes of natural phenomena are no longer directly linked to their visible or sensible qualities, those causes can only be conceptualized by analogy with phenomena that can be seen or felt" ("Analogy, 108). The judge, jury, and audience present at the hearing can see no logical cause for the events described by Arroway because the mediation technologies intended to document her experiences failed to transduce the information at the other side of the alien detection device in the

same manner as her memory and her words. The judge, jury, and television audience have not benefitted from the empathetic qualities of a filmic narration of Arroway's story as the movie audience has, and they therefore don't share her experience, nor do they trust her story. In the eyes of the court, her peers, and the public, she has become lost in microenvironmental laboratory conditions that have no bearing on a common-sense, everyday experience of the natural world. To mechanical and human observers outside of Arroway's person, her experience just could not have been real.

3.3 COSMIC MICROWAVE *BACKGROUND* RADIATION

One important way that representational theatre participates in the performance of science is by depicting the domain of science in the language of the everyday. Shapin's tone-lowering historiography sheds light on the ways that institutional hierarchies contribute to notions of authority to access and engage with the natural world. He suggests that the infrastructure of scientific institutions and organizations often perpetuate cultural biases based on race, sex, and ethnicity within those institutions. He brings up the fact that scientists often find themselves in disagreement with one another, and that popularity of certain concepts often overrides differing scientific claims by equally credible science practitioners. He goes on to state that, "what [scientific] success meant, especially in the West, and most especially in America, was that science became so closely enfolded in the institutions that produced wealth and projected power that accepted accounts of the nature of science and the conditions of its thriving lost their salience and cultural grip" (*Never Pure*, 12). An examination of these figures through the metaenvironment of representational drama lowers their tone. Lauren Gunderson's play, *Background*, is a biographical

drama that performs social bias as it was enacted during the 1930s at major science institutions in the United States. Her dramatization of Alpher's struggles within authoritative scientific infrastructure of pre-WWII U.S. lowers the tone of the domain of theoretical cosmology because it is Alpher's personal struggle that is the central theme of the play. It is Alpher's emotional journey—enacted through a telescopic theatrical device—brings the audience to care about the history of the theory of CMBR and ultimately performs the moral: scientists are people, too.

Whereas *Sidereus Nuncius* constitutes a textual medium for the transduction of science concepts to non-scientist audience readers, *Background* is a theatrical medium through which a non-scientist audience might perceive the often invisible disputes that transpire within science communities**.** The play embodies the question of intra-disciplinary trust within academic physics circles and reveals the long-term fallout of broken trust and power play between junior and senior scientists. *Background* introduces a private realm of culture where scientists are exposed to be as funny, sensitive, ambitious, and fallible as other humans. By repositioning scientists as everyday humans, Gunderson invites her audiences to contemplate the science that inspired Alpher along with the ups and downs of his family life, as well as the interpersonal conflicts that plagued his professional career.

Background moves backwards in time in order to examine an old story from a new perspective. The play is written so that audiences might experience Alpher's life like astronomical observers at the viewing end of a Galilean telescope; the entire play is a transductive, mimetic machine that translates Alpher's memories of helplessness in the face of Arno Penzias's (b. 1933) intellectual theft, and, later (earlier) elation that his discovery is important enough to warrant a press conference. *Background* begins in September 1978, when historical cosmologist Ralph Alpher (1921-2007) suffered a heart attack just two weeks before the Nobel Prize would be

awarded to Arno Penzias and Robert Woodrow Wilson (b. 1936) for finding CMBR at the frequency that Alpher and his partner Robert Herman (1914-1997) had predicted in 1948.[167] The discovery of CMBR by Penzias and Wilson, both working at Bell Laboratories at the time of their discovery in 1965, gave popular credence to the Big Bang theory of the universe, which had been a cosmological theory since the 1920s.[168] Alpher and Herman were not acknowledged for their preliminary research. This "Nobel snub" is the play's inciting incident as Gunderson telescopes backwards in time (Scientific American, "No Nobel"). The plot gradually reveals the reasons for Alpher's professional disappointment as it simultaneously dramatizes the importance of his discovery. Gunderson takes swipes at the institutional network of U.S.-based physics research that served as both the source of his training as a trustworthy scientist as well as a reason for his questionable credibility within the science world.

Perhaps if Alpher had been a more established (i.e., socially credible) scientist at the time that he made his theoretical prediction, his research would not have been overlooked years later when Penzias and Wilson proved his theory to be correct but failed to acknowledge his significant contributions to the development of the theory. Whyte and Crease describe a subtle difference between trust and credibility. They state that scientists institute themselves as trustworthy experts through acts of, "[s]cientific training, research experience, and sustained participation in the research community" (413). No matter how trustworthy the scientist's practice, one's credibility can be harmed by social factors unrelated to her or his contributions to the advancement of science.

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[167] Specifically, Alpher and Herman predicted that the constant temperature of the universe should be "about 5° Kelvin," or, 5° above absolute zero.

[168] "Scientists at the Bell Laboratories have observed what a group at Princeton University believes may be remnants of an explosion that gave birth to the universe. These remnants are thought to have originated in the burst of light from that cataclysmic event. Such a primordial explosion is embodied in the 'big bang' theory of the universe" (Sullivan, Walter, "Signals Imply a 'Big Bang' Universe," *New York Times*, 21 May, 1965).

Whyte and Crease claim, "social factors are often behind whether scientists are perceived as credible in the eyes of ordinary citizens" (414). Gunderson's text indicates that Alpher's contributions to the expanding universe theory and CMBR were disregarded partially due to his social status as a student (Laurence, "Physicists," 29).[169] One popular theory regarding Alpher's Nobel snub is that his student status, combined with his rank below two senior scholars on his own dissertation, caused other scientists to overlook his prediction of the wavelength at which CMBR could be detected.[170]

In one early scene, Alpher explodes in a frustrated outburst that provides enough basic information needed for a non-scientist audience member to understand the science behind the history-of-science drama**.** Alpher, still in the "present," is situated in a hospital room after his heart attack. He blurts out:

> YES. 1965 Penzias and Wilson, two radio scientists working at Bell labs accidentally discover cosmic background radiation while trying to fix a radio dish. 1978 they win the Nobel Prize.
> But THIS is history *too*: 1940 a young Ralph Alpher meets with displaced Russian physicist George Gamow. Gamow convinces Alpher to study the origin of the universe… As they work their way from the original explosion of energy and waves to the present day of solid matter and 117 elements, they realize that there may still be remnants of the initial explosion in our world today. This remnant is in the form of light waves flooding the universe… we call it cosmic background radiation. We write papers, we present the math, we are forgotten for twenty years. (*Background*)[171]

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[169] It also appears that other physicists were able to use Alpher's research. He and Gamow, a senior scholar, were also credited for his work in certain other scientific publications, which, though not widely circulated in the United States due to the Cold War (the scientists who relied on Alpher's theory were Soviet), suggests that his publications were available to the appropriate scientific, scholarly, and popular public. This suggests that, indeed, the people at Princeton were either sloppy in their scholarship or that they deliberately plagiarized Alpher's work.

[170]The website, *Everyday Cosmology*, a publication of the Observatories of the Carnegie Institution for Science, devotes a page to the importance of intellectual credit and professional credibility for science professionals, and uses Alpher's story as its case in point. Here, Alpher's status as a graduate student is used to illustrate one of the reasons why he may not have been deemed worthy for the intellectual content of his own doctoral dissertation: "[t]he paper turned out to be a famous landmark in the history of cosmology, but because Alpher was a student, credit for the work has largely gone to the senior authors," (www.cosmology.carnegiescience.edu).

[171] George Gamow (1904-1968) was a theoretical physicist and cosmologist, known in the science community for his practical jokes and cartoons about cosmology. As a teacher, he inspired the careers of many astronomers, theoretical

The action proceeds with each scene set farther back in time, but the audience is now equipped with enough of the history of cosmology to maintain an interest in this drama in reverse: Alpher meets Penzias in a diner shortly before the Nobel event so that Penzias can pick Alpher's brain about the physics and cosmology he had "forgotten" during the thirteen years since he stumbled upon CMBR; further back, a series of scenes depict Alpher's deep depression that accompanied the slow realization that Penzias and Wilson would never acknowledge his original research that; a press conference scene reveals that Alpher's discovery was no secret in the 1940s; earlier still, scenes show the hard work that Alpher put into his doctoral dissertation and his bewilderment when George Gamow (Alpher's advisor) announces that he would include " 'Bethe' Hans Bethe, from Los Alamos. The paper reads, 'Alpher, Bethe, Gamov.' Alpha Beta Gamma!" (*Background*).[172] Bethe had nothing to do with Alpher's work, and some historians suggest that this physics joke, on the title page of Alpher's dissertation, helped damage Alpher's credibility.

Social status wasn't all that caused Alpher's research to be left on the shelf. Other aspects of this telescopic drama indicate that the timing of the idea was wrong. Lack of interest in Alpher's theory, compounded by limited funds available to test, it may have contributed to Alpher's decreased credibility in spite of his trustworthy skill as a theoretical cosmologist. Some historians of science suggest that there wasn't sufficient interest in Alpher's research at the time because the big bang was still a new cosmological theory.[173] The technology existed to test the theory

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physicists, and cosmologists, including Vera Rubin (who discovered dark matter through astronomical observation, and whom I discuss briefly in the following chapter). Alpher and Herman offer a personal and professional biography for their teacher in their book, *Genesis of the Big Bang* (2001).

[172] Hans Bethe (1906-2005) was a German nuclear physicist whose specialty was on stellar energy production. He acquiesced to Gamow's joke, "for the reason that the work might even be right" (Alpher and Herman, *Genesis*, 77).

[173] Marcia Bartusiak reflects upon the reasons that Alpher's and Herman's findings were ignored: "Perhaps it was because cosmology was still a young discipline skeptically regarded by mainstream astronomers, and radio astronomy, also in its infancy in 1948, had other pressing concerns" (Bartusiak, 364.)

empirically, but because of Alpher's outsider status as a young scientist whose work centered on an unpopular theory, his dissertation remained out of the light of American mainstream science.[174] The unpopularity of Alpher's discovery had a lot to do with its timing. Shapin suggests the popular and political environment in which scientific research is performed has as much to do with the credibility of the science as the trustworthiness of the scientist's performance itself. In 1948, the Big Bang model of the universe was still contested, so it is very likely that Alpher's discovery of CMBR was ignored because of a, "late modern instance of the politicization of credibility-judgments," indicative of, "the relationship between political interests and technical judgment" (Shapin, *Never Pure*, 25).

Gunderson's play, through its structural metaphor of the telescope and its mix of professional, personal, and physical storytelling, allow the audience to engage with the natural world by introducing the mathematical language of cosmology in human terms. A telescope doesn't physically manifest on Gunderson's stage, but the arrangement of scenes that push deeper into the past, all the way to the big bang, metaphorically achieve the function of the telescope, but as telescopic theatrical medium. The backwards-looking narrative explains the fraught circumstances that defined the publication of Alpher's dissertation and extends further into the depths of time as the Gray Narrators urge Alpher towards earlier memories until he iterates the Big Bang model of the origins of the universe. Alpher's memories are mixed with painful reminders of the present because he is suffering a heart attack throughout the play. This serves the dramatic function of re-engaging the audience should Alpher's memories and thoughts about

[174] There was some press coverage of Alpher's discovery, to which a press conference scene in *Background* attests. But Alpher's discovery quickly faded from the spotlight of popular trends in physics and astronomy.

cosmology become too technical or abstract for the non-scientist observer to remain engaged with the science content of the play.

> Gray1: Merging matter, hot gasses, Radio waves, microwaves, visible light—red, yellow green blue…
>
> Harriet: oh god.
>
> Gray2: Ultraviolet, x-rays, gamma,
>
> Ralph: (*The heart attack begins*) Oh. God. (*Background*)

Much of the information that the Grays narrate while Alpher is experiencing the heart attack is an all-but indecipherable tidal wave of inconceivably tiny numbers and quantum theory taking Alpher and the audience back to, as Alpher states near the end of his heart attack, "the limit of physics… that's where we began…" (*Background*). His very human heart attack serves to spark the direct, shared emotion of fear as Alpher's pain interrupts his telescopic memories.[175] If audiences are able to feel with Alpher's physical distress, they may also be able to extend their attention to entertain Alpher's emotions as they pertain to the cosmological theories that meant so much to him. By this extension, audiences may be able to care about the things that mattered to Alpher because Gunderson's narrative has lowered the tone of abstract physics concepts.

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[175] Bruce McConachie, in *Evolution, Cognition, and Performance*, traces a related trajectory regarding audience reception of Richard Pryor's heart attack as he performed it in Long Beach, CA in 1978: "In the case of listening to Pryor's heart attack story, the spectator may be torn between two possible actions: to join in **sympathy** with Pryor and empathize with his experience or, secondly, to shut out any stories about heart attacks – perhaps the spectator is just recovering from his own heart problems – by disengaging from Pryor's storytelling. The first alternative would allow him to remain within the fictional flow of the comic narrative, while the second would temporarily end the story's claim on his attention and emotions. Both possibilities are what Kelso would term attractors, desirable responses to the immediate stimulus within the present boundary conditions of the spectating system. In general, attractors are "attractive" because they promote long and short-term survival and flourishing. Following Freeman, we can say that the immediate and long-term goals of the spectator shape the construction of both attractors. In effect, our recent heart-attack victim needs to decide, "Can I stand more **fear,** which might get my heart racing, or should I just try to relax and enjoy myself?" Both options have some likely near-term survival value. This is rarely a conscious decision, of course; the body-mind of the spectator will sense the better possibility and prepare accordingly" (n.p. 2015).

One of the principal functions of a performance studies approach to the exploration of space is to restore the importance of individual bodies as they appear in the domain of the laboratory—an aspect of the experimental process that had been all but excised during the Age of Reason. In fact, it might be argued that the primary function of the biographical science drama is to soften the sharp edges of "pure science" by representing the flesh and bone, head and heart, bodies of the humans who perform that science. Biographical dramas such as *Background* enact the body behind the numbers and participate in a turn-of-the-millennium shift in science performance to reintegrate the cultural context that informs the process of scientific inquiry. This intervention can work to disrupt the hierarchy of science practitioners established during the late seventeenth and eighteenth centuries. The representation of a diverse population of historical scientists—whose cultural contexts are often not at the forefront of science histories—can increase imaginative access to science careers for an exponentially more diverse population of audiences who witness these dramatized histories of science.

Representation of cultural context intervenes into the parts of the history of science that can disappear behind the "pure" data. Not only was Alpher's research disregarded as a graduate student who worked in an unpopular branch of theoretical cosmology, and whose reputation at the time was overshadowed by the more famous names on his dissertation, but Alpher had also been excluded from elite science circles early in his education because he was Jewish. Gunderson dramatizes this obstacle late in the play when Alpher remembers his college entrance interviews:

> Gray 1 [an MIT representative]: Your dedication is incredible.
>
> Ralph: Yes, sir.
>
> Gray 1: Your age is unusual.
>
> Ralph: Sixteen years old, sir.

Gray 1: Your work is impeccable.

Ralph: Thank you, sir.

Gray 1: And you're

(*He stops, checks his notes*)

… Jewish.

Ralph: … yes.

Gray 1: Well. Good luck, son… goodbye. (*Background*)

Diversity among practitioners in the domain of the laboratory contributes to the realization of an accessible science praxis.

3.4 DIVERSE PERSPECTIVES AND PERCEPTIONS MATTER TO AN ACCESSIBLE PERFORMANCE OF SCIENCE

As Whyte and Crease point out, communication between science experts and non-expert society is vital to the project of philosophy of science. Performance is a part of that mediation process because it is in metaenvironments such as the theatre that non-science experts contribute to the enaction of previously unknowable things. Productions such as *Background* and *Contact* may contribute to the creation of a public of "interactional" science experts (non-scientists who are educated enough to converse knowledgably about science issues and communicate between scientists and non-scientists in communities) (Whyte & Crease, 417). More importantly, they empower non-scientists to engage with the natural world by sparking an imaginative impulse in individuals from social groups that have historically been excluded from the domain of the laboratory.

Contact concludes with a prompt to the audience to maintain a level of open-mindedness when dealing with questions regarding the as-yet unknown. The final scene stages human and mechanical mediators together in order to suggest that more than surface-level evidence may be necessary to prove or disprove theories about unexplored space. During the hearing, detractors to Arroway's testimony draw from data that was produced via remote recording media that timed her experience in the alien machine at only forty-five seconds, which would have been insufficient time for Arroway to have logically experienced all of the events contained in her report. The only material evidence that supports Arroway's testimony is the video recorded through a video-camera/headset, which (as the film audience can attest), never left her person throughout the journey since it was attached to her head. This recording becomes the confidential property of the government, represented by Angela Bassett's character Rachel Constantine.[176] Nothing but static is detectable to Constantine, but she is not unconvinced of Arroway's story, because the video is eighteen hours long, not the forty-five seconds reported by exterior witnesses to the experiment. The recording is an extension of Arroway's embodied experience. With "nothing" contained in the video but time, Arroway's testimony that any lengthy sensory experiences transpired within the alien pod becomes plausible. Constantine entertains the possibility that Arroway's embodied experience was differently real than that of her observers. Arroway's cognitive process as a machine/human hybrid will be taken up more explicitly in the following chapter that explores other detection devices.

[176] As far as the audience knows, Arroway is unaware of this material evidence

4.0 PRAXIS: TOWARDS AN ACCESSIBLE PERFORMANCE OF ASTRONOMY

"I love any telescope that I'm working at…. What the telescope can do defines what you're doing… I really love to observe… I would work at any real telescope."
-Vera Rubin[177]

4.1 DIVERSE AND EMBODIED REPRESENTATION OF ASTRONOMY IN ACTION MATTERS TO THE PROJECT OF AN ACCESSIBLE PERFORMANCE OF SCIENCE

"In the Still of the Night" is a one-woman show that I devised in 2013 as an overtly feminist play about women in science. The play dealt with the themes of the women who struggle for recognition in their profession, dark matter, and dating on the internet. In it, I performed four separate roles: the real-life astronomer, Vera Rubin; the fictional metaphysicist, Caroline Hershcell (after the historical woman astronomer); the mythological Andromeda; and a sea monster. I imagined all of these characters to be women. In the play, Vera delivers descriptive excerpts of her life as a woman scientist who has forged her career during a time in the history of the United States when there were few if any other women working as astronomers. Carolyn is a metaphysicist who is stuck in the basement of the University of Pittsburgh's Cathedral of Learning. Andromeda functions as a personified celestial confidante for Rubin as well as an escapist fantasy for Carolyn whereby she faces her demons and takes control of her life. Sea Monster, the most abstract character in the

[177] Rubin, Vera, personal interview. 2011.

show—and the only invisible one—is the dark force that encourages Andromeda to free herself from her rock.

I offer this anecdote as a transition from the last chapter that dealt with criticisms of the performance of science to this chapter that presents examples of works by two women—a scientist and an artist—who are highly respected in their fields, but who cross disciplinary boundaries in an attempt to bridge the "two cultures" divide. Laurie Anderson and Vera Rubin perform hybrid tasks in their careers; they incorporate text, images, technologies, and sometimes sound into their work. In this chapter, I draw primarily upon theories of the cyborg and the posthuman—which in turn derive from feminist, cosmopolitan, and post-colonial thought—to depict Anderson and Rubin as embodiments of diverse and accessible performances of science. By juxtaposing an artist with a scientist, I hope to demonstrate that arts and sciences are both necessary to the performance of science across a cultural spectrum.

4.1.1 Introducing Laurie Anderson and Vera Rubin

Laurie Anderson's *The End of the Moon* (2005) is the second in a trilogy of performance pieces that she has devised in response to the post-9/11 cultural climate in the United States. [178] *The End of the Moon* is also the product of an early twenty-first century arts residency at NASA, which is an experience that she construes as simultaneously wonderful and somehow connected to the perpetuation of fear and reticence that she suggests is endemic to the post-9/11 American condition. Anderson seeks to reclaim a sense of wonder for an American public that she perceives to have grown away from unauthorized participation in the experience of all of world's domains.

[178] The other two performances in this trilogy include *Happiness* (2001) and *Dirtday!* (c. 2011).

Anderson's storytelling is a proposal for a citizen engagement with the process of exploratory and experiential astronomy as it was being practiced by NASA in the mid-2000s. Anderson's combination of the human, the technological, and the animal—represented onstage physically, imagistically, and textually—constitutes a cyborg system intent on subverting culturally accepted notions of science that have come to be, she implies, accessible to those agents performing within the secret domain of the military rather than the rest of general public.

Vera Rubin's career marks an important moment in the history of women in science. Her perspective has led to observational evidence that favors the existence of the unseeable substance, dark matter.[179] Her essays and lectures for general audiences and interested amateurs have explicitly addressed the feminist concern regarding access for women and other minorities to the field of astronomy. She writes from a materialist feminist point of view in her publications for popular audiences. If a female figure in the history of astronomy did something, observed something, wrote something, Rubin includes that observation in her history, and emends the archive. For instance, with respect to the observational history of M31, Rubin points out a 1959 flat rotation curve for galaxy M33 that had been generated by Louise Volders.[180] This discovery had been ignored by the astronomical community, which Rubin finds "curious," and makes no more comment other than, "perhaps the instrumental capability was doubted" (Rubin, 136).[181]

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[179] Dark matter and dark energy are theorized to make up about 96% of the universe. Although dark matter has yet to be detected by any human, detection device, or combination thereof, its existence is inferred through the behavior of other objects that share space with it. Vera Rubin's early observations and subsequent work on the question of dark matter provide strong observational evidence for its existence. However, it remains a theory. Dark matter will be discussed in greater detail later in this chapter.

[180] A flat rotation curve indicates that objects in orbit far away from a system's center (a solar system or a galactic system) move at close to the same speed as objects nearer to the center. Most systems exhibit a rotation curve that drops off, with objects at the edges of systems (like our own solar system) that slow down the further they are from the center. This will be discussed in more depth later on in this chapter.

[181] She notes that her graphic evidence essentially repeated similar evidence generated by Volders for a different galaxy. This chapter, "A Century of Galaxy Spectroscopy," is adapted from the Russell Prize Lecture, 9 January 1995, at the 185th meeting of the American Astronomical Society in Tucson, AZ.

Perhaps audience members at the conference—through Rubin's vocal tone, physical gesture, and facial expression—might have detected a subtext lurking beneath the words, "instrumental capability": *authority of a woman scientist to interpret data* at a point in history when women were denied access to most of the observatories in the United States.[182] Female agency in the domain of science is essential to the project of a culture that supports an accessible performance of science. Vera Rubin's professional work with dark matter is an example of this. The status that she accrued through her work with dark matter contributed to the extent to which she has been able to advocate for inclusive science practices in her activist writing and speaking for general audiences.

Anderson and Rubin are both devoted to making invisible aspects of the science process available to non-scientists, and one of the ways that they accomplish this is through the creation and examination of astronomical images. Anderson opens *The End of the Moon* with a scenic tableau that features a projected image of the popular photograph taken of Neil Armstrong's first step on the moon**.** By reframing that historic moment of space exploration on her stage, Anderson allows her audiences to contemplate certain social and ethical issues that surround space exploration. She generates many of her own impressions of what it must be like to experience outer space if one were able to have access to Neil Armstrong's shoes. Anderson augments her physical and imagistic storytelling with emotional anecdotes, ephemeral violin solos, and politically driven monologues. Vera Rubin's performance in the domain of astronomy is likewise politically driven. Her performance in the domain of astronomy is, like Anderson's performance, deeply concerned with making invisible things visible to science professionals as well as the interested amateur. It was Rubin's skill as a spectroscopist and authority as an astronomer that allowed her to capture

[182] This is not the sentiment that Rubin articulates in writing, but my reading of her words in the broader context of her writing about the need for more women working in astronomy.

images of M31, which she then interpreted graphically in order to produce the rotation curves that made the astronomy world re-examine notions of what the universe is made of, and where it is going.

Both Anderson and Rubin rely on the manipulation of visual data in the performances within their respective domains. A recurring point of reference in this chapter will be the images produced by the HST.[183] Although Rubin's early work did not incorporate this telescope, the history of astronomical research relies on the persistent reference to and manipulation of many forms of visual representations of the same object taken over a period of time. Rubin's expertise is evident in her manipulation of this data. Anderson speaks for the non-expert as she performs her curiosity about the way that astronomy manipulates images of celestial objects. In 2015, images created by the HST are an easily accessible way for curious amateurs to get an idea of what things in outer space look like, and both Anderson's and Rubin's performances indicate what knowledge-generative labor is accomplished by the HST and its team of astronomers, technicians, astronauts, and media-magicians that would have little meaning without the general public's capacity to participate in the cultural practice of knowing space.

4.1.2 An Accessible Performance of Science is Hybrid

In all your travels, have you ever seen a star supernova? …Well, I have. I saw a star explode and send out the building blocks of the universe. Other stars, other planets, and, eventually, other life. A supernova. Creation itself. I was there. I wanted to see it and be part of the moment. And

[183] The HST is a 2.4m wide reflective telescope that is situated three-hundred and eighty-one miles above the Earth's surface. It was placed into orbit on 24 April 1990, carried in the cargo bay of the space shuttle *Discovery*, and placed into orbit by a crew of astronauts and astronomers. Science historian Robert W. Smith identifies the three main advantages of situating a telescope above Earth's atmosphere: "Improved wavelength coverage… [an] extended observing day… [and] improved angular resolution." Of these three, the first will come to bear on this chapter's examination of the HST assemblage's performance of the invisible spectra in the visible theatre of astronomy outreach media as it appears in Rubin's and Anderson's respective domains.

do you know how I perceived one of the most glorious events in the universe? With these ridiculous gelatinous orbs in my skull. With eyes designed to see only a tiny fraction of the electromagnetic spectrum. With ears designed only to hear vibrations in the air.… I don't want to be human. I want to see gamma rays. I want to hear x-rays. And, I want to smell dark matter. Do you see the absurdity of what I am? I can't even express these things properly because I have to conceptualize complex ideas in this stupid, limiting spoken language. But I know I want to reach out with something other than these prehensile paws, and feel the solar wind of a supernova flowing over me. I'm a machine, and I could know much more. I could experience so much more, but I'm trapped in this absurd body. And why? Because my … creators thought that God wanted it that way.

-John Cavil (Dean Stockwell) *Battlestar Galactica*, Season 4, Episode 15

The 2004 television series *Battlestar Galactica* features a fictional class of performing agent, the Cylon, which is a good (if a bit on-the-nose) example of a cyborg as it appears in science fiction. *Battlestar Galactica* is a contemporary of Anderson's *The End of the Moon*. While Anderson's cyborg performance is not as obvious as that of *Battlestar Galactica,* these productions share certain cyborg performatic elements.[184] Cyborgs, as they tend to appear in late twentieth/early twenty-first science fiction television and film, are agentic entities in humanesque bodies that are capable of tapping into a network of data streams and robotic mechanisms at a moment's notice.[185]

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[184]*Star Trek: The Next Generation*'s Borg also present a good example of a cyborg that appears in a popular entertainment of the late twentieth century. The Cylons are a better example for this work because of the post-apocalyptic thread in the show's narrative arc that matches Anderson's sociopolitical interests. *Battlestar Galactica*, a remake of the 1978 ABC sci-fi TV drama, lasted for five seasons in the early 2000s. The Cylons of *Battlestar* were machines created by humans. They gained consciousness and rebelled against their human creators. After a war, the Cylons retreated and hadn't been heard from for fifty years, until, suddenly, they waged a massive attack on the entire human race. This forces a small number of surviving spacecrafts into an extended journey into the deepest reaches of outer space in search of a home, the mythical "Earth." The Cylons, conscious beings, are also in search of Earth, because they, too, believe it to be their destiny to populate this new planet. In the end, Cylons and humans must learn to put down their arms and work together – human and machine on equal footing – in order for both groups of beings to survive. A thorough plot analysis is beyond the scope of this chapter about feminist science performance, but such an analysis would be a worthwhile endeavor in work relating to trauma studies and post-9/11 globalization and cosmopolitan theory.

[185] Jennifer Parker Starbuck's *Cyborg Theatre* is an excellent resource for those interested in the scholarly pursuit of robots and cyborgs as they appear in theatre. Other writers such as Kara Reilly, Michael M. Chemers, and David Z. Saltz are also good sources for robots in performance.

In her book, *Cyborg Theatre*, Jennifer Parker-Starbuck states that the cyborg appears in performance at moments when a culture is responding to a shared crisis that has caused a reassessment of its values and norms. Parker Starbuck fears that, counter to Donna Haraway's provocative feminist deployment of the cyborg, popular representations of the cyborg uphold rather than challenge liberal notions of access to social status and authority. She cites Anne Balsamo:

> The challenge remains to think about how we can study and write about identity in such a way that the on-going production of identities is honored and recognized as a potential source of feminist empowerment in our postmodern era. The cinematic imaging of cyborgs might suggest new visions of unstable identity, but often do so by upholding gender stereotypes. To this end, we need to search for cyborg images which work to disrupt stable oppositions. (Balsamo in Parker-Starbuck, 3)

The End of the Moon and *Battlestar Galactica* share a post-9/11 socio-political critique, but they differ in their narratives' ends. While *Battlestar Galactica*'s Cylon and human populations must struggle for survival in a post-apocalyptic universe, Anderson's concerns are more immediate. Her virtuosic performance of and with an array of technologies cause her take on a cyborg aesthetic as she articulates one aspect of American culture—NASA—that often comes across as science fiction to people who are not science experts. Her aim is to engage her audiences with science concepts in order to trigger a productive curiosity about those concepts that can be applied in a cultural domain that encompasses science as well as the rest of society. Anderson's *The End of the Moon* is an example of theories of the cyborg and posthuman because the performance artist isolates parts of socio-scientific systems in order to address the whole society. These systems include the technological systems on her stage, the networks of her professional life, and the corporate and government systems that affect global culture.

The examples discussed in this chapter are analyzed in terms of performatics, in order to indicate their role as science-arts hybrid entities at a moment during which global culture is

processing enormous socio-political changes. A performatics of science can encourage the viewer to identify and evaluate the cyborg interfaces within the socio-scientific system. Here, I apply the term "performatics," borrowed from Diana Taylor's use of the term within an Americas context, as I see it connecting to theories of cyborg, posthuman, and boundary politics. Haraway's definition of the cyborg includes three levels of "crucial boundary breakdowns that make the… political-fictional (political-scientific) analysis possible": animal-human, human-machine, and physical-non-physical (Haraway, 151). She suggests that the "cyborg appears in myth precisely where the boundary between human and animal is transgressed" (152). In this chapter, cyborg performances challenge notions of truth in images that conceal or awaken extra-visual data. These cyborg manifestations in performances of astronomy and cosmology indicate that something is amiss in the way that the public perceives new ideas about the previously unknown aspects of the universe. By highlighting the cyborg moments in performance, action might then be taken to emend social practices of unequal access to the domain of science.

Haraway defines the cyborg as, "a cybernetic organism, a hybrid of machine and organism, a creature of social reality as well as a creature of fiction" (149). She nudges this definition towards the recognition of the cyborg's place in second-wave feminism by insisting, "[t]he cyborg is a matter of fiction and lived experience that changes what counts as women's experience in the late twentieth century" (149-50). Haraway recognizes the world-generative role of imagination, both in the sense of literary domain of science fiction and in the political domain in which Arjun Appadurai's fluid imaginary works.[186] Haraway is, "making an argument for the cyborg as a fiction

[186] In *Modernity at Large*, Appadurai claims, "The image, the imagined, the imaginary–these are all terms that direct us to something critical and new in global cultural processes: *the imagination as a social practice,*" (Appadurai, *Modernity at Large*, 31). Rosi Braidotti, in *The Posthuman*, articulates the feminist underpinnings of a posthuman philosophy. Braidotti is interested in the identification of hybrid subjects that enact the global culture in which we all live. Her ground-up approach is be body-centric. She brings critical race theory, post-colonial theory, and feminist

mapping our social and bodily reality and as an imaginative resource" (150). She challenges liberal, male-dominated, textual, sight-oriented interpretations of science practice. A cyborg approach to the performance of science acknowledges qualities within science practice that have historically been neglected or taken for granted: women's contributions, mechanical labor, sense perception in addition to sight, and emotional investment.

Battlestar Galactica and *The End of the Moon* perform aspects of posthuman perception. N. Katherine Hayles's concept of the posthuman provides some connective tissue between the extended cognitive theories of Hutchins and Clark and the contained but emotionally-driven cognitive theory of Michelle Maiese, whose Emotional Embodiment Thesis (EET) will come to bear on the non-expert's reception of HST photographs.[187] Maiese recognizes networked detection

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theories to address the imbalance she perceives between the humanities and the sciences: "Feminist anti-Humanism, also known as postmodernist feminism, rejected the unitary identities indexed on that Eurocentric and normative humanist ideal of 'Man'… It went further… and argued that it is impossible to speak in one unified voice about women, natives and other marginal subjects. This emphasis falls instead on issues of diversity and difference among them and on the internal fractures of each category. In this respect, anti-humanism rejects the dialectical scheme of thought, where difference or otherness played a constitutive role, marking off the sexualized other (woman), the racialized other (the native) and the naturalized other (animals, the environment or earth)" (Braidotti, *Posthuman*, 27). Braidotti's posthuman perspective is important to hold in mind throughout this chapter, which on the surface may seem to engage with the same visually-oriented, science-contained, data-driven issues as have been associated with the performance of science since the seventeenth century. A closer look at these examples reveals a sense of the planetary, a need for a recognition of an approach to the performance of science that acknowledges all of its parts as essential to the actions of the whole.

[187] Hayles, in the book *How We Became Posthuman*, offers four basic defining attributes of the posthuman condition:

1. "… the posthuman view privileges informational pattern over material instantiation…"
2. "… the posthuman view considers consciousness… as an epiphenomenon, as an evolutionary upstart…"
3. "… the posthuman view thinks of the body as the original prosthesis we all learn to manipulate, so that extending or replacing the nod with other prostheses becomes a continuation of a process that began before we were born."
4. "…the posthuman view configures human being so that it can be seamlessly articulated with intelligent machines…" (Hayles, *Posthuman*, 2-3).

Her concern is with the materiality of information, or, the embodiment of knowledge. Like other cognitive theorists such as Hutchins and Clark, Hayles maintains an extended, embedded, and embodied position regarding cognition, but she is concerned with the idea of disembodied intelligence. She never asserts that a single human agent is entirely responsible for all actions, but she suggests that an inherently entangled network of human, machine, environment, and history is at work. She uses the example of her own body as "original prosthesis" in order to articulate an inherent posthumanity about the embodied human experience. As she works out this problem, she ascribes desires and actions to different parts of her corporeal system: her stomach wants food and so her body eats, her muscles require exercise and so she goes for a run, her brain desires words with which to think and so she

processes within the human body as related to networked perceptive processes involving machines, objects, and other beings outside of the individual human. Hayles disrupts a tradition of data-driven evaluative practices, like the critical scenario enacted in *Contact*, by placing embodied perception of the unknown on equal footing with machines capable of collecting data about otherwise imperceptible phenomena such as x-rays and infrared light. Anderson renders her technological environment at once a part of and distinct from her own body. She does not lose a sense of self, even as she operates her digital performance art assemblage as if it were a part of her. Rubin describes a similar sort of physical virtuosity necessary to the performance of astronomy. She waxes nostalgic when recounting stories about the days of her early observations and the skill required to manipulate the mechanical objects (spectroscopes and telescopes) necessary to the generation of new knowledge about the universe (Rubin, Interview, 2011). The performance of contemporary astronomy has become collaborative, involving many engineers, lab technicians, assistants, and computers to accomplish the high-quality imaging of previously unobservable astronomical objects. Within this highly fragmented, distributed system, the role of the lone astronomer has become a legendary antecedent to the performance of twenty-first century astronomy. However, in a Latourian sense, that astronomer has never really been alone, amidst the assemblage of actant objects that make such performances possible.

An accessible approach to the performance of astronomy adds a third domain of politics and activism to disrupt the false arts-science binary. Diana Taylor's performatic approach to the study of live events in the Americas helps to develop the theoretical connective tissue between live performance and the politics of access and opportunity across the boundaries of professional

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reads a book. By recognizing each human impulse as coming from within her own proprioceptive network, she defines herself as posthuman, and claims that, "[p]eople become posthuman because they think they are posthuman" (Hayles, *Posthuman*, 6).

disciplines. I rely on the Taylor's concept of performatics in order to keep the analysis of science performance centered on the body but within the hybrid networks of knowledge-generation that are not skin-bound. Taylor explains the term, "performatic," in *The Archive and the Repertoire*:

> Although it may be too late to reclaim performative for the nondiscursive realm of performance—*performático* or performatic in English—to denote the adjectival form of the nondiscursive realm of performance… it is vital to signal the performatic, digital, and visual fields as separate from, though always embroiled with, the discursive one so privileged by Western logocentricism. (Taylor, 6)

Taylor's approach works from the ground up and decenters the authority of text that pervades much of contemporary Western cultural analysis. As such, it equates bodies and live performance repertoire as sources of history, tradition, and cultural values with the kinds of information available in textual archives.[188] Like Taylor's application of the term to the domain of the arts, I suggest that *performatics* can be applied to the domain of the sciences. An accessible performance of science disrupts notions of cultural authority latent in so-called pure data research and the conservation of unequal power structures established during the early modern era. A performatic approach to science highlights the extra-male, global, multi-sensory, cyborg labor involved in the production of knowledge. Scientific visioning praxes can serve or resist existing power structures at work in the domain of science as well as the arts. An understanding of performatics helps to reveal where the performance of science already is already accessible to a general public, and where disparities still lurk.

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[188] Taylor upsets liberal power dynamics that can be replicated through purely text-based analyses of dramatic literature that ignore the specific bodies that work to bring that literature to life onstage, in the streets, and in other performance arenas. Taylor's use of the performatic enables a historiography of Conquest in terms that enrich, and sometimes replace, information contained within a text-based archive. Emphasis on performing bodies, visual representation, live performance, and digital documentation makes a diverse interpretation of the Conquest possible through analysis of bodies that enact, resist, and intervene into that scenario now, as they have also done in the past.

A performatics of science blends the two cultures of science and art by acknowledging both data/text and body/image as authoritative elements of a science event. Performatic examinations of science performance events focus on visual and embodied elements as much as dramatic text or scientific data. This is a potentially socially subversive act. Although Taylor invokes this terminology in order to bridge language barriers and academic prejudices stemming from the European Conquest of the Americas, a performatic analysis can also be helpful in bridging gaps between disciplines of arts and sciences. Performatics, the study of the body and its image in performance across domains helps to bridge interdisciplinary cultural divisions. Performatics necessitates the examination of drawings, material properties, and first-person accounts of performances in the domain of theatre and the domain of astronomy in order to assess embodied experience as meaningful. One important question that a performatic analysis of science raises is this: if bodies in the arts and humanities domains can be understood as performing science, then would Western society come to value these previously separate areas of interest (and the bodies that enact them) equally? Or, would the recognition that the performance of science in laboratory settings entails creative aspects traditionally associated with the arts—such as musical performance and graphic illustration—merge the sciences and the arts so that both might be valued equally in our current culture?[189]

Haraway explores the positive and negative aspects of technology that make informatics a trickster entity in late twentieth-, and, we can extrapolate, early twenty-first century culture. She defines "the informatics of domination" as a global status, "a massive intensification of insecurity

[189] There are many other possibilities beyond these two. One remains that neither the arts nor the sciences retain cultural authority in the twenty-first century. Other factors from other domains such as business and social media contend for popular audience. This chapter will touch on this line of thinking, but the focus remains on the development of the continuum of arts and sciences in global popular culture.

and cultural impoverishment, with common failure of subsistence networks for the most vulnerable" (*Simians,* 172). Haraway is interested in disrupting boundaries. She suggests that access to information and power has become more fluid due to communication networks and data storage systems that have become smaller. In recent years, digitization has added to this fluidity of information and capital. She observes that despite this new, boundary-defying, socioeconomic power network, people cannot cross boundaries with nearly as much ease: "these machines are eminently more portable, mobile—a matter of immense human pain in Detroit and Singapore. People are nowhere near so fluid, being both material and opaque. Cyborgs are ether, quintessence" (153). Cyborgs are neither body-bound nor as free as the air that humans breathe because they entail informatics, organics, and mechanics. Haraway's views on the radical equalizing potential of these portable, hybrid technics follows:

> From another perspective, a cyborg world might be about lived social and bodily realities in which people are not afraid of their joint kinship with animals and machines, not afraid of permanently partial identities and contradictory standpoints. The political struggle is to see from both perspectives at once because each reveals both dominations and possibilities unimaginable from the other vantage point. Single vision produces worse illusions than double vision or many-headed monsters. Cyborg unities are monstrous and illegitimate; in our present political circumstances, we could hardly hope for more potent myths for resistance and recoupling. (154)

Cyborg performances such as Anderson's *The End of the Moon* highlight the performatics of science practice, increase empathy for all of its parts, and make the domain of science more accessible to a general public.

4.2 "STARS. FIRES OF THE UNIVERSE. SO MANY DIFFERENT COLORS." LAURIE ANDERSON AND *THE END OF THE MOON*

Randy Gener, in his review of *The End of the Moon* praises Anderson's "faux-naif mutability, her techno-artist reputation and cross-wiring of art modes [that] are part of her idiosyncratic appeal—the reason she was selected by NASA's Art Program.…" (Gener, n.p.)[190] The Program's original director, James Webb, "wanted to convey to future generations the hope and sense of wonder that characterized the early days of space exploration" (NASA ArtSpace). Anderson does stage a sense of wonder at the unknown aspects of outer space, the uncanny nature of abstract cosmological theories, and the many new technologies that have been invented in order to understand space in greater detail. Her cyborg performance also underscores hidden connections between the U.S. government and NASA during the years directly following 9/11. Anderson awakens a sense of wonder and curiosity in her audience, but towards the end of increasing access to science issues so that a general public might become empowered to speak up in the face of the informatics of the post-9/11 United States war machine.

The opening image of *The End of the Moon* is a pastiche of familiar twentieth century entertainment and news media icons that have come to define an American relationship to the night sky. The tableau is reminiscent of Clement Hurd's illustration of Margaret Wise Brown's children's book, *Goodnight Moon*. Anderson is seated in the downstage right chair (where Wise's mother bunny sits), surrounded by stars represented by tea candles scattered across the stage, with the man-made moon image contained in its upstage left corner. Anderson's moon is a fragment. It

[190] The NASA Art Program was founded in 1962 as an attempt to make NASA's enterprises more available to a popular American public.

represents the partial relationship that a twenty-first century human has with any visible piece of the universe. Anderson's synecdochal moon is a projection of the well-known photograph of Neil Armstrong's footprint, taken in 1969. As with its original appearance in newspapers and television screens, the image on Anderson's stage is square and close-up, not round or crescent-shaped and distant. Familiar, small, and conquered, the moon that appears in Anderson's play is projected onto a standard, classroom-sized screen. It holds its place as moon in the corner of the tableau of the night sky. These images' ubiquitous status to American pop culture renders them familiar. The sense of familiarity that Anderson intentionally evokes sets up an immediately empathetic relationship between the general audience and a performance that is highly science-oriented.

Anderson's text, like the images she stages, is also partial. This performatic point of view is also posthuman in the sense that each part of the performance is depicted as actant within the whole, if not entirely autonomous. She verbally introduces her story by identifying only a small piece of the NASA system—a single voice—before identifying the whole organization. The stasis of her tale begins with a description of a typical day in her studio in the company of her dog. Already, a cyborg system is in place: a human works in the company of an animal and is then interrupted by a technological communication device that connects her to a government agency with networks that extend deep into outer space. The telephone rings. She describes the NASA representative on the other end of the line not as a person, but as a piece of a human, a voice: "the voice said, 'this is so and so and I'm from NASA and we'd like you to be the first artist-in-residence here.' 'You're not from NASA,' and I hung up the phone." She goes on to recount how the voice from NASA called back, and so her astronomy-integrative performance devising process began. Anderson's choice to depict NASA as a voice renders the giant organization more manageable—for herself as the character that she portrays, but also for her audience. One person

can have a conversation with a voice on the telephone, but to encounter a high-profile organization such as NASA in its entirety might be overwhelming and alienating. Anderson transduces NASA into a familiar object by taking it apart and giving it a voice. Thus, she allows the audience to share her science-arts residency in an empathetic manner.

Jennifer Parker-Starbuck proposes "cyborg theatre" as a more accurate moniker than multi-media to describe work such as Anderson's:

> Cyborg theatre is a term that can address … work that, through the integration of bodies and technologies, might offer provocations about cyborg subjectivities… it looks… into the points of contact and integration between bodies and technologies, investigating the impact of such integrations in contemporary performance. (Parker-Starbuck, 6)

Anderson's *End of the Moon* addresses Parker-Starbuck's concerns regarding the body and cyborg embodiment while also engaging with socio-political commentary. Anderson wonders at the human being behind sublime HST images. She remarks upon her dog's terror at being hunted by a hawk and draws a direct correlation to the dumbstruck horror shared by many Americans after 9/11. She revels in the fantastic elements of space suits that make the wearer super strong, and then pauses as she reflects upon the U. S. Army's appropriation of this NASA project during the early years of the second war in Iraq. In every scenario, human bodies are narrated as part of a hybrid network of technology, politics, and environments that are all transduced for the audience through Anderson's skillful manipulation of stage technology that becomes, as we shall see, a sort of detection device for her audience.

Anderson's performance is joyfully cyborg; she fully inhabits her organic body, but her hybrid stage presence extends through her deployment of an assemblage of technologies. Multi-media performance has long been a part of Laurie Anderson's theatrical repertoire. *The End of the Moon* incorporates a slew of technologies which share focus with Anderson as her story weaves

between expressions of wonder at the perceptual enhancements that technology is able to produce and experience of the technique involved in creating representations of newly detectable phenomena. In his 1997 essay, "Laurie Anderson for Dummies," Jon McKenzie describes Anderson's hybrid performance as "… an electric body in which gestures, stories, and songs mix with synthesizers, video projections, printed matter, and, most recently, personal computers" (30). He never applies the term "cyborg" to Anderson's work, but linguistically dances around it, and arrives at a definition that is close to my own combination of the terms "cyborg" and "performatics":

> … she supplements living behavior with film, video, tape, synthesizers, and computers to enhance the building and playback of her idiosyncratic archive. Through her electric body, she connects cultural performance to other performances… she plugs her electric body into corporations… who mass produce her work and in turn plug her through various media blitzes. Through such corporate bodies, she thus links up with the language of bureaucratic performance. (McKenzie, 31)[191]

Among the stage technologies assembled for *The End of the Moon* can be found projection and imaging technologies, the synthesizer and microphones that allow her to provide digitally enhanced background sound and to alter her voice during her storytelling, her trademark electric violin, Anderson's virtuosic performing body, and fire. His description of Anderson's cyborg body as plugged into the system of globalized United States corporate and government enterprises is an apt descriptor for her performatic comment on science and society. And yet, McKenzie's description of Anderson's body as "electric" fails to acknowledge the organic component of her system. Anderson's performance may be posthuman in the sense that she is capable of deconstructing networked systems into their component parts, but she does so in order to make

[191] McKenzie's aim here (in part) is to rehearse the corporate, business aspect of the term "performance," which constitutes a significant third leg in the stool that supports his 2001 *Perform! Or Else…*

large, science-oriented systems accessible to general audiences. She performs herself as part of the system of NASA, along with the voice and the synthesizer that allows her to create that voice, but Anderson the creative agent is not lost among the technologies that share her hybrid stage.

4.2.1 "We're always fixing up photographs": HST and the Familiarity of Space

Part of Anderson's critical performance is the simple expression of her curiosity about how NASA scientists do their job. She verbalizes a discrepancy between how celestial objects exist in their original environments (in distant galaxies undetectable to the unaided human eye) and how those objects are represented to consumer-audiences of science media. Anderson's concerns resonate with the centuries-old debate over whether or not authentic information about celestial objects can be trusted. Anderson brings her critique of technologically mediated images back to the human body. "We're always fixing up photographs," she remarks as she compares the work of NASA Hubble engineers to photoshopping a "miserable family Christmas" photo. "One of the things that really bothers me about photography," she continues, "is that you never know how hot it is in the photograph" (*End*).

Anderson's problem with photoshopped digital pictures and heavily mediatized HST images has to do with the fragmented, posthuman condition that has been at work in the performance of astronomy since Galileo's introduction of the telescope to the discipline. As Crane points out in her examination of early modern examples from the domain of science, Anderson's examples still run counter to "basic sensorimotor experience," and her allegorical explanation to HST colorization is an attempt to bridge the Crane's "gap" "between nonscientists and nature" ("Analogy, 107). Anderson allegorically describes her frustration with astrophotography's incapacity to accurately convey the environment of a star or a galaxy in a two-dimensional image.

She compares HST images to the presence of a sweater in a family photograph which only suggests a cold exterior temperature, but doesn't allow the observer to really feel the cold or the heat; temperature and physical comfort or discomfort are not accurately indexed in a photograph. Colorized HST pictures, she argues, are simply archives of data that document conditions which remain outside the experiential grasp of the earthbound human observer. A photograph's observer cannot distinguish the difference between the photographic subject's embodied experience (i.e., what was the temperature at the time and place that the photograph was taken?) and the record of that experience (the colors that astrophotographers assign to different temperatures and spectra). The human observer experience the discomfort caused by a bulky holiday sweater, but that information—the fact that a family was assembled at a particular point in time and space—is indexed by the presence of the sweater in the photograph. The colors, texture, and size of the sweater, and who was wearing it are embedded in the photograph, but the embodied experience of wearing the sweater is a much trickier experience to share with an observing agent across distances of time and space. A photograph lacks the ability to convey a one-to-one relationship between the observer of the photograph and the photographic subject.

In the case of the HST, this translates to the observer of the photograph's inability to sense data that does not exist on the visual spectrum in its original environment; earthbound humans are always a step removed from the original subjects of astrophotography. But, the observer of the family photo may have a memory of the kind of tactile, sensory experience that is indexed by the appearance of a sweater. In this sense, the photograph performs a warm human body at a cold time of year, regardless of whether or the photograph was staged in New Mexico in July or New Hampshire in December; the narrative triggered by the photograph is not necessarily an accurate representation of original photographic conditions, and digital manipulation makes this illusion all

the more possible, which keeps second-hand observers to the photographic performance at a distance from experiencing that originary environment. The use of color in HST photographs is an index of the presence of a substance, temperature, or radiation, but at a distance. Colorization is a step towards the posthuman project as articulated by Hayles in that it attempts to, "[configure] a human being so that it can be seamlessly articulated with intelligent machines…" (*Posthuman*, 3). Ultimately, the colorized photo fails to reproduce a celestial original for an earthbound observer. Like Cavil's frustration at not being able to experience a supernova in all its spectral splendor, so Anderson is unsatisfied by the capacities of HST mediation to replicate similar celestial objects and events.[192] HST images will resurface later in this chapter in a discussion of graphic and photographic imaging in the performance of astronomy.

4.2.2 Embodying a Posthuman Sense of Wonder

Anderson frames wonder at the natural world—the universe, the stars, the moon—as an antidote to the fear that she perceives to be endemic to American life in the early twenty-first century. She does this through a playful manipulation of technology.

Anderson performs a moonwalk sequence in order to discuss the performatics of NASA's process of human space exploration. She creates an illusion of weightlessness onstage through the use of a live feed video camera. Anderson doesn't pretend to be weightless in this sequence; instead, she delights in sharing the creation of the illusion of the moon-walk with her live audience. Anderson's video play makes the performance artist's stagecraft transparent as it engages audience members in a narrative about gravity. Anderson stages only herself and replications of her body

[192] The performatics of HST colorization are taken up later in this chapter.

through multiple media. At this moment in the show, she shifts from storytelling into the manipulation of her body's image in order to encourage the audience to deepen their empathy during her discussion of gravity and the moon. "Our moon is just the moon," she points out, as she turns on camera and turns it towards herself and the audience. (*End*). The static image of the astronaut's footprint on the upstage screen is replaced with the live projection streaming from Anderson's camera. She holds the camera upside down so that her projected image appears to be floating on the space of the stage, also upside down, with the stage light shining like a sun behind her disembodied head. At the same time, the camera picks up some of the tea candle stars on the stage, and in an instant doubles the amount of "space" represented through Anderson's handheld projection device. She keeps the image moving, so that her inverted head gently bobs up and down as she talks about gravity, reflects on the experience of seeing old photographs of astronauts "suspended, floating in space" during her residency at NASA, and imagines what it must be like to walk on the moon.

Anderson uses popular science concepts such as gravity to hook the audience's curiosity before she embarks upon her quest to re-instill a sense of civic authority to access and act within domains of science and politics. Anderson's use of technology in performance, while there are some funny moments, is overtly political in its call to audiences to engage with science issues that permeate the political domain. The overlap between the capacity to be moved to a state of wonder and the capacity to be moved to a state of civic action is the space that Anderson fills. The simultaneous contexts of a New York still emotionally responding to 9/11 and a political resistance to the 2003 invasion of Iraq inform much of Anderson's narrative in this performance, the second in a trilogy composed with a post-9/11 world in mind. Anderson's performance makes visible the hidden scientific engines that are appropriated by a cultural war machine. She maintains a healthy

skepticism about NASA's ends, though it is not her intent to mock NASA scientists. Early on in the performance, she reminds the audience that, for NASA, there is no such thing as pure scientific research, but that NASA research is often coopted by the American military.[193]

For example, she describes the technology that is built into this cyborg creation of NASA's new spacesuits. These suits, according to Anderson will, "increase your strength, say, forty times." The suits contain all kinds of "liquids" and "entry points for medicine." Just as the audience starts to dream about space suits capable of transforming the human into the superhuman, Anderson reveals that the super suit project's contract has been transferred from NASA to a "new joint team" between MIT and the United States Army. Contrary to a pure science ideal of research performed for the sake of discovery, the suits will not be worn by astronauts on the moon, but will be sent, "out into the desert. Out into the world" (*End*). Domains of performance activate the domain of the political through an understanding of the domain of science. Anderson deploys a Brechtian technique of disrupting the audience's reverie by shocking them out of a quasi-sci-fi fantasy report on space suits and back into their seats with news about the grim reality of war times.

Anderson's video-play achieves a Brechtian *verfrumdungseffekt*, wherein audience members are alienated from their familiar relationship with gravity in order to appreciate it and share in Anderson's wonder. Anderson proclaims, "Gravity is an illusion, a trick of the eye, not a force" (*End*). Gravity, in its ubiquity to the experience of life as it is situated on Earth, is often taken for granted in the thoughts and actions of most people as they go about their daily business. Most people are not astronauts and never have the opportunity to experience a spacewalk for themselves. Imagination and illusion enable non-astronaut humans to participate in this rare aspect of the human experience. Anderson mediates the experience of gravitylessness for her audience.

[193] This is not a new theory. Many books and articles link the space race with the Cold War.

"Excuse me, can you tell me where I am?" The subtext of this question is another question: which is real—my body that is holding the video camera or the body projected by the video camera? Or, how can the observer trust the images that come through a hybrid transductive process? She segues into a musical interlude that provides the reflective space for her audience to continue to ponder the experience of weightlessness and the role of the individual in the socio-technological tangle of post-9/11 culture. She holds the camera in her bow hand, and now the image on the screen is from the point of view of the bow as it strokes the violin strings. The bright stage lights remain in the background and the illusion of space persists as the audience is presented with the live Anderson playing her violin beside the projected, more intimate, close-up image of her closed eyes as she plays. If the experience of gravity is an illusion, then perhaps so is the experience of self.

The End of the Moon can seem to be internally contradictory—should the non-scientist viewer love NASA or fear it, for example? Seen as a whole, the balance between science and art, fear and wonder, becomes evident. This ability to isolate individual parts in order to realize a whole system is part of Anderson's posthuman stage presence. Ultimately, Anderson's piece is about the balance between scientific curiosity and the potential dangers of its application in a war-mongering, fear-driven culture. Her doubled self—on the stage as well as on the projection screen—becomes an embodied and extended metaphor for the ways that humans can hold simultaneously contradictory opinions about the same subject. She brings up social stases of war and peace as poignant examples for 2005, "yes," she says, "you can keep two things in mind… we can hold both at once without dropping" (*End*). She shares an observation about time that she made on a visit to NASA's jet propulsion lab:

> If there's one thing I learned at the jet propulsion lab, is that it's pretty pointless in sending people out on these really long expeditions… Taking a trip like that depends. It depends on how you choose to see time moving… Slow… Running

> down… Breaking down… Or maybe you believe instead that things are picking up, getting faster, more beautiful, more hopeful…. We believe both. (*End*)

Anderson closes the show with a monologue in which she imagines the end of time that is a mixture of theories of quantum physics, dream sequences, and, of course, the haunting musical accompaniment of her electric violin. She finishes with a comment on the insufficient, wonderful, and hybrid nature of human cognition at the dawn of the quantum age: "Sometimes, I think I can smell light" (*End*). Anderson's closing sentiment anticipates *Battlestar Galactica*'s Cylon desire: "I don't want to be human. I want to see gamma rays. I want to hear x-rays. And, I want to smell dark matter" ("No Exit," 2009). The difference is that while *Battlestar Galactica*'s fictional cyborgs lack the capacity to detect the otherwise undetectable, Anderson's suspicion is that (post)humans already can. Anderson acknowledges that those media are already a part of the network through which we know the world. Anderson's performatics encourage her audiences to engage with the domain of science in order to stay informed and active in a culture that would apply detection-related technologies developed in the domain of science to the art of global warfare.

4.3 TO SEE GAMMA RAYS AND TASTE THE MILKY WAY: MULTIPLE SENSE PERCEPTION EMBEDDED IN ASTRONOMICAL IMAGES

The process of enacting astronomy in the domain of science is inherently posthuman because it involves a hybrid assemblage of machines, humans, images, and spaces for its successful performance. The introduction and acknowledgment of underrepresented agents and actant objects into an existing science practice can result in an expansion of the human capacity to detect

previously undetectable details about outer space. Expanding the inclusion, visibility and acknowledgment of underrepresented agents involved in the performance of astronomy has been a part of Vera Rubin's path that runs on a course parallel to her important contributions to the domain of astronomy. As the first woman to observe at the San Diego's Palomar observatory in 1965, she broke barriers of access to the profession of astronomy that had historically prohibited women from practicing as lead astronomers in the United States. Once she had proven her trustworthy science practice, she was able to apply her status towards the end of advocating for increased access to the field through popular science writing and public speaking. The production of new knowledge based on highly mediatized images of deep space data have been a central component of her work as an astronomer.

4.3.1 Vera Rubin and the Visualization of Dark Matter

Vera Rubin used a combination of traditional observation devices and data imaging systems in order to collect evidence to support the theory of dark matter by training her gaze on the relatively nearby Andromeda Galaxy.[194] Dark matter is invisible to the unaided human eye in all aspects except in its effects on the visible objects in its proximity. Astronomers use graphic organization systems to communicate complex cosmological theories such as the theory of dark matter and dark energy to people who are not professional theoretical cosmologists. Images help the numbers to perform for a general audience.

[194] "Andromeda, also known as Messier 31 (M31), is a spiral galaxy located about 2.5 million light years away. It is thought that the Milky Way and Andromeda will collide several billion years from now" ("Andromeda Galaxy," *NASA TV,* www.nasa.gov, 12 June 2013, web, 20 June, 2015).

In 1965, Rubin, then working with Kent Ford and his new image tube spectrograph, performed new observations of M31.[195] Visual representations of the velocities of the stars moving in the Andromeda Galaxy and other spiral galaxies are called rotation curves and are plotted as line graphs. Rubin's new rotation curves caused the astronomy community to take notice because they evidenced the probable existence of dark matter. Nothing else, then or now, accounts for the surprising motion of M31. Rubin's observations, transduced as visual images, provided the evidence necessary to convince a skeptical audience of peers of dark matter's probable effects upon the movement of spiral galaxies.

Vera Rubin betrays her bias for observation (as opposed to model-making) as a preferred method for understanding the universe in, "A Century of Galaxy Spectroscopy," included in her collection of essays, *Bright Galaxies Dark Matters*. She praises H. Arp's project, the *Atlas of Irregular Galaxies* (1966) as "a monument to the importance of just looking, even before an understanding of process is in place" (140). She underscores her fondness for the painstaking, time-consuming, intimate process of observational astronomy with an analogic quote from the visual artist Georgia O'Keefe, "It takes time to see, just as it takes time to make a friend" (O'Keefe in Rubin, 140). Astronomical observations are, like the observation involved with creating a representational work of art, emotional, embodied experiences that take place in time and space. A familiar relationship must transpire between the object observed and the observing subject in the several domains of the laboratory, the observatory, the gallery, and the theatre.

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[195] "For the past six years, Rod and I have been obtaining spectra from selected areas within M31…. We have been working on the spectra of the HII regions since 1966, using a spectrograph that was designed and built in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington…. The spectrograph has been attached to the 72-inch Perkins reflector of Ohio Wesleyan University and Ohio State University at the Lowell Observatory and to the 84-inch reflecting telescope at the Kitt Peak National Observatory near Tucson, Arizona" (Rubin, 37). This article was originally published in *Scientific American* in 1973.

Visual aids that resemble familiar celestial objects hook audiences with recognizable content. Once an observer is engaged with a familiar image, that observer becomes better able to perceive new information about that object. Rubin's most convincing evidence for the existence of dark matter comes in the form of a line graph.

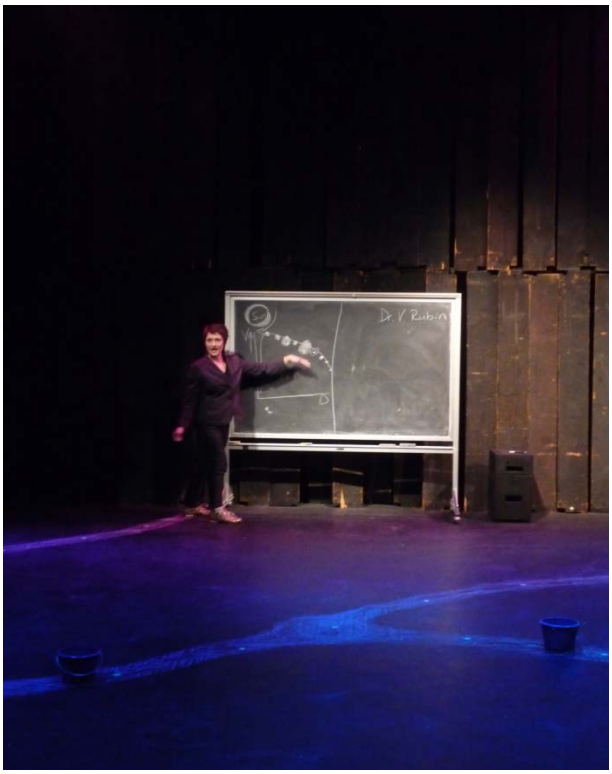

Figure 7: Vivian Appler as Vera, 'In the Still of the Night,' demonstrates the rotation curve of our solar system behaving according to the Newtonian laws of gravity. Photo by Peter Wood.

Graphs that appear in popular science publications are often accompanied by representational photographs of M31**.** The familiar photographs function as a human entry point into the cartography of directions, rotations, distances, and velocities represented on the charts that accompany them. The picture of the Andromeda Galaxy placed with the graph provides a familiar enough reference for the non-expert viewer to contextualize new information about M31.

Vera Rubin's line graph/rotation curve provided the compelling, empirical evidence for the existence of dark matter in the galaxy of M31. As she describes in interviews and essays, her graph

demonstrates that the motion of stars in a galaxy do not behave in a manner that astronomers had predicted based on their observations of the planets moving in our solar system, in which planets closer to the solar system's center move at a higher velocity than the planets farther from it.[196] The velocities drop the farther they are from the center of our solar system because of the lack of gravitational pull on them from the large object (the sun) at the center. Rubin discovered that when the velocities of the stars in the Andromeda Nebula were plotted on a line graph as a function of their distance from the center of the galaxy they did not decrease, which was a surprise. The stars at the edges of M31 moved at the same speed as the stars closer to the center, and appeared as a flat rotation curve when Rubin reframed the information, and placed the center of the Andromeda Galaxy at the intersection of the *x* and *y* axes of the graph to create an image that looked like the image on page 40. Without extra mass, the stars at the outer edges of M31 would not have sufficient gravitational pull to move so quickly. Therefore, Rubin and subsequent astronomers suspect that there must be matter that is somehow undetectable to current spectrographic technologies. Scientists, including Rubin, are still performing experiments in pursuit of this anonymous player in the material corps of the universe.

4.3.2 Embodiment and Image in an Accessible Performance of Astronomy

Graphic images communicate information quickly and efficiently, without mathematical equations and intricate textual supplements; the pie chart performs this task particularly well. The images used to convey abstract concepts may appear simple, but there are reasons why scientists and non-scientists alike respond to certain kinds of iconic images even though the indexical nature of these

[196] This is an observation that adheres to our understanding of Newtonian physics.

images is interchangeable. Whereas an icon represents an idea or an object through an image on a one-to-one basis, indexical referents suggest the presence of a certain kind of data that is not necessarily otherwise present in the image. For example, many popular cosmology books that endeavor to explain dark matter to non-scientists include a chart that looks something like this:

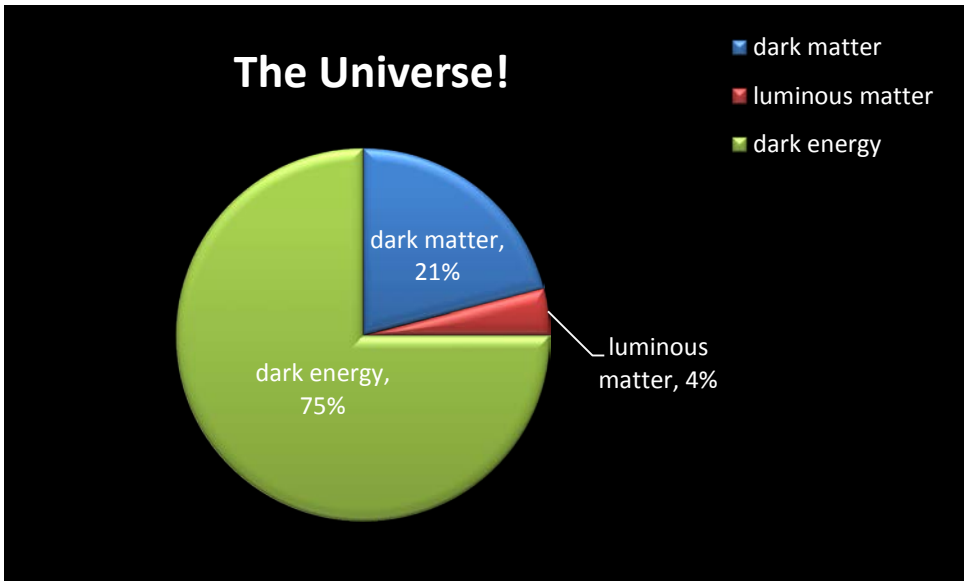

Figure 8: Pie chart of dark energy, dark matter, and luminous matter.

It is always a pie chart. The same information could be represented as a bar chart, which would look like this:

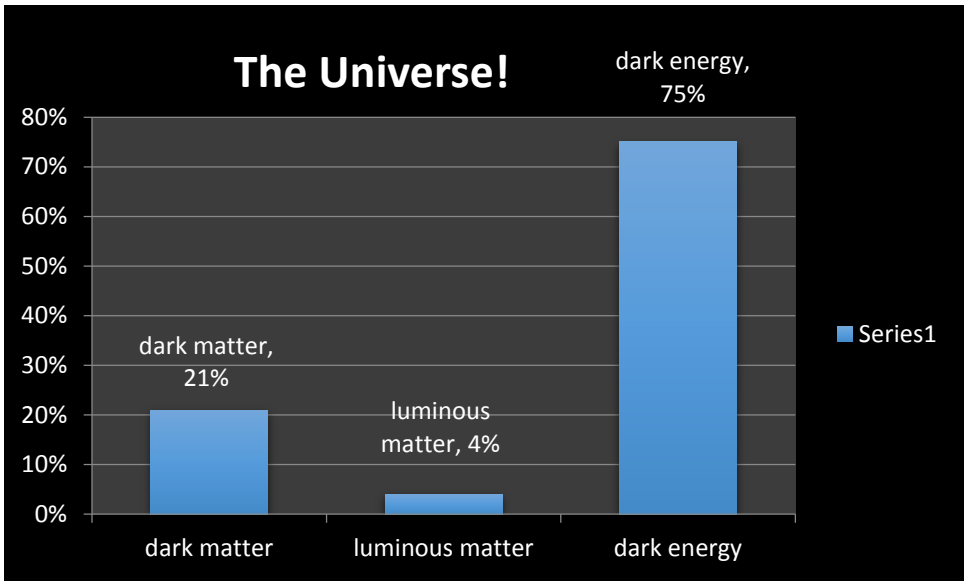

Figure 9: Bar chart of dark matter, dark energy, and luminous matterBar chart of dark matter, dark energy, and luminous matter.

A line graph would look like this:

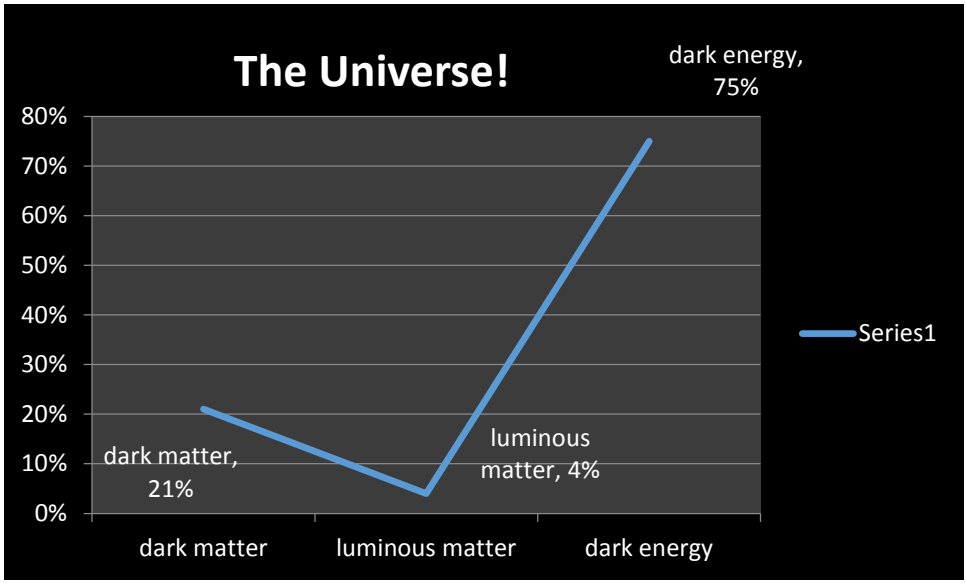

Figure 10: Line graph of dark matter, luminous matter, and dark energy.[197]

[197] All three kinds of graphic illustration tools were invented by William Playfair between 1785 and 1801. For more information about the history of graphic illustration, please refer to Ian Spence's article, "No Humble Pie: The Origins and Usage of a Statistical Chart."

The pie chart is an efficient medium for the conveyance of proportions within a contained set of information, even when that container is as vast as the universe and the information is as ineffable as dark matter.[198] The medium of the pie chart outperforms other graphic illustration tools in popular science news. In terms of its technical performance, McKenzie argues, "we can say that engineers and technicians measure the effectiveness of performance in terms of executability, the technical 'carrying-out' of prescribed tasks…" (*Perform*, 97). For the task of comparing quantities of parts within a whole, the pie chart depicts the universe's proportional composition as well as if not better than the bar chart. Ian Spence argues that pie charts are simply more elegant than bar charts or line graphs. He offers that the reason for the pie chart's success as an easy visual reference is because, "the pie provides at least five natural anchors (0%, 25%, 75%, 100%) compared to only two or at most three, for the divided bar (0%, 50%, 100%). A bar chart—without a reference bar—affords no natural anchors to assist in the accurate estimation of proportions" (Spence, 363). The observer sees a whole circle and can imagine a whole universe within that circle. The subsequent imagination of dark matter, dark energy, and luminous matter as a part of that circle follows easily.[199]

In the twenty-first century, the data an individual encounters when embarking upon research into the astronomical is far greater than the data that stretched the imaginations of seventeenth-century audiences after the introduction of the Galilean telescope. As we have seen through Crane's historiographical analysis of early modern astronomy, analogy served to assist the

[198] As Spence notes, the pie chart is not necessarily the most accurate of Playfair's graphic illustration tools, but it works well for the communication of quick estimates of parts within a whole.

[199] The avalanche of cosmological questions suggested by the placement of the title, the legend, the surrounding box outside of the circle that represents the universe, and the viewer reading the article imply that our notions of wholeness and universe are in need of reevaluation. Please see Kaku, Greene, and Randall for further discussions of extra dimensions, bubble universes, and parallel worlds.

scientist and the non-scientist in relating to vast amounts of new information about previously undetectable cosmic phenomena. In the twenty-first century, embodied analogy continues to aid non-experts as they encounter new information about deep space objects. However, the analogy is often embedded within the performance of visual images that transduce new data about familiar objects.

The KWL chart visually organizes information about an unfamiliar topic, but it explicitly builds upon an extant emotional connection with that topic, and the subjective desire—or lack thereof—of the individual to learn more about that topic. Maiese emphasizes a mindfulness of the present moment that is required for perception, a process that she argues is essentially emotional. Mediated images have a simultaneously forward- and backwards-working effect on the non-expert observer who remains, unavoidably, in the present moment of engaging with mediatized images of otherwise invisible cosmological phenomena. In the moment of observing a heavily mediated image of an object that would otherwise be impossible to perceive, non-scientists engage in a cognitive process that requires them to draw on any previous knowledge about that object, and apply that knowledge to the image before them. Then, it is up to the intentional observer to act or not to act upon—to incorporate or not—that new knowledge as she or he follows time's arrow into the future.[200] This is not unlike the way that a very basic KWL chart is used to organize information with groups of students in elementary classrooms across the United States. A KWL graphic organizer is used by teachers to lead students through a brainstorming process about new curricular material. They discuss what they already know (K) about the topic, what they want to know (W),

[200] In the case of a pie chart about dark matter, one might remember the act of eating pie and then associate pleasant sense memories to the new content contained within the chart.

and, after having done their research, what they have learned (L).[201] This kind of elementary graphic organizer looks something like this:

What We Know (K)	What We Want to Know (W)	What We Have Learned (L)

Figure 11: Example of a KWL graphic organizer.

By taking the time to assist students in a communal brainstorming session about a topic, such as the Andromeda Galaxy, teachers bring the past to the present in order to better act in the future as they plan to encounter text about a new subject. Although KWL is not an image like the pie, it visually separates information about a topic while remaining true to the student subject's desire to know.

KWL charts establish that the reader or audience member recognizes that she knows more than she thinks she does when encountering a new concept, even if that knowledge is a feeling towards the concept. For adults engaging with popular news media, the science writer and graphic illustrator facilitate the adult non-expert's experience with new information about science news by graphically and imagistically arranging that information in an empathetic manner. Emotion, memory, and extra-visual sensation each contribute to the feminist performance of science as it appears in popular media. The gustatory appeal of the pie chart may be related to a trend in science

[201] Donna M. Ogle introduced this approach to learning in the article, "K-W-L: A teaching model that develops active reading of expository text," in 1986. Since then, it has become ubiquitous to elementary school education.

outreach to draw the attention of non-experts in an embodied manner. In Chapter 3, I discussed the audience's need to empathize with characters in plays about scientists in order to care about the story enough to understand the science content. Similar cognitive functions are at work when it comes to the representation of science content in twenty-first century popular news media. Maiese's EET offers some clues as to why multiple sensory experiences can help the non-expert to engage with unfamiliar science concepts in the news.[202] Sensory experience and personal memories contribute to a feeling of familiarity with an object of an observing agent's attention. When popular science writers and astronomy illustrators wish to attract the attention of non-experts, they compose images and accompanying texts that stimulate as many senses as possible. By referencing senses in addition to what is readily available to sighted readers, popular science writers trigger emotional audience response based on individual memories of past experiences. This kind of science writing incorporates subjective experience and sensory mechanisms other

[202] EET is a version of cognitive theory that supports a feminist approach to the performance of science because it embraces the ephemeral nature of the present—the moment in which performance exists—as well as the subjective desires of the individual, performing subject. Maiese suggests a number of ways that an observer might come to actively care about the objects in her or his environment. She describes these components as the five "intrinsic… structures of every consciousness…" (25) that include:

1. conative affectivity, "… the 'experiential' aspect of consciousness… which… necessarily involves desire" (26);
2. egocentricity, "…whereby the body serves as both the source and the target of affection" (27);
3. spatiality, the sense by which "[s]ubjective experience necessarily occurs *here*, wherever the body happens to be located" (28)
4. temporality, the sense by which, "[o]ne always experiences one's conscious states as occurring now and as unfolding in time, and the intransitive and direct acquaintance that one has with one's bodily subjectivity involves a flowing or streaming" (29); and
5. and intentionality, or, the way that, "… the body is that *in and through with* the organism is directed toward the surrounding world during both perception and action" (41).

According to Maiese, these qualities are inextricably linked to embodied perception of phenomena that occur in the world outside of the body's physical boundaries. For Maiese, the body is seen as the subject that is capable of desiring sensational experiences of the world outside and within its proprioceptive system. This process of perception occurs in the here and now, but it is the performing agent's desire to enact the perceptual experience, the desire to know, that drives a body to take action and thereby come to know about that which is previously unknown to it.

than vision in order to elicit diverse engagement with astronomical events and objects that exist beyond the range of unaided, earthbound observation.

Sensory and memory components contained within visual representations of abstract ideas such as dark matter help the non-expert relate to these abstract concepts. Maiese states:

> Emotions, essentially, are how minded persons like us *care*, and it is because we *care* that we are capable of apprehending the world as meaningful and as an arena of possible goals. An essential component of care is *desirideraitve bodily attunement*, which is what anchors us in the world and makes all that we encounter intelligible by virtue of the fact that it *matters* to us in some way or another. (3)[203]

Like the audience member who is likely to care about a protagonist that performs a familiar lived experience, a popular science reader is more likely to be interested in reading an article about abstract science concepts if there is something familiar about that article's content. A pie chart may appeal to a novice scientist because of a subtle sense of recognition. A pie chart may strike a familiar chord with Western readers because they see the familiar shape of a circle, understand the graph's popular connotation as "pie chart," and are reminded of the experience of eating.[204] Part of the pie chart's popular appeal has to do with its capacity to stimulate multiple sense memories in the body-mind of the observing agent. The pie chart is particularly useful in communicating abstract information to a general public who might be more likely to read *Newsweek* than *Scientific American*.[205]

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[203] Italics original.

[204] While this theory may not be universal, it does apply to several Western European and American cultures. In the United States and Britain, the term "pie chart" has been adopted to refer to a circular graph. In Italy, people refer to it as a *grafico a torta*. In France, it's not pie, but cheese; a circular graph is colloquially referred to as a *camembert*. Spence observes, "Like us, the French employ a gastronomical metaphor when they refer to Playfair's pie chart, but they have preferred instead to invoke the name of the wonderful round soft cheese from Normandy—the camembert," but he does not ponder the underlying cognitive appeal of applying an edible metaphor to statistics (Spence, 360).

[205] In fact, Spence notes that the use of pie charts is lowest in publications dedicated to business and science news. Magazines such as *Scientific American*, geared towards science "experts," are less likely to sue the pie chart than publications with a more general audience (Spence, 365-6).

A popular performance of science frequently stimulates senses other than the visual in order to engage a diverse participatory audience. Extra-visual senses come into play when outreach astronomers appeal to general audiences. Part of the project of choosing colors that people will respond to is also an attempt to encourage an emotional popular response to images of objects that already hold some sort of cultural authority.[206] The performance of astronomy is not empathetic in the way that a representational film is. Rather, compound images of celestial objects engage non-scientist audiences in embodied and empathetic responses to the objects themselves through their propensity to attract human sense perception. While the images discussed above primarily elicit a visual response, one science news headline in recent years announced, "Galaxy's centre tastes of raspberries and smells of rum, say astronomers: The hunt for chemicals in deep space that could seed life on other planets has yielded a large, fruity molecule" (Sample, n.p.)[207] Astronomy, as it is performed in this headline, is irresistibly sensual; who wouldn't want to know what the center of the Milky Way tastes like, were they able to eat it? The headline grabs the non-scientist because of a likely familiar taste memory of rum and raspberries. While the center of the Milky Way galaxy is probably not a fantasy land that "tastes of raspberries and smells of rum," the sense memories evoked through the act of naming those pleasurable smells and flavors engage a potentially otherwise disinterested non-science audience in the act of thinking about astrobiology.

[206] For more on the questionable cultural authority of the photograph, please refer to Dingley's, "The Unreliable Camera." For more on the authority of the astronomical photograph in particular, please refer to Shana Cooperstein's article, "Imagery and Astronomy." These articles, when read together, provide an interesting insight to the oppositional points of view about the authority of the photograph that were held during the nineteenth century, with Dingley on the humanities side of the "two cultures" rift and Cooperstein on the side of science and technology.

[207] Sample reports that astronomers studying Sagittarius B2, "a vast dust cloud at the centre of our galaxy" discovered the existence of ethyl formate, a molecule that is taste-able in raspberries and, "also smells of rum."

Emotions are an essential component of memory and desire, both of which drive an intentional agent to take action towards knowing its environment, which includes the images that appear in performances of outreach astronomy. Maiese's intervention into Noë's Strong Sensorimotor Model (SSM) underscores the subjective and intentional aspects of perceiving the unknown. Noë suggests that, "…perceptual experience acquires content thanks to our possession of bodily skills. *What we perceive* is determined by *what we do* (or what we know how to do); it is determined by what we are *ready* to do… we enact our perceptual experience: we act it out" (Noë in Clark, 170). Noë's explanation implies a sense of future action latent in the present moment.[208] Maiese intervenes into Noë's theory by adding, "Perhaps even more than the changes in the visual field, emotions attract and direct our attention, and definitely seem to impose themselves upon us and our bodies from the outside" (Maiese, 44). Emotions direct our attention, but in what direction? In what direction does the intentionally observant agent direct her attention when faced with a pie graph depicting the theoretical proportions of luminous to dark matter and energy in the universe—towards the past that contains all of her experiences of pie and knowledge about the universe? Or, towards the future, in which direction she might apply this new knowledge about the previously unknown? Or both? Noë suggests that what an intentional agent already knows about pie prepares that agent to enact an experience with a recognizable pie shape. Maiese suggests that our sensual desire—to know/taste more pie or to happily contemplate the mysteries of the universe—drive the intentional observer to further future acts of perception and cognition about the contents of the pie graph.

[208] One of the appealing aspects of Noë's SSM of perception for an argument towards a feminist performance of science is its reliance on extra-visual sensory experiences as essential to cognition.

4.4 ASTROPHOTOGRAPHY AS A SUBJUNCTIVE ACT

Highly mediatized images that represent unseeable elements of astronomical phenomena combine the cognitive and embodied elements present in simple graphic illustration tools such as the pie charts, KWLs, and photographs in order to encourage a general readership's engagement with abstract science concepts. In this section, I build upon arts-science integrative work done by Elizabeth A. Kessler and Shana Cooperstein on HST imaging and bring it into a performance studies context.

One of Anderson's vignettes concerns the HST and the posthuman act of envisioning otherwise unseeable objects in deep space. Her questions for HST engineers have heart; they are driven by Anderson's curiosity and the joy she experiences when she embarks upon a project that expands her knowledge of the world. She introduces her NASA arts research with a description of an encounter with some of the scientists who work with HST data. Their job is to transduce digital information about radiation levels, most of which occurs beyond the human visual spectrum, emitted by objects in deep space, into images that an unaided human eye can perceive, comprehend, and contemplate. Anderson performs the kind of expectation that an average person with a casual interest in science might share: one might think that there is some esoteric system for creating the pictures that the HST transmits as it travels farther into unexplored outer space. She asks, "Could you have used a whole different color range…. How did you arrive at these colors?" By "these colors" she means the pinks and blues used for the birth of stars instead of potential choices of brown and gray. The answer the scientists offer is simple: "We thought people would like them." She pauses as the audience laughs at the arbitrariness of human choice involved in the mediation of information that comes to us through the deep space telescope, interpreted by engineers who manipulate that data, into the media news networks of newspaper and internet, and

appears before our eyes. Her tone waxes lyrical and her text shifts back to the sublime as she muses, "It looks like a painting of heaven" (*End*).

The intentions of astrophotographers are similar to those of actors: both deal with subjunctive situations. Konstantin Stanislavski's "magic if" applies to the imaginative repositioning that the outreach astronomer performs when colorizing data from the HST: what if we could be closer to the Ghost of Jupiter? How would that planetary nebula be perceived by human eyes were they capable of perceiving x-rays? Composite photographs are composed by astronomers and technicians who engage in the same kind of subjunctive imaginative process as dramatic artists.[209] The HST astronomer is tasked with presenting a subjunctive question to herself and her audience: what would this object look like if I were able to "see gamma rays," as the fictional Cylon, Cavil, puts it? The astrophotgrapher's subjunctive performance engages with this type of sci-fi whimsy: what if an intelligent being could witness supernovae at close range without fear of death—what would be perceptible to that intelligence? Or, what if humans could see gamma rays on the optical spectrum—what color would they be? This has to do with the subjunctive challenge that the representation of extra-visual information poses to the outreach astronomer. An actor trained in Stanislavski's method must ask himself how he might behave were he placed in such and such a situation. For example, in the *Battlestar Galactica* scene in which Dean Stockwell delivers the monologue discussed earlier, the character Cavil is confronting his creator, an earlier Cylon model. Stockwell might have prepared for his role by asking himself how he might behave were he in a similar situation. The thought process might go something like this: "If I were able to have a face-to-face conversation with my maker in which I could complain about my inferior

[209] This is a gross generalization of Stanislavski-based training and Lee Strasberg's American Method. Many books have been written on both. Good primary sources for these schools of actor training are Stanislavski's *An Actor Prepares* (1936) and Strasberg's *A Dream of Passion: the Development of the Method* (1987).

perceptive capacities, how would I feel? Angry? Empowered? Saddened? How would those feelings inform my actions? Would I raise my voice, whisper, run around the spaceship and bang on the walls?" Such subjunctive questions help the Stanislavski-trained actor take the beginning imaginative steps that help him or her to make acting choices necessary for coloring a role with believable actions. The HST astronomer engages in similarly emotional and subjunctive lines of thought, choice, and action when colorizing HST data for science news audiences.

The effect of mediated HST photographs on science media viewers is similar to that of acting and staging technique on audiences of realist theatre: both engender a simultaneous sense of wonder and familiarity on the part of the spectator towards the observational object. Shana Cooperstein, in her article "Imagery and Astronomy: Visual Antecedents Informing Non-Reproductive Depictions of the Orion Nebula," introduces astrophotography terms that bear some relationship to the vocabulary often used to discuss theatrical performance.[210] Both reproductive images and non-reproductive images are created with the intention of leaving a realistic impression on the viewer. [211] Much like the unnatural techniques that actors deploy to convey a sense of realism in representational theatrical genres (vocal choices, physical poise, and stage blocking are some examples of unnatural performance techniques used to create a realistic effect), HST astronomers isolate wavelengths that are not on the visible spectrum and ascribe color to them, to create a fantastic image that the unaided human eye could never see. Neither realist acting

[210] Cooperstein does not make a theatrical analogy. Here, I rely on her work in the field of visual arts as it applies to my performance studies point of view. Her article is useful because she also refers to HST images. But she does not discuss Laurie Anderson's performatic discussion of them.

[211] Cooperstein's key photography terms are: 1) Reproductive image: "an image representing data that potentially could be seen by a human observer," 2)Non-reproductive image: "images that could not exist as images in the absence of instrumental detection data," 3)Non-reproductive processing: "manipulation of data in service of an invented schema for scientific inquiry, such as the application of color in public outreach images generated by the Hubble Space Telescope… or the acquisition of 'raw,' non-manipulated photons from outside the range of the visible" (Cooperstein, 129).

techniques nor HST image manipulation replicate identical copies of the original object of observation: a character or a star. In both theatrical and photographic forms, reality is not what matters, rather, a sense of familiarity with a scenario or an image is essential for spectators to engage with the representation of a wondrous and unfamiliar object—a play or an exploding star—performed before them.

The composite HST photograph is the hook for the science news article. Like a star actor in a new television show, recognizable photographs of celestial objects in science news media cause audience members to tune in because of an initial familiarity with the celebrity object, and then they are introduced to new concepts contained within the rest of the image (or T.V. show). As is the case with Shapin's observation that most people learn about science from other people with whom they are already familiar, so a general public already familiar with an image of an object such as the Orion Nebula (Cooperstein's key example) is more likely to respond to a headline with its recognizable image than to a graph with a collection of numbers that bears no resemblance to what is already popularly known about it. With the HST images, the new information is embedded in the colorized image. As Cooperstein puts it, "the use of non-reproductive imaging encourages people to imagine links between photography and vision, as well as between 'truth' and visional perception" (133). Kessler discusses accusations of fakery that have been levied at the creators of HST images. She states that notions of truth when it comes to colorized HST images depends "on a definition of truth that rests on human perception; but color carries a greater range of meanings… color can be used to label, to measure, to represent or imitate reality, or to enliven or decorate. Furthermore, it incorporates both objective and subjective elements" (Kessler, 154). She describes the process of colorization as one that depends upon the variability of human perception as well as a number of possible choices that might be made by

individual imagists working across history. Graphs can represent the same information, but the composite, colorized image emotionally engages a general audience because of that audience's familiar memory of the old image.[212]

The subjunctive process of HST image creation is enacted through networked, hybrid, but nonetheless embodied transduction systems. Creators of HST outreach images must weigh factors of emotional connectivity, scientific objectivity, and personal memory in the subjunctive work of representing truthful information while also stimulating popular imagination towards distant celestial phenomena. Audience matters to the astrophotographer just as much as to the actor. As with the actor who makes individual choices as well as choices informed by the director, so the astrophotographer ascribes color based partially on practical qualities and partially on personal preference.[213] Ultimately, it is the creative agency of the individual scientist, working with a network of deep space detection devices, data-processing software, scientific research agendas, and outreach audience expectations that determines how distant astronomical events appear to a

[212] Cooperstein takes pains to demonstrate that astrophotographers create images with new, previously undetectable information, embedded within images of older, more familiar photographs. Older images of distant celestial objects are not only more familiar to a popular audience, but they also hold more authority for that audience than a stream of data generated by the HST. She compares nineteenth century astrophotography and the photography techniques used by turn-of-the-millennium astronomers. "Typically," she says, "early 19th-century photography aimed to reproduce that which could be visible to the eye through earth-based telescopes."[212] Early nineteenth century photography endeavored to replicate an experience of astronomical observation that was mediated by the telescope alone.[212]

[213] Cooperstein points out that a number of factors inform astrophotographers' color choices: "Color selections frequently depend upon a scientific understanding of the phenomena that produce particular wavelengths of emission and knowledge of the hues perceived by the human vision system for these wavelengths" (Cooperstein, 131). Elizabeth A. Kessler gives a detailed history on the colorization of astronomical photographs in *Picturing the Cosmos*. She discusses "false color," as "hues" that "need not have any relationship to the visual appearance of the phenomena or the wavelengths of light registered by the instrument. Instead, different colors might indicate another dimension of the data—for example, a continuum from red to yellow might represent differences in light intensity. In addition to what the color indicates, false color has come to describe a particular color palette—flat, garish hues that do not resemble natural phenomena in our world" (Kessler, *Picturing*, 157).

general public. The subjective memory of the scientist affects the color choices made, even when those color choices don't represent the "true" color that the human eye would see.[214]

HST outreach images are composites.[215] A composite photographic image is created by layering several negatives on top of one another and thereby blending information of each to create one image that represents the idea of a photographic object, but does not reproduce visual information in a one-to-one manner. Astronomers who create HST images compose a picture of a single object that is more detailed than what the human eye could observe even if that eye were situated at the same proximity to the object as the HST. Kessler describes the process of creating HST's composite photographs:

> … Hubble images have conditioned us to see the universe in vivid hues. To create images with a full spectrum of colors, astronomers and image specialist assign different colors—red, blue, and green—to three exposures and then create a composite. If additional observations are available, they may combine more than three images, choosing a fourth or fifth hue for the additional exposures. This requires them to make a series of choices about what color should signify. (153-4).

The public images created by the scientists working with the HST can be thought of as archives of information, if only the viewer can be made aware of the choices made by the scientist-illustrators. Astronomers create new images that index more information than ever before, but that continue to resemble the iconic images captured by earlier astronomers with their less advanced technologies. Visual reference to earlier astronomical icons encourages non-scientist viewers of the images to

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[214] Cooperstein gives an extensive explanation for this: "[I]n Robert O'Dell's image, a mosaic of 45 images captured between 1994 and 1995, the scientists render oxygen as blue, hydrogen as green and nitrogen as red in order to retain and signify information concerning the nebula's energy emissions and physical composition…. Although oxygen would appear green to the human eye, O'Dell explains that in this depiction of the Orion Nebula, the color balance or relative brightness of each color resembles his memory of the nebula as perceived by the eye through an earth-based telescope."

[215] In Josh Ellenbogen's *Reasoned and Unreasoned Images*, he gives the following definition of the composite image: "One way to understand the composite… is as a synthesis of data—a condensed, abbreviative representation of the kinds of information one might otherwise derive from a binomial curve [such as Rubin's rotation curve], or better, a series of binomial curves that measured the particular features a given composite shows."[215]

access any memory they may have about what they already know of these objects. A colorized, composite, archival image represents extra-visual information in a visual manner, which is not a realistic interpretation of that information, but it is usually accompanied by a brief, textual explanation of the picture. In this way, astrophotography distorts the truth but represents reality as it encourages audiences to learn something new about the object in question. Mediation of the celestial image becomes an empathetic means to communicate new information about scientific objects to a non-expert audience.

The hybrid transductive process required to bring these objects into the optical spectrum leave much to be desired about the truth of the object. In astrophotography, the celestial body may be real, but it is also a product of the technology that detects it, the telescopic camera that captures previously unknowable information, and a mediation process that involves choices to be made by intentional human agents.[216] As with the family portrait in Anderson's narrative, images of celestial bodies as performed by HST images in popular science media are marked by the choices made by the scientists who "fix up" Hubble's data to communicate them to a general audience. The original object—the Andromeda Galaxy, a mountain on the moon, the Eye of Jupiter—disappears even as it is created for observation by a general, earthbound-but-universe-extended audience. This kind of choice is similar to Galileo's illustrative idiosyncrasies in *Sidereus Nuncius*, when he exaggerated the appearance of new stars visible through the telescope in order to differentiate them from stars that were already known through a history of naked-eye observation.

[216] In a discussion of mid-late nineteenth century photographs that contain extra-visual data, Ellenbogen states, "[p]hotography does not reproduce data in such images, but instead it produces them" (Ellenbogen, 6).

5.0 CONCLUSION

Throughout this dissertation, I have articulated a cultural relationship between the domains of the astronomy and theatrical performance as performed in English, Continental, and American culture. What I hope is becoming clear is that popular and theatrical performance can be a part of the knowledge-productive process of astronomy. In this conclusion I insist that the performance of science in multiple public arenas is vital to the achievement of a society in which all people might pursue a productive curiosity across all cultural domains. Such an accessible model of science performance benefits the ends of scientific progress and egalitarian culture.

I began with an examination of the history of astronomy as it was performed on the English stage throughout the seventeenth century. Thomas Tomkis's *Albumazar* dramatized an historical moment at which the public was still skeptical about the usefulness of the telescope. Produced just four years after the publication of Galileo's *Sidereus Nuncius*, the idea of the telescope is crucial to the dramatic action, but the physical presence of a staged telescope is not. The likelihood that the telescope's actions may have been pantomimed implies a doubt on behalf of the playwright, and possibly the royal audience for which the play was drafted, regarding the productive application of the telescope towards astronomical ends. By the end of the seventeenth century, Aphra Behn's *Emperor of the Moon* premieres in the same year as the publication of Isaac Newton's *Principia*, 1686. Although Behn does not implicate Newton by name, she does take stabs at members of his socio-scientific class, the Royal Society, and their mechanical trappings. Behn's interest in the philosophy of science at the time reflects a public opinion of the telescope that is dubious about the extent to which a person can trust its images.

The third chapter examined examples of plays that dramatized situations in which the information produced by telescopes was considered trustworthy, the credibility of the scientists who operated them was brought into question. Lauren Gunderson's *Background* dramatizes the social factors that impacted Ralph Alpher's professional career as a cosmologist. *Background* is an excellent example of how the scientific biographical drama can encourage audiences to care about science content by performing that content as a part of the emotional cognitive networks that provide a common ground for empathy. The fictional film, *Contact*, like *Background*, builds a plot based on discoveries made by radio-astronomy. Robert Zemeckis's film situates the character Eleanor Arroway as a mediator of extra-terrestrial intelligence that comes to Earth through an extended, hybrid network of humans, telescopes, government authority, and corporate financial structures. In a manner similar to *Background*, audiences come to care about the science that drives the plot of the film because they also empathize with its protagonist. When Arroway's testimony doesn't hold up during the hearing at the end of the film, Sagan's criticism becomes clear: embodied experience is an important, but often unexplainable, component of the hybrid performance of science. There is still work to be done in the cultural domain of science that will revalue individual experiment so that humans can trust their own judgment, even when it doesn't agree with data-oriented explanations of new scientific phenomena.

Chapter Four examined performances from the domains of science and theatre that seem to already embody a model of science praxis that is accessible to general audiences. If these acts do not actually meet the criteria for an accessible mode of the performance of science, then they are explicit in their desire to do so. Vera Rubin forged her career in astronomy at a time when very few women were able to, due to many restrictive cultural barriers in place in the United States throughout the mid-twentieth century. She later became a feminist voice in the field of astronomy

and addressed the issue equality of access for women and other minorities to the discipline through lectures, interviews, individual conversations, and popular science writing. Her feminist position is implicit to her performance in the domain of science. Where Rubin embodies a scientist who acts upon her passion for equal rights, Laurie Anderson is an artist who enacts her curiosity about science through performance. In *The End of the Moon* Anderson inverts the liberal hierarchy of scientific authority outlined by Shapin by placing the institution of NASA at the other end of her performatic scope. She doesn't take on the whole of NASA, but gives the audiences glimpses into elements of it, mediated by her sparse verbal narration, lyrical soundscapes, and a few, well-chosen images. This hybrid performance captures a twenty-first century human's role in the universe that is at once infinitesimally small as well as extended almost beyond the reaches of the imagination. Anderson and Rubin, although their work may be situated on apparently opposite ends of the "two cultures" binary, embody two different ways of articulating the same call. Both women endeavor to reinstate wonder at the world in their audiences towards the end of encouraging a broad audience to actively participate in the social structure of the culture in which the domain of astronomy is embedded.

There are still many steps that a performance studies approach to the practice of astronomy can take towards a general acceptance of science as a part of culture. One of the appealing aspects of performance studies as a method for pursuing this project is its capacity to examine many different kinds of actions and events under the same umbrella. The Venn diagram below shows some of the different kinds of performance that can all be considered in a project that works towards an accessible performance of science:

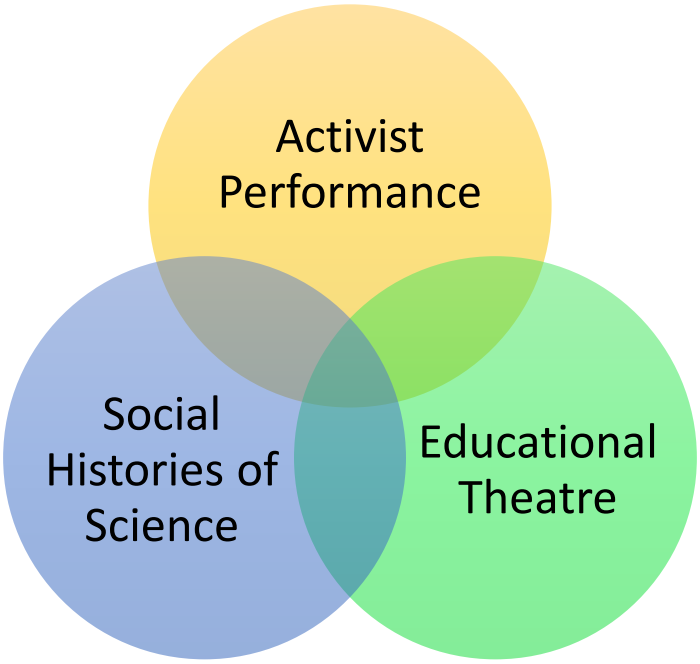

Figure 12: Overlapping domains of an accessible performance of science.

This dissertation has touched on aspects represented in the above diagram, which, when their ends combine in the center, address activities that work towards an accessible performance of science. For instance, Vera Rubin's lectures are activist in nature, but they also educate her captivated audiences because her activist work also explicitly narrates a social history of science in which women's stories drive the action. Laurie Anderson's politically activist ends may be towards the end of war, but she educates her audiences about some of the hidden processes involved in the creation of HST photographs, all while narrating her own, personal, engagement with socially relevant science issues.

The following is a list of qualities that I imagine accessible performances of science might embody. I include this list not as a neat conclusion of the examples already discussed in this dissertation, but as a springboard for further performance research, which might manifest in any of the overlapping domains of theatre, laboratory, social media, and scholarship. As such, I intend

this list as a provocation more than an exhaustive template of actions that must be taken towards an accessible performance of science. An accessible performance of science:

a. is body-driven as well as data-driven and is at times subjective.
b. is hybrid, distributive, and knowledge-productive.
c. acknowledges emotion as an essential component of sense perception.
d. is interdisciplinary, after McKenzie's paradigmatic provocation, "objects are produced and maintained through a variety of sociotechnical systems, overcoded by many discourses, and situated in numerous sites of practice" (*Perform*, 18).
e. resists universalism in its alignment with feminist, post-colonialist, and post-human, "insights about the importance of the politics of location and careful grounding in geo-political terms" (Braidotti, 39).
f. is secular in its reliance upon the work of the community to achieve its goals. Much observational science already embodies this crowd-sourced aspect of its practice that involves amateur reports of phenomena such as sightings of near earth asteroids and bird counts.
g. keeps its processes transparent, and therefore accessible. As the hybrid technologies make more of the universe detectable to the human, so the social machine that makes these new technologies possible must maintain open and inclusive environments.

An accessible approach to the performance of science holds enormous potential to transform cultural habits through overt, socially embodied actions. Global culture needs more overtly diverse performances of science in order to adjust our cultural imagination towards a new model of cultural equality. This can be achieved in part by increasing the number of visible women,

minorities, and disabled people in the role of scientist/physicist in professional laboratories, onstage, and onscreen. On its own, the token placement of a woman or minority in that role is not a strong enough action to resist the ascription of gender onto a professional role that should not be limited by race, gender, ethnicity, or ability. What is needed is a movement, or, a series of explicit actions performed with the intention of creating an accessible performance of science. Trans-disciplinary performances that transparently address the hybrid nature of knowledge production are a step towards the realization of such an equitable platform across multiple cultural domains

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