FAILURES TO SELF-LOCATE:
COUNTERFACTUAL ONTOLOGIES IN CONTEMPORARY THEATRE AND PHYSICS

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ABSTRACT

Failures to Self-Locate examines the overlooked influence of quantum mechanics on the development of contemporary theatre aesthetics. Physicists began openly grappling with the ramifications of quantum theory in 1926. The same year, influential theatremaker and theorist Bertolt Brecht announced his theatre for a scientific age as an arena for atomic man. Unsatisfied with the metaphysical implications of the first formulation of quantum mechanics, known now as the Copenhagen interpretation, physicists and philosophers of science spent the twentieth century advocating, developing, and testing alternative interpretations of the atomic realm. Throughout that same period, the Western stage witnessed a resonant series of developments on Brecht's aesthetic project. Placing the interpretations of quantum mechanics in dialogue with contemporary theatre from North America and Europe, this dissertation uncovers how, after an initial point of direct contact between Brecht and physicists, physics and theatre have developed similar ontological paradigms to interpret experiments and performances respectively.

In physics, these paradigms fall into two distinct camps: those that salvage strict determinism at the expense of a singular world (collapse-free interpretations of quantum mechanics) and those that safeguard our world's uniqueness by accepting fundamental stochasticity in reality (collapse interpretations of quantum mechanics). Experimental evidence supports both options, and so these groups must also explain the apparent validity of the other. Theatremakers actively investigated a similar ontological issue, exacerbated by Brechtian stage techniques and centred on the storied divide between reality and representation. Where the physicists navigated between determinism and locality, playwrights return to the ancient tension between fate and free will. Those crosscurrents may bring ruin to the classical protagonist, but the quantum protagonist experiences one framework (e.g., free will) while secretly being ruled

by the other (e.g., determinism). So positioned, these protagonists fail to self-locate among their myriad possibilities.

To navigate the ontological commitments of science and theatre, I develop a method that combines cognitive theories of world-construction and the philosophical tool of possible worlds semantics. I discover that the formal arrangement of worlds in physics and theatre fit snuggly within two interpretations of counterfactual logic. In summary, this dissertation maps the resonances between the scientific quest to reconcile determinism and stochasticity and the theatrical quest to reconcile free will and fate within the quantum theoretical paradigm, by analyzing the scientific and theatrical output through the lens of counterfactual analysis.

DEDICATION

I dedicate this dissertation to my family and friends who have supported me through every well- and misguided step of this journey. My parents, Cheryl and Randall, have sacrificed much in raising me, allowing my scholarly pursuits, and supporting my education. Without their constant encouragement and aid, even the first step on my educational journey would not have been possible. I am a first-generation university student, and I have unspeakable admiration for my parents' understanding. My brother, Dustin, his wife, Kim, and their son, Mason, are also a constant fount of inspiration and vivacity. My partner, Felicia, has coached me in sainthood. She weathers the academic ups and downs with humour, generosity, and a spirit of thankfulness, without which I would be totally ungrounded at the worst of times. Without my family, I would not be where or who I am today. Foremost, this is for you.

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"For me the director is rather the person who knows the subatomic reality of theatre and who experiments with ways of breaking the obvious links between actions and their meanings, between actions and reactions, between cause and effect, between actor and spectator."
—Eugenio Barba, director (qtd. in Sykes 126)

"[O]ne must never forget that in the drama of existence we are ourselves both actors and spectators."
—Niels Bohr, atomic physicist (63)

"This is the old Platonic riddle of nonbeing. Nonbeing must in some sense be, otherwise what is it that there is not? This tangled doctrine might be nicknamed Plato's beard; historically it has proved tough, frequently dulling the edge of Occam's razor . . . [Such] an overpopulated universe is in many ways unlovely. It offends the aesthetic sense of us who have a taste for desert landscapes."
—Willard V. Quine, logician (21-23)

Introduction: . . . When Acting as a Particle

In the early decades of the twentieth century, the results of experiments on reality's most minuscule scale had perplexed scientists. At the time, physicists pictured atoms as miniature solar systems. The atomic nucleus took the sun's central place, and its electrons orbited as planets. But when the earth travels around the sun, it passes through every possible point on its path; were a powerful blast to catapult the earth from the sun, it would careen away in an unbroken motion until it settled in a new orbit. By contrast, early atomic experiments suggested that particles leap from one state to another without an intermediary transit. When scientists agitated an electron, it refused to budge until it received a specific quantity of energy. Then, it instantly jumped into a new well-defined state. Where a planet could settle into any orbit, nothing could coax an electron into inhabiting anything but a handful of predetermined orbital levels. Against the spatial continuity of everyday-sized objects, atoms appeared to exist and move in discrete chunks, *quanta*—anathema to classical physics. To solve the conundrum, physicists appended a heuristic corrective to the classical model. The *quantization condition* translated the smooth movement of the mathematics into a quantum that fit the measurements. This patchwork approach, now known as the old quantum theory, was Werner Heisenberg's quarry.

Heisenberg had an inkling that the old quantum theory had misaligned its sights. Like any object in classical physics, their electron was defined by its precise location along its orbital path—its position (i.e., where it is now) and momentum (i.e., where it is through time). In practice, however, one could never observe an electron's position or path. In fact, one had no evidence that an electron orbited at all. Instead, the measuring device passes an atom's light emissions through a prism, which decomposes that light into a spectrum. In the resulting

spectrograph, the colour and brightness correlate to the frequency and intensity of the emissions. In other words, the apparatus measures the effects of an atom's interactions, and then the scientists subsequently deduce the motions of the electrons. Were the electrons emitting energy continuously as they followed an orbital path, the spectrograph would return a gradient:

Fig. 1. Spectrum of white light (Ohanian and Markert 1289).

But atomic emissions generate discrete bands:

Fig. 2. Emission spectrum of hydrogen (Ohanian and Markert 1289).

Thus, Heisenberg demanded a revolutionary shift. If we cannot see atoms move, and their emissions are discontinuous, why adhere to the fictional account? Why not define them per those factors that we can, in principle, observe?

In 1925, Heisenberg holed up in a hostel on Heligoland, an archipelago in the North Sea, where he spent a week and a half "resting, reading Goethe, [and] . . . thinking, always thinking" (Lindley 113). Equipped with the spectrograph for a hydrogen atom, he devised a calculus that accounted for its demonstrated frequencies and intensities. As physicist David Lindley describes, he had unknowingly reinvented matrix mechanics, a curio from the cabinet of pure mathematics. His bizarre formulation "yielded a consistent result for the energy of a system—but only so long as that energy was one of a restricted set of values. His new form of mechanics was, in fact, a quantized form of mechanics" (112-13). The old quantum theory had assumed that classical rules underlay the discontinuous findings. In contrast, Heisenberg's matrices quantized themselves—

his system only returned discrete and valid answers. His mathematics suggested a fundamentally discontinuous reality, comprised of entities whose states abruptly shifted. Publishing his results, he chastised the fictionalization of the old quantum theory and called for a "physical theory [that] attempts to derive the correct laws of atomic . . . mechanics from experience, through a precise discussion of those quantities that are in principle observable."[1] This matrix mechanics was the first formulation of *quantum mechanics*. It shifted the attention of physics to reality's observable features alone and embraced discontinuity.

As "first" implies, other quantum theories soon followed. Many of Heisenberg's colleagues and mentors, including Niels Bohr and Max Born, promoted Heisenberg's "mystical" calculus as "correct and profound" (qtd. in Lindley 115). However, an opposing camp reviled the formulation as *Knabenphysik*: colloquially, *punk physics*. Their bugbear was ideological. Matrix mechanics enshrined the controversial notion that things are quantized. In contrast, many physicists saw quanta as a stopgap, bridging a theoretical lacuna until science unearthed the secret continuity. To this end, Erwin Schrödinger also spent 1925 devising a quantum mechanics. Compared to Heisenberg's matrix mechanics, he offered the simpler wave mechanics. In his picture, atoms are not granules but tightly packed *matter waves*, described by mathematical wave functions. As wave-like entities, they consist of undulating fields, from which static patterns emerge—the discrete quanta found in observation. Schrödinger's wave function salvages the aims of classical physics. Nature itself is continuous. The discontinuous-seeming emissions are misleading side-effects. However, Schrödinger's mechanics were motivated not by observation but metaphysics. As he explained in his Nobel lecture, he sought to "sav[e] the soul of the old system . . . flattering it as it were into accepting the quantum conditions . . . as issuing from its innermost essence" ("Fundamental Idea" 309). Heisenberg's *Knabenphysik* took observation as

primary and devised a predictive system; Schrödinger assumed that a continuous entity supported those observations and mathematized a classical field, which generated the correct results. Ultimately, neither picture would reign unchallenged. These sparring formulations combine in the wave-particle duality that still undergirds physics today.

Also in 1925, Bertolt Brecht wrote the acerbic and darkly comic *Mann ist Mann* (*Man Equals Man*), which had simultaneous twin premieres in 1926, one in Darmstadt and the other in Düsseldorf. Where the Düsseldorf production was somewhat traditional, Brecht oversaw the Darmstadt rehearsals and tapped collaborator Caspar Neher for the production design. "For the first time," Stephen Parker reports, "Neher deployed a half-curtain, which enabled the audience to follow the changes of scenery" (231). Shortly after Heisenberg had enticed his colleagues to embrace observables, this production encouraged its audience to question the apparatus of dramatic representation and focus on the theatre's observability. During the press circuit for the premiere(s), the playwright declared that *Mann*'s script exposes "the continuous self as a myth. A person is an atom, perpetually decaying and forming anew."[2] A mere year after quantum mechanics arrived, Brecht emphasized observability and theorized character as a discontinuous atom undergoing quantic disintegrations. Heisenberg and Schrödinger presented duelling pictures of reality. The former stripped physics of its stories and centrally placed the observables and their framing apparatuses. The latter theorized the existence of an unmeasurable wave, which spooled disparate threads into a uniform reality. And Brecht's technique balanced the dual frames of the real stage and the fictional world. He eventually described this dramaturgical approach as a theatre fit for a scientific age.

This trio participated in a paradigm shift on the topic of observation. In the framework developed from René Descartes through Isaac Newton, the mechanical formalisms (i.e., the

mathematics describing a science) were anchored in easily observed phenomena. Electromagnetism, radiation, and the micro-scale universe eroded this connection. One could demonstrate gravity in the public square with an apple and a ladder, but it is difficult to present the half-life of nuclear decay. We cannot *see* atoms; we merely detect the effects of their interactions via complex machinery. Given this new condition, Heisenberg opted to centre physics on those observable effects, which are reliably real. Eventually, he and Bohr would integrate the importance of observational perspective into their final quantum theory. Instead, Schrödinger desired a continuous universe, even if that continuity required an unmeasurable speculative entity. The two preeminent scientists proposed contradictory solutions to the same epistemological question: what is the reality of the objects of our investigations as they are exposed by our method of interrogation? Throughout the twentieth century, atomic experiments continued to reveal bewildering interactions at the subatomic level, and physicists grew increasingly anxious about science's relationship to reality. Does a water chamber or photoelectric plate expose nature itself, or does it merely present an accidental feature of our increasingly complex machinery?

Brecht worked with the machinery of theatre, its pulleys, curtains, and bodies. He positioned himself against the drama of the previous century, and a likeminded epistemological question took centre stage. What is the reality of a play? Does a play expose some universal truth of humanity, an expressionistic truth of the playwright's psyche, or does it lay human nature bare under simulated conditions? In 1925, both Brecht and Heisenberg responded to epistemic anxieties by adopting an operationalist stance. As P.W. Bridgman defines it in *The Logic of Modern Physics* (1927), operationalism supposes that scientific concepts are "synonymous with the corresponding set of operations" (5). The concept of an atom or a character is nothing more

than the set of measurements we collect about them. In science or theatre, the truth is that which we can observe and, therefore, relate to everyday life, which lies beyond and contains our apparatuses. Brecht's operationalist aesthetic of "conscious theatricality" had a profound effect on American and European theatre (Shepherd-Barr, *Science* 33).

This dissertation uncovers how contemporary theatre has echoed the development of quantum mechanics and the philosophical anxieties it engendered. Brecht's theatre for the atomic age resembles the Copenhagen interpretation of quantum mechanics, as Bohr and Heisenberg's model of subatomic physics came to be known. Furthermore, the playwright's aesthetic principles contributed to a paradigm shift analogous to that of the physicists. In both cases, a renewed skepticism about the epistemological validity of our framing apparatuses emerged. In science, the Copenhagen interpretation proffered a new fundamental ontology, according to which science can never reveal nature in itself. We peek at the true reality by oscillating between contrasting pictures—for example, the wave and particle descriptions of an atom. However, we can never, in principle, know what the underlying reality *is.* Heisenberg named his stance *practical realism.* Brecht enacted a similar revolution in performance ontology. He presented a complex dramatic situation and destabilized its continuity, exposing the experimental apparatus while emphasizing the spectator's place in an observational environment. This conscious theatricality bears an uncanny resemblance to practical realism. One must assume that there is a persistent reality, where cause-and-effect (physical or dramatic) applies. However, one must admit that our access to reality is speculative, arbitrary, and prone to revision.

During the subsequent century, many physicists discarded the Copenhagen interpretation for competing means of parsing the mathematical and experimental outcomes. These *interpretations of quantum mechanics* relate the mathematics of quantum theory to observable

reality in radically different ways. Moreover, they present unique ontologies. One spate of physicists has followed Schrödinger's path and emphasized an underlying continuity. To this day, these interpreters extol an undulating wave as the true reality, from which our world emerges. In the most radical cases, such as the many-worlds interpretation, these theorists suppose the existence of myriad, equally real worlds, which emerge from the single, fundamental wave function. An opposing school maintains that Heisenberg's original hunch was precisely correct—granular, jumping particles are the true objects of reality. These theorists understand the continuity of Schrödinger's wave mechanics as a secondary characteristic. It formally represents the evolving "possibilities or better tendencies (*potentia*)" that a particle accrues in between interactions (Heisenberg, *Physics* 27). But the leaping, observable particles are the reality to which those tendencies defer. In the most famous (and mystic) variant, physicists like Eugene Wigner argue that human minds literally *cause* one possibility to actualize over the others. The philosophy of physics has become a fertile land of competing worldviews, each of which presents a distinct ontology and, moreover, seems equally supportable by evidence.

Likewise, theatremakers have worked through Brecht's dramatic experiments to develop diverse aesthetic paradigms. Some theatremakers have built on Brecht's willingness to present many versions of a single dramatic moment—a technique he called *fixing the not-but.* In extreme cases, such as Nick Payne's *Constellations* (2012), one play stages dozens or hundreds of alternative worlds, a performance-length sequence of not-buts. These plays explore the sheer volume of realities that exist on stage. Other theatremakers have instead delved deeper into Brecht's exploration of the performative body and the mechanisms of making theatre. Odin Teatret's *Kaosmos* (1993), for example, showcases the body's potential to inhabit discontinuous relations. These competing trends abandon Brecht's operationalist approach to theatre and stake

a claim about the nature of reality—performed, fictional, and actual. In the former case, different versions of the same event are given equal ownership of the stage, in turn, as if each possibility were a separable dramatic world. Such plays stage many possible variants as distinct, robust actualities, rather than ways one reality could have been. Later, I argue that these plays stage possibilist worlds, because every micro-play constructs a separate, causally complete reality. One play may offer many internally consistent dramatic worlds, but a more extensive system entangles each one: the play itself, the overarching wave function. The audience exists in a superior actuality, perched at a safe and ironic distance with a godlike overview. In the latter case, a character's possibilities are concomitant with those of the performer's body. Rather than enacting entire possible scenarios, these plays enact violent transformations in a single discontinuous situation. Characters change motivation mid-scene, actors switch between characters on stage, and a piece of dialogue lacks any causal relationship to the next. The swirl of staged activity is restrained only by the spatiotemporal relations of the actual venue. Because the actors are the loci of variability (rather than the inhabitants of worlds in which they happen to reside), their bodies generate staged worlds through enacted relations. Later, I posit that these plays stage actualist worlds because possibilities are anchored in a single actuality, in which the spectator's reality also partakes. The border between fiction and reality becomes a mere artifact of observational pragmatics.

These post-Brechtian practices developed independently of the interpretations of quantum mechanics, but they present resonant ontologies. Where physicists and philosophers of science interpret atomic phenomena through thought experiments and mathematics, theatremakers make sensible the ramifications of an alien reality by staging it in cognizable experience. Both disciplines ultimately grapple with an unknowable reality by embracing

counterfactuality—a space for could-have-beens and might-bes. In short, contemporary theatremakers (I demonstrate) create worlds on stage that unmistakably resemble those worlds described by contemporaneous quantum theorists.

The Copenhagen interpretation encouraged continued skepticism about the epistemology of science. In *Physics and Philosophy,* the interpretation's most clear-eyed presentation, Heisenberg tells us that atomic experiments never reveal "nature in itself but nature exposed to our method of questioning" (32). Atomic phenomena resist unaided observation, and therefore the design of an experiment choreographs the picture of reality it delivers. However much we want to discuss the atom, our experiments only return things we can see: "black spots on a photographic plate" or "water droplets in a cloud chamber" (153). To circumvent this limit, the quantum physicists used thought experiments to bridge the gaps. Perhaps none is as famous as Schrödinger's unfortunate cat, forever smeared between life and death. As Brecht's dramaturgy showcases, thought experiments are themselves a kind of fiction: they establish operating rules, suppose a counterfactual inciting incident, and then narrativize the consequences through time (Davies 29-33l; Sorensen 202-06). These fictions suggest new routes of inquiry, jumpstart scientific revision and, in the case of quantum theory, excite public imagination.

Where measuring apparatuses are limited by technology, thought experiments are bound in language. Atomic events are so distant from our experience of the world that they resist description. Thus, quantum theorists also faced an unprecedented limit in the realm of thought experiments. In the *Physikalischen Prinzipien der Quantentheorie* (*Physical Principles of Quantum Theory*), Heisenberg explains:

> [A]tomic phenomena cannot be described directly in our language . . . due to the essential inadequacy of our language. . . . [It is also] by no means strange that our language fails to

> describe atomic processes, because linguistic concepts ultimately relate to the experiences of daily life, in which we . . . never observe single atoms . . . Luckily for mathematics, no such picture is necessary.[3]

The Copenhagen interpretation meets this linguistic challenge with a call for "an ambiguous language . . . [that uses] classical concepts in a somewhat vague manner in conformity with the principle of uncertainty" (*Physics* 153). This language crystallizes in the cornerstone *principle of complementarity.* As Bohr explains, "we have to do with contrasting [complementary] pictures, each referring to an essential aspect of the empirical evidence. . . . [This situation] demands mutually exclusive experimental arrangements" (40-41). Under this rubric, a spate of scientists embraced a blossoming set of new descriptions. Traditional binaries, like continuous and discrete or wave and particle, co-exist as incompatible but complementary explanations of the same phenomena. Schrödinger's and Heisenberg's mechanics were wed as complementary viewpoints. We can treat an electron like a wave or a particle, just never both in the same moment.

Theatre seems well-positioned to answer this call for an ambiguous language. As Kirsten Shepherd-Barr demonstrates in *Science on Stage: From* Doctor Faustus *to* Copenhagen, "drama lends itself particularly well to the staging of science" (9). In the quantum conversation, theatre's materiality fulfils a unique role: the staged experiment, analogous to, though far from identical with, a thought experiment. A thought experiment moves from existing data through a counterfactual scenario to reach a conclusion. Theatre moves from existing notions through embodied practices to inscribe a counterfactual world in the real space on stage. The performance tests that world's ontological, sensual, and ethical dimensions. In the wake of the atomic bombings, the last century saw a proliferation of plays that directly investigate science's ethical role in society. Shepherd-Barr tracks a new genre, the *science play,* through which theatre

has become "the site of substantive interaction between the hard sciences and the humanities" (1). Indebted to Brecht's developments, science plays include his *Leben des Galilei* (*Life of Galileo* [1939]), Tom Stoppard's *Arcadia* (1993), and Shelagh Stephenson's *An Experiment with an Air-Pump* (1999). On quantum mechanics, Michael Frayn's *Copenhagen* (1998) is the most celebrated example. As Shepherd-Barr notes, successful science plays evince a "self-conscious merging of theme and form" (7). These dramatists integrate scientific concepts into their approach to dramaturgy when they stage their worlds.

My focus is broader than science plays, and this dissertation concerns a *quantum theatre* broadly conceived. In *What is Philosophy?*, Gilles Deleuze and Félix Guattari tell us that science, art, and philosophy offer three modes of thinking about the same reality. Science generates functions that predict outcomes, philosophy defines concepts that organize reality, and art ("a compound of percepts and affects") makes sensible both functions and concepts (164). In their tripartite definition, interpretations of quantum mechanics are philosophical works, developed by scientists. Following this categorization, I focus on plays that intersect the operations and concepts of quantum mechanics, whether or not the theatremakers are intentionally tackling the topic. In doing so, I chart an underappreciated resonance between a contemporary mode of staging worlds and a mode of scientific and philosophical thought. Following David Kornhaber's work on theatre and philosophy, I define the quantum theatre as any theatre that plays a "philosophical role that exceeds any simple instance of example or explication" in the conversation about quantum mechanics and its ontological implications (429).

It follows that this dissertation involves a third interlocutor: philosophy. The ontologies of contemporary theatre and physics evince a modal or counterfactual structure. In one form or another, they take seriously the notion that things could have gone otherwise. In physics, an

interpretation of quantum mechanics must explain why, had I treated an atom differently in an experiment, it would have appeared wave-like instead of particle-like. In theatre, many versions of the same event or potentials for one body are treated as counterfactual realities. Per Deleuze and Guattari, any claim about ontology—stated plainly, implied, or presented on stage—is by nature a philosophical one. It follows that I turn to the philosophical language of modal logic and counterfactuality—known as possible worlds semantics—to describe, analyze, and compare the physical and performative ontologies. I organize the worlds of quantum mechanics and theatre around two approaches to possible worlds ontology: *possibilism*, which imbues possibilities with their own kind of reality; and *actualism*, which treats possibilities as properties of our sole robust reality.

Recently, Michael Bennett's *Analytic Philosophy and the World of the Play* similarly approached theatre through the lens of possible worlds. Bennett's aims are more philosophical than my own. He proposes a new theoretical account of imaginary beings that corrals possible and fictional objects, arguing that a possible world and a "world of the play" are two examples of "dialectical-synecdochic objects" at "different degrees of complexity" (2). A dialectical-synecdochic object, Bennett's own contribution, finds its abstract being in the dialectic between necessary features and possible variations. With theatre as his staging ground, he develops a theory of reference that places all media—from single words to elaborate live productions—on a scale of dialectical-synecdochic complexity (38-42). Because he promotes a theory, however, he must adopt a single interpretation of possible worlds. In contrast, I am concerned not with the ontology of theatre itself but with the ontological paradigms presented by theatremakers in their works. As I examine the worlds described by physicists, philosophers of science, and theatremakers, I adopt matching understandings of possible worlds. In summary, I use the

conceptual scheme of possible worlds to consolidate the functions of quantum mechanics, the sensations of contemporary theatre, and the conceptual baggage both tactics purposefully and accidentally adopt. Because I do not ally myself with a particular school of possible worlds analysis, I discover another exciting convergence: the anxieties in recent possible worlds scholarship echo those found in quantum mechanics and post-Brechtian theatre.

Throughout the dissertation, possible worlds semantics permits me to excavate the values of different ontological paradigms in physics and performance. In physics, quantum mechanics creates tension between determinism and accessibility. For quantum mechanics, if reality is purely deterministic, it must have some inaccessible component (i.e., an underlying wave). Or, if reality is to be fully accessible, then it must be indeterminant (i.e., Heisenberg's leaping particles). In either case, we retain a sense of both options because the alternative description is equally valid: reality seems both deterministic and indeterminant, physically accessible and utterly inscrutable. Similarly, theatre negotiates between a script and a performance and, more fundamentally, the forces of fate and free will. Plays with many worlds, such as *Constellations*, are deeply fatalistic. If everything that could happen does happen, how could choice matter? The plays that instead situate potential within the individual body, such as *Kaosmos*, emphasize choice. In the fatalistic universe, individual ignorance nonetheless permits the sensation of free will; in a world of radical potential, a network of expectations suppresses most possibilities. As in physics, both free will and fate are suspended in an unresolved dialectic. Approaching physics and theatre through a single philosophical framework exposes this common theme—in the post-atomic world, the quantum subject fails to self-locate among myriad worlds or potential-limiting entanglements.

A surge of scholarship in the last decade places contemporaneous theatre and science in fruitful dialogue. Shepherd-Barr's other publications include *Theatre and Evolution from Ibsen to Beckett,* and Pannill Camp's *The First Frame: Theatre Space in Enlightenment France* considers the exchange between dramaturgy and physics in eighteenth-century France. Likewise, scholarship on theatre and philosophy has asserted the value of such an exchange in the last decade. R. Darren Gobert's *The Mind-Body Stage: Passion and Interaction in the Cartesian Theater*, Kornhaber's *The Birth of Theater from the Spirit of Philosophy: Nietzsche and the Modern Drama*, and Martin Puchner's *The Drama of Ideas: Platonic Provocations in Theatre and Philosophy* are prime examples. These scholars do not read drama through a particular philosopher's lens. Instead, they reposition theatre as philosophy's and science's interlocutor in the history of ideas. Furthermore, Shepherd-Barr, Gobert, and Puchner recognize an undeniable connection between Brecht's aesthetic, the possibility of scientific performance, and contemporary performance ontology. In *Philosophers and Thespians: Thinking Performance*, Freddie Rokem suggests that Brecht's aesthetic articulates the historiographical philosophy of Walter Benjamin. Instead, I position Brecht as a conduit between early quantum mechanics and contemporary theatre aesthetics broadly. My project joins these voices, clarifying theatre's position in the twentieth-century conversation on quantum mechanics, beginning with Brecht and then developing beyond.

The first chapter of this dissertation briefly surveys the historical engagement between physics (and philosophy) and theatre at key junctures—Attic Greece, early modern Europe, and enlightenment Europe. This trip through time is essential because Heisenberg and Bohr define the Copenhagen interpretation as a rejection of Cartesianism and classical empiricism. Moreover, their interpretation revives Aristotelian and Platonic terminology, owing in part to the

Heisenberg family lineage of classics scholars. After establishing this history, I place *Galilei* in conversation with the Copenhagen interpretation of quantum mechanics. Brecht was directly influenced by modern physics, as the original version of *Galilei* (1939) proudly announces and the final version from 1956 bemoans. In particular, both the physicists and Brecht redefined the function of counterfactuals in their respective domains.

Contemporary interpretations of quantum mechanics abandon Heisenberg and Bohr's key concepts (though they retain the mathematics). Contemporary examples of the quantum theatre likewise diverge from the conscious theatricality of Brecht's aesthetic. Brechtian theatricality avoids examining the nature of an underlying reality (his interests lie elsewhere), but subsequent playwrights unearth the ontological anxiety buried in modernist theatre practice. As physicists reinterpret the Copenhagen interpretation to reassert strict determinism, a one-world frame, or determinability, playwrights re-examine the ancient theatrical themes of fate, free will, and the limiting effects of one's environment. The first chapter thus provides the groundwork for the remainder of this dissertation.

My selection of plays and performances highlights the diversity of subject matters and aesthetic practices found within the quantum paradigm. Despite these differences, each text advances Brecht's dramaturgy and the worldview demanded by quantum theory. The second chapter makes a broad contrast between actualist and possibilist stage ontologies by comparing Caryl Churchill's *Traps* (1978) and Yasmina Reza's *Trois Versions de la vie* (*Life x 3* [2000]). *Trois Versions* marches ahead with a sense of bleak fatalism. Reza's middle-class Parisians discover the inconsequentiality of their successes and failures in a fundamentally unsympathetic multiverse. Isolating her three versions into separate realms, Reza echoes Schrödinger's demand for local continuity, with each world guided by ennui, disappointment, and decay. Chapter 3

expands this fatalistic thread. By analyzing John Mighton's *Possible Worlds* (1990), Payne's *Constellation*s, and Jennifer Haley's *The Nether* (2013), I demonstrate how dramatic fatalism resonates with the strictly deterministic interpretations of quantum mechanics. Since Schrödinger, likeminded physicists have elaborated models in which a universal wave function is the "true" quantum reality. It evolves, branches, and persists while we only ever witness one of its infinite threads. Each thread is a world, and each world is subservient to the greater reality – even if, when viewed in isolation, individual worlds exhibit dynamical sovereignty. The same dynamical relationship emerges in these plays. From its superior vantage, the audience witnesses multiple robust worlds. However, the audience's position also reveals an underlying continuity, invisible to every character.

By contrast, Churchill's *Traps* locates the revolutionary potential of the performance itself and exposes the mutability of the relations that bind us. As actors and characters alike vault into disorienting affairs, Churchill's actualist world recalls the discontinuity of Heisenberg's leaping particles. In the final chapter, I explore three plays that likewise seek radical potential within individual bodies. Roland Schimmelpfennig's *Idomeneus* (2008), Martin Crimp's *Play with Repeats* (1989), and Odin Teatret's *Kaosmos* explore the individual's entanglement with a vast network of beings. This entanglement, in turn, generates a world, which binds the individual's otherwise expansive set of possibilities. These plays reflect the fundamentally discontinuous interpretations of quantum mechanics that follow Heisenberg, known as collapse theories. Collapse theories posit that atomic entities are nebulous bundles of potentiality, which actualize (or collapse) into a single outcome under select kinds of interference. In these plays, sociopolitical history, culture, and family duties ceaselessly interfere with the atomic subjects. Thus, their field of possibilities never evolves, and their actualization is one of repetition and

dissolution. Such plays forward actualist performance ontologies, which foreground the spatial continuity between staged world, actor, venue, and audience. Per the collapse interpretations of quantum mechanics, these plays also remind spectators that our circumstances ceaselessly limit our potential. The audience, too, is ensnared by the same systematic relations.

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[1] "einer neuen physikalischen Theorie, die den Versuch unternimmt, durch eine genaue Diskussion der Frage nach den prinzipiell beobachtbaren Größen die Gesetze der für Atomsysteme gültigen Kinematik und Mechanik aus der Erfahrung herzuleiten" ("Über" 683). All German and French translations are my own unless otherwise noted.

[2] "Das kontinuierliche Ich ist eine Mythe. Der Mensch ist ein immerwährend zerfallendes und neu sich bildendes Atom" (Brecht, *Werke* 26: 682).

[3] "die Atomphänomene nicht unmittelbar in unserer Sprache beschreibbar. . . . [Diese Situation] liegt an der wesentlichen Unzulänglichkeit unserer Sprache. . . . Es ist auch . . . keineswegs merkwürdig, daß unsere Sprache bei der Beschreibung atomarer Prozesse versagt; denn ihre Begriffe gehen auf die Erfahrungen des täglichen Lebens zurück, in denen wir es . . . nie einzelne Atome beobachten. . . . Für die mathematische Ordnung der Phänomene ist glücklicherweise eine solche Anschauung auch gar nicht nötig" (7).

Chapter 1: Science and/as Theatre

"The goal of science is not to open the door to infinite wisdom, but to set a limit to infinite error."[1] With these words, the titular scientist in Bertolt Brecht's *Leben des Galilei* (1939) launches his lesson on floating bodies. He then recounts Aristotle's theory of floating bodies with the help of Andrea, his prized pupil: "a disc of ice, although heavier than water, floats because it is wide and flat and so unable to divide the water" whereas "a [thin and narrow] needle sinks beneath the water."[2] Therefore, breadth and width, not weight, cause buoyancy. At his insistence, Galileo's students hound the philosopher's argument for errors. Andrea poses a telling counterexample: "after it is pushed underwater, a disc of ice easily parts the water as it rises back to the surface." Therefore, contrary to Aristotle's account, ice can "separate water."[3] The students invent alternative explanations, but none explain why ice floats while needles sink. Moreover, Galileo ferrets out flaws in every countertheory. To settle the ancient dispute, Galileo does "something that no one seems to have done in a long time . . . lay a needle on water."[4] His students watch. The needle floats. "It doesn't sink," Andrea laughs, "and that is a fact."[5] The lesson is clear: analytical procedures might uncover logical inconsistencies, but experimentation exposes our false assumptions to the light of truth. Brecht's audience, like the students and unlike centuries of Aristotelian scholars, looks. Our senses engage a world on stage, and, in turn, we learn about our world and its workings. Brecht describes his approach as "a theatre for the scientific age" (*Brecht* 228-29). Drama and experiment merge, standing together opposite the inherited philosophical tradition.

Of course, science has been closely associated with rigorous demonstration and skepticism since Francis Bacon's *Novum Organum* (1620). Brecht embraced Bacon's legacy and situated himself within it. Where Bacon had rectified Aristotle's natural philosophy in his

Organum, Brecht tackles the philosopher's poetics in his *Kleines Organon für das Theater* (*Little Organum for the Theatre*). The theatremaker even apes Bacon's organization, and both documents consist of seventy-seven numbered sections (Silbermann 220-21). Despite Brecht's protestations, however, philosophy and science are not so separable. Empirical science requires more than laying needles on water. In everyday practice, scientists also rely on rational tools, per Aristotle. As Albert Einstein explains:

> It has often been maintained that Galileo became the father of modern science by replacing the speculative, deductive method with the empirical, experimental method. . . . This interpretation would not stand to close scrutiny. There is no empirical method without speculative concepts . . . only the boldest speculation could possibly bridge the gaps between the empirical data. . . . Galileo opposes the deductive methods of Aristotle and his adherents only when he considers their premises arbitrary . . . and he does not rebuke his opponents for the mere fact of using deductive methods. (Forward xvii-xix)

Philosophy too is not so disconnected from the sensible world. Philosophers may emphasize reason, but they still use evidence. Aristotle's *Physics* is rife with careful, qualitative studies. His Organon attaches mathematics to observable premises, and he derives his (albeit wrong) conclusions from observation and inference. If one points a needle downward in water, it does indeed sink. As Galileo and Einstein understood, Aristotle would reject "even the most plausible deduction . . . if it [were] incompatible with empirical findings" (Einstein xix). Science and philosophy (like empiricism and rationalism) share a porous border.

Furthermore, both scientists and philosophers borrow ideas, forms, and metaphors from the stage. Philosophers have used dramatic dialogues to interrogate concepts and perform thought experiments since Plato. Scientists share the habit. The Inquisition saw Galileo arrested

for his *Dialogue Concerning the Two Chief World Systems* (1632): a dramatic exchange comprised of alternating thought experiments, fictions embedded within a fictional frame. During the Inquisition, dialogues were detested precisely because they render challenging ideas more accessible and mask the playwright's views behind those of a character. Likewise, playwrights adapt ideas and modes of thought from philosophy and science. Brecht's Galileo demonstrates the floating needle experiment for his students, and the audience observes its real results. However, that demonstration resides in *Galilei*'s aesthetic experiment and the rational processes of dramatic storytelling. Philosophical and scientific methodologies cohabit the stage.

Plays, like Aristotle's theory and Galileo's experiment, are rethought and restaged. Brecht first wrote *Galilei* in 1939 in Svendborg on Funen Island, where physicist Niels Bohr wrote his dissertation on electron shells and inaugurated the quantum theory of atoms (Parker 321-36). Like Einstein, Brecht had just fled Nazi Germany. In exile, he sensed a kinship with these scientists. His plays confronted nineteenth-century dramatic conventions, and upstarts like Bohr and Einstein confronted that century's ardent Newtonianism. Galileo's struggle against the Catholic church offered a heroic precursor. According to Martin Wekwerth, Brecht's friend and collaborator, the playwright esteemed Bohr's atomic model alongside the Hegelian dialectic and Shakespeare's oeuvre as an example of the truly "classic": a status after which his theatre strived (303-06; *Brecht* 276-77).[6] He nurtured his interest in physicists throughout his life. Before his untimely death, he was drafting a *Leben des Einstein*, and the Berliner Ensemble was in rehearsal for a new version of *Galilei*—the play's third. This version reflected the atomic bombings of Hiroshima and Nagasaki overtly. "Overnight," states Brecht in his notes, "the biography of the founder of the new system of physics read differently" (qtd. in Bentley 16). In a new dialogue, Andrea condemns Galileo for selling star-charts to generals and merchants instead of aiding the

masses. “Even in the field of ethics,” he states wryly, “you were centuries ahead of us.”[7] Brecht’s Galileo trumpets science as the sole arbiter of human error, but, in its revisions, *Galilei* reminds us that philosophy, science, and theatre articulate (and re-articulate) one another’s limits and engage with one another’s impact on the world. The unfinished *Einstein* play would have extended *Galilei*’s investigation directly into atomic physics, but traces of quantum theory nonetheless linger in Brecht’s oeuvre (Parker 594).

Brecht’s amalgam of classical and neoclassical stage conventions offers a compelling origin for the convergence of theatre and contemporary physics. In his *Organum*, Brecht develops from *Galilei* a set of dramaturgical principles that (intentionally or not) resembles quantum theory’s earliest formulation: the Copenhagen interpretation, advanced by Bohr, his assistant Werner Heisenberg, and their associates since 1926. The quantum realm is famously strange. In what Thomas Kuhn dubs a crisis period, the late nineteenth and early twentieth centuries saw an accumulation of egregious anomalies that contradicted the Newtonian paradigm (*Structure* 66-68). This crisis gave way to the quantum revolution when, in 1900, Max Planck introduced the notion of quantized energy (energy in packets) to solve the blackbody problem. Planck’s theory inched toward a granular picture of reality: phenomena that were once understood as continuous (e.g., light waves) were soon described as discrete (e.g., photons). This shift opened the floodgates for a discontinuous and uncertain understanding of fundamental physics. The mathematical solutions to atomic problems, calculated by scientists such as Einstein, Heisenberg, and Erwin Schrödinger, suggested a strange reality: wave-particle duality, substantial uncertainty, discontinuous quantum leaps, and so on. The following century brought new experimental apparatuses, which confirmed these (and many other) interactions. Mathematics and experiments both seemed to refute long-held scientific assumptions, such as

strict determinism, mass conservation, and the givenness of spacetime. Since René Descartes reasoned himself out of skepticism, scientists had held that their approach exposed nature itself. Now, scientists could not be so confident. Are leaping electrons and packets of light nature itself, or artifacts of our approach to reality?

This introductory chapter has a few tasks. First, it contextualizes my investigation by outlining the historical dialogue among theatre, science, and philosophy. Heisenberg describes atomic physics through Aristotle's terminology and contrasts the quantum situation with the natural philosophies of Descartes and early empiricism. Luckily, Aristotle analyzes theatre through his own proto-scientific method, and recent scholarship has revealed the cross-fertilizations between early modern science and theatre theory. In this section, I consider the relationship between various historical modes of scientific thought and their contemporaneous aesthetic and critical practices. I delay my analysis of the ontological commitments of these paradigms for subsequent chapters. This introduction merely situates scientific methodologies in the history of theatre and clarifies the unique nature of the quantum revolution.

Second, I offer a general description of quantum mechanics and its core features: indeterminacy, the Schrödinger equation, the Born rule, and the measurement problem. I explain why quantum mechanics requires (or seems to require) an interpretation at all. This primer relies on Bohr and Heisenberg's description of the atomic situation, though I indicate points of interpretational contention. Alternative interpretations take the stage in the subsequent chapters. To be frank, I am no atomic physicist. Throughout this dissertation, I only present my reading of the works of experts, emphasizing their attempts to describe the reality beneath their findings. Brecht's *Galilei* is my constant interlocutor in this chapter. His response to the theatrical tradition runs parallel to Bohr and Heisenberg's response to Newtonian physics. In 2015, *Brecht-*

Tage (*Brecht Days*), the German-language conference dedicated to Brecht, took as its topic "Brecht und die Naturwissenschaften" ("Brecht and the Natural Sciences"). In his presentation, Lukas Mairhofer argued that Brecht's aesthetic was modelled on early quantum mechanics. Mairhofer's research, however, is not yet publicly available. Regardless, as this dissertation demonstrates, quantum theory and Brechtian dramaturgy share salient features whether intentionally or not. Most strikingly, the Copenhagen interpretation imbues counterfactual thinking with new ontological weight, and Brecht orchestrates a similar move on stage. Counterfactuality became a renewed topic of scholarship and an interpretational battleground throughout the twentieth century.[8] Where Brecht's self-conscious theatricality sidesteps interpretation for political activation, later playwrights delved into interpretational problems.

1. A brief history of theatre and/as science

Western theatre and philosophy share a fraught history. Playwrights and dramatists have sparred since (at least) Aristophanes and Socrates. In the *Republic,* Plato's Socrates bans most poetry from his ideal state altogether. Like the Inquisition some millennia afterward, he recognizes drama's ability to coach spectators toward dangerous beliefs. Strangers to wisdom, poets teach the public to invest their emotional energy in inappropriate places and, worse still, to lie (595a-607b). Aristophanes countered these jabs by foisting Socrates onstage, his head literally in the clouds. *The Clouds*, a comedic masterpiece, portrays Socrates as a sophist and crook. However, this ancient feud betrays theatre and philosophy's common ground. Socrates performed his philosophy on the street with all the ephemerality of live theatre. And, as *The Clouds* lambasts philosophers, it stages a sophisticated philosophical argument on the nature of instruction (see Strauss 28-35). Similarly, the *Republic*'s antitheatrical invective culminates with

Socrates asking posterity to produce a defence of the imitative arts (607c). As we see later, the quantum theatre foregrounds this tension between performed materiality and imaginary rationalization. Where Plato may defend theatre through his use of the dialogic form, however, Aristotle defends theatre with scientific rigour in his treatises.

1.1. Theatre as science in ancient Greece

Aristotle's reputation as a system builder is well-deserved. His investigations into physics, metaphysics, ethics, politics, and rhetoric stand together as diverse facets of one project. *Poetics* inaugurates the tradition of theatre studies as one pillar in his topic-spanning system. Moreover, the mature Brecht developed his poetics in conversation with Aristotle's, and Heisenberg adopts Aristotle's terminology to describe the atomic world. In short, the interaction between Aristotle's science and poetics (and metaphysics, addressed in Chapter 4) foreshadows the relationship between quantum mechanics, philosophy of science, and theatre.

Aristotle's six works on logic, collected posthumously as the Organon (i.e., the tool), offer a procedure to analyze myriad topics. He introduces his system's basic form, the syllogistic argument, in the *Prior Analytics*. A syllogism combines a major premise about one category of analysis with a minor premise about another. Their synthesis discovers a consequential relation between those two categories via an intermediary. It takes the form

(1) B are A (the major premise)

(2) C are B (the minor premise)

(3) Therefore, C are A (the conclusion)

One could then use the conclusion "C are A" as the major premise in a new syllogism (and so on).[9] In *Galilei,* Brecht mocks this structure because it allows you to leap from syllogism to

syllogism ad infinitum and thereby abandon the physical world entirely. However, the relationship between categories must be coordinated by valid modifiers, which contribute the rules for deduction. Common modifiers include *all* (e.g., all humans), *some* (e.g., some humans), *necessity* (e.g., must), and *possibility* (e.g., might). Only select combinations of premises and modifiers construct valid arguments, and this calculus gives form to Aristotle's science. When Aristotle inventories the kinds of knowledge, logic threads each as the sole tool for knowing (see Miller xv-xvi). Theatre scholars should find these modifiers familiar. In the *Poetics*, Aristotle defines a tragic plot as a sequence of events that "permit[s] a change from . . . good fortune to bad . . . in accordance with *probability* or *necessity*" (1451a, emphasis added). Aristotle portrays dramatic action as a chain of syllogisms, where the conclusion of each event becomes the premise of the next. This procedure only finishes when one such conclusion reverses the protagonist's fortune.

When *Galilei* ridicules Aristotle's logic, Brecht overlooks the empirical corrective that Aristotle outlines in the *Posterior Analytics.* The syllogism is the *form* of scientific thought (its shape or appearance), but the *matter* of scientific thought (its constitutive makeup) is the content of the premises. An argument is scientific only when its form and matter fit. The syllogism must follow the mechanisms of logic, and the premises must be verified by evidence or intuition. As *Poetics* describes, a chain of necessary premises (*musts*) ultimately reveals a universal truth about their matter (1451b). These universal truths are the principal aim of science but not strictly observable. Thus, Aristotle prefers intuition over observation. We develop intuitions by applying inductive reasoning to our history of experience. In *Posterior Analytics*, he explains: "from a sensation there arises a memory . . . and from many memories of the same thing there arises [one] experience . . . from experience . . . [there arises] a principle of art or of science" (100a;

brackets in original). That principle is a universal truth, which gives matter to the highest order of scientific knowledge. In other words, experience fits centrally in Aristotle's science. We watch many examples of one kind of thing until our memories coalesce into a principle about it.

Aristotle's *Poetics* treats the theatre as an extension of the same processes. Though he privileges plot over all else, he recognizes that figures on stage offer the primary sense data in performance. Thus, he claims, "whatever a character of any kind says or does may be the sort of thing such a character will necessarily or probably say or do" to ensure that "the events of the plot may follow one after another either by necessity or probability" (1454a). Because the spectators observe the characters' actions, those actions stand in as the premises of the plot's syllogistic chain. Spectators first rely on prior intuitions to measure the soundness of a character's actions. By the climactic moment of tragic suffering, the protagonist's internal consistency has followed that coherent syllogistic chain into a hypothetical situation. As long as the plot's logic remains valid, and the characters are sound, the spectators cannot help but mimic the protagonist's suffering. Each spectator undergoes this process, fomenting the conditions for *katharsis* (understood here as clarification).[10] Each spectator sees the actor's tragic response, mimics it, sees it in himself, and then sees it in his fellow spectators. Witnessing so many examples of one response, the spectator can form intuitions of principles and grasp universal truths. In short, tragedy stabilizes and makes cognizable a universal fact of human nature.

Of course, Brecht reviles Aristotle's description of tragedy. He complains that, in Aristotle's process, "the actor imitates the hero . . . and he does this with such suggestion and transformative power that the spectator imitates him and thus takes possession of the hero's experience" (*Brecht* 141). Consequently, "the individual whose innermost being is thus driven into the open then, of course, comes to stand for Man with a capital M" (127). The tragic

situation lures spectators into internalizing the protagonist's emotion as if it were their own. Subsequently, the imitation stabilizes an image of an "innermost being," which the spectators see in themselves. In turn, the spectators are ensnared by the laws of necessity and probability. They are immutable and unchangeable, and so, he claims, the theatre lacks space for revision, reaction, or activism. Aristotle might disagree with Brecht's evaluation—cognizing a universal capacity does not necessitate its second actualization (Chapter 4). Nonetheless, Aristotle justifies theatre with a process that Brecht scorns. Both thinkers understand theatre through science and, moreover, conceptualize theatre as a truth-seeking activity. But their definitions of truth differ.

Despite his anti-Aristotelian posture, Brecht's dramaturgy retains a trace of *katharsis* as clarification. As R. Darren Gobert demonstrates in "Cognitive Catharsis in *The Caucasian Chalk Circle*," the process of recognition, comparison, and clarification "helps spectators refine the beliefs that inform their emotions and, in turn, the ethical 'attitudes' that Brecht seeks to transform" (28). In the final scene of *Galilei*, Andrea contends with the Italian border guards while three boys argue nearby. Two boys believe a nearby domicile houses a witch, and the third vehemently disagrees. The witch-hunters inventory their proof: "She flies on a broom every night[,] . . . she never goes to the city, even to exchange her milk jug[,] . . . the devil left her a box on the stoop," and so on.[11] Andrea takes the box (which is his), reveals a delivery jug hidden behind it, and states: "no one can fly through the air on a stick. He needs a machine at least. However, such a machine doesn't exist. It might never exist since man is too heavy. But, of course, we cannot know. We don't know nearly enough. . . . Truly, we stand at the beginning."[12] Andrea, like Galileo, slays superstition with evidence about what can and cannot float. In the first version of the play, the previous scene shows Galileo triumphant: the trials of the common man in mind, he releases the *Discorsi* from prison. Andrea smuggles the great work out of Italy,

knowing that we stand "at the beginning" of a scientific revolution. In the 1956 revision, however, Galileo's work is spurred on instead by obsessive determination without moral compunction. The utility of his discovery does not concern him. For the spectators of this version, the atomic bomb looms in the future of Andrea's "beginning." This second version clarifies an ethical attitude and refines the spectator's understanding of the scientific worldview. As Gobert argues, "Brecht severs katharsis from mimesis and attaches it to praxis. . . . He thus rescues the spectator from an emotional passivity before the spectacle, facilitating the 'attitude' for ethical action" (29). The scientist can be a single-minded obsessive and, therefore, science requires our engagement. The structure of the play encourages the spectator to examine science's promise and its actualization in our history.

As we see later, the quantum theatre interrogates the notion of a universal nature and continues to experiment with *katharsis*. When a play meets Heisenberg's call, and its action oscillates between complementary frames, characters confront the presence or absence of an innermost being. When we stage the electron's particle-like or wave-like actions, what role does the apparatus play in delineating its nature? The quantum theatre also echoes the structure of *katharsis*, though it clarifies a different object of cognition. Aristotle's tragedy makes cognizable a universal feature of humankind by stabilizing it in many exemplars; the quantum stage makes cognizable an unrecognizable facet of reality by destabilizing space.

Heisenberg and Bohr openly court Aristotle's metaphysics, but atoms elude the philosopher's method. We cannot form intuitions at the atomic scale. Without technological aids and mathematics, there are no examples of sensation, and, without sensation, there is no intuition or universal principle. Thus, according to Aristotle, atomic entities might sit outside scientific consideration. Furthermore, the scientists were likely familiar with Aristotle's poetics. The late

nineteenth and early twentieth centuries saw the increasing institutionalization of theatre and science. During the same period, Greek tragedy experienced a fortuitous "large-scale revival" in live performance (Michelakis 149). When Heisenberg turned to Aristotle's terms to describe the atomic situation, he was undoubtedly familiar with Greek tragedy as a spectator and, moreover, as an academic. His father was Germany's sole full professor of middle Greek studies, and his grandfather was an expert on Greek tragedy (Cassidy 1-19). The resurgence of Attic staging and the birth of modern physics developed side-by-side in the European universities.

But the quantum stage is also filtered through the worldview of the scientific revolution. In the seventeenth century, technological improvements and publications like Galileo's *Dialogue* and Descartes's *Discours de la méthode* (*Discourse on the Method* [1637]) sparked widespread rejection of Aristotle's method. The natural world and all its beings were envisioned not as imbricated universals but as gears and pulleys interlocked in divine harmony. Histories of philosophy characterize early modern science as the battle between opposing traditions: rationalism, represented by Descartes, and empiricism, represented by Bacon, John Locke, David Hume, and many others. This crass dichotomy has rightly fallen out of favour, but the twin lineages will always offer valuable dramaturgy. First, Cartesian rationalism reconceptualized spectatorship; second, empirical science sterilized the stage as an operating theatre.

1.2. Early modern science and theatrical spaces

In the *Discours*, Descartes advocates a scientific method far removed from Aristotle's, which engenders different practices of theatre spectatorship. Aristotelian science builds from particular examples to intuitions and, ultimately, universal truths. Instead, Cartesian science operates through the hypothetico-deductive model. One proposes a reasonable hypothesis,

deduces predictions, critically examines the senses, and then evaluates. Like Aristotle, Descartes founds his practice on everyday experience. However, he lauds mental activity (not sensation) as our most primary experience. In a famous thought experiment, he deduces that one can doubt his sense data, as demonstrated by mirages and dreams, but one cannot doubt that he thinks during any given act of doubting. Therefore, his thoughts must reside in a thinker who is "a substance, whose essence . . . consists of thinking and which does not need to be in any place or to depend upon any material thing . . . [that] is completely distinct from the body."[13] This substance is the Cartesian subject, the *res cogitans*. As humans, our substantial existence (i.e., our soul) is distinct from material reality, the *res extensa.* We are anchored to a body by the grace of God, so that we may know His creation, but, fundamentally, we are bodiless, thinking things. Thus, our pure thoughts—not our perceptions—grasp the truth. Because God wants us to comprehend his creation, we can describe *res extensa* with the rationalist tool par excellence: mathematics.

This dualistic outlook provides a new foundation for science. A thinking thing, the Cartesian subject posits a hypothesis from a position outside of the machinery of the material world. Then, he gathers data through experiments and compares it to his expectations. The initial hypothesis is not abstracted from memories of prior perceptions; it stems from clear and distinct notions, sorted with mathematical precision by a canny mind. The Cartesian scientist's detachment from the world causally quarantines him from his experiment. In a telling metaphor, Descartes suggests that a philosopher must "try to be a spectator rather than an actor in all the dramas that are played out there [on the world stage]."[14] However, this total objectivity is an unattainable ideal. After all, the philosopher admits that he can only "try to be" a spectator. The Cartesian subject is defined through its ability to know material substance, and material substance is likewise defined by its ability to be understood by minds. As the spectator seems

inevitably drawn into the suffering of the protagonist, the philosopher is enticed to perform on the world stage.

Descartes's thoughts on the theatre notwithstanding, Descartes-inspired moralists saw a tension between the spectators' subjective souls and the intersubjective dangers of theatregoing.[15] In *Les Passions de l'âme,* Descartes concludes that, when a subject perceives an emotional reaction in another subject, it affects the mind of the viewer and inclines his or her body to move in a manner that affects other minds. This picture bolsters Platonic antitheatrical anxieties with scientific legitimacy: evils on stage may enter the spectators' souls and then spread to other people. In *The Mind-Body Stage: Passion and Interaction in the Cartesian Theatre,* Gobert posits two dramaturgical tropes that blossomed from this Descartes-inflected antitheatrical bias: consanguinity and ocularity. Consanguinity, "in which subjects and objects threaten to bleed into one another," is the intersubjective exchange between actor-spectator and between spectator-spectator that encourages identification and *katharsis*. Ocularity, "in which the spectating subject visually apprehends the performing object," is the corrective measure to limit troublesome consanguinity (*Mind-Body Stage* 122). If theatremakers could convince the spectators to apprehend the space on stage as a third substance through techniques of refraction (another Cartesian science), then its contents should be rendered causally inert. Thus, Gobert suggests, Descartes-inspired playwrights tended "to think of the world of the play as distinct from the world of the spectating space," solely for observation (130). The ocular stage appears alien to the spectator, as *res extensa* remains estranged from *res cogitans.* Thus, a framework designed for scientific inquiry came to correct practices of spectatorship.

As Gobert demonstrates, stagecraft underwent fundamental shifts to stabilize the stage image and direct observation. The theatre building itself was reshaped to encourage spectators to

be only spectators: fixed seats replaced parterres to control where spectators looked, and decorative proscenium arches distinguished the object of viewership from the space of spectatorship. Dramaturgs developed a new set of acting conventions to supplement the ocular stage and limit the risk of intersubjective *katharsis*. For example, Charles Le Brun developed a semiotic code, extrapolated from Descartes's emotional theories, to signify emotions without engendering them in others (*Mind-Body Stage* 85-87). Aristotle's characters are the premises for a soul-searching induction, but these Descartes-inspired characters merely signal their emotions as cogs in the plot's machinery. These changes "distance[d] the spectator from the actor onstage[,] . . . disentangle[d] subject and object[,] . . . [and made the actor] the object of the audience's gaze . . . not merely one party in a reciprocal relationship of intersubjective possibility" (159). An interpretation of the Cartesian method became a tool to fix the theatre's potential ethical dangers.

Brecht's epic theatre utilizes similar techniques to different ends. Le Brun's sign system objectifies the actor to disentangle him from the spectators. If spectators understand characters as an unreal substance, the performance stays intersubjective bleeding. Brecht's system of *gestus* pushes objectification further. A gest is a pose or movement that captures the "particular attitudes adopted by the speaker towards other persons" (*Brecht* 167). Brecht's attitudes stem from social and power relations and not one's divine essence. In *Galilei¸* a theologian and a philosopher conclude that Galileo painted newfound stars onto his telescope's lens. The theologian "takes out a handkerchief and wipes the lens with a significant glance at Galileo" and the pair exit without looking through the device.[16] The artificiality of this gesture does not signify emotions (as with Le Brun); instead, it makes present the social arrangements among the church, educational institutions, and revolutionary ideas. Like LeBrun, Brecht objectifies the

actor, and the spectators are estranged from the character. Instead of a causally neutered world, however, Brechtian alienation points to the system of "human machinations" that extend beyond (*Brecht* 127). Furthermore, Brecht encourages his actors to become alienated from their own characters. Through the gest, an actor points to a character's attitude instead of embodying it. The gestic approach does not stabilize the fictional world for distant viewership; instead, it destabilizes the stage space and encourages spectators to relate its contents to reality.

The quantum theatre pursues this destabilization further: it nudges spectators toward destabilizing the everyday world. In all interpretations, quantum theory retains the Cartesian faith in hypotheses. The early theory rested on radical speculation and mathematics. However, quantum mechanics (in the Copenhagen interpretation!) rebuffs the possibility of cleaving subject from object. By isolating a component of reality for observation, we entangle our expectations and hypothesis with the natural phenomenon that we observe.

Before Brecht or quantum theory, another movement rejected the Cartesian approach and offered an alternative optics of stage stability. Bacon laid the groundwork for the empirical approach that developed in parallel to Descartes's hypothetico-deductive method. Where Descartes founds science on mental activity and deduction, Bacon doubts the reliability of his mind and advocates the senses. In his *Organon,* he explains that "the human understanding is like a false [distorting] mirror, which, receiving [light] rays irregularly, distorts and discolors the nature of things by mingling its own nature with it" (48). Our minds are prone to logical fallacies and interpretive prejudices, Bacon posits, so the prudent scientist must trust only the senses. Like Descartes, Bacon still rejects Aristotle's framework. Where Descartes distrusts Aristotle's intuitional basis, Bacon disapproves of the syllogism and its categories of analysis. When he moves from perceived evidence to a principled premise (e.g., from Agamemnon's suffering to

the premise “all men can suffer”), Aristotle invents “intermediate axioms . . . [which] consist[] of propositions, [which] consist of words, [which] are symbols of notions,” and “if the notions . . . are confused and overhastily abstracted from the facts, there can be no firmness in the superstructure” (41). Aristotle rightly relies on observation, Bacon opines, but he shifts too carelessly from observation to principle and thereby smuggles “fantastical and ill defined” notions into science (42). To purge the science of these middle terms, Bacon argues that “our only hope therefore lies in true induction” (41). For Bacon, science and induction are synonymous. But observation must proceed without any categories or, to an extent, analysis. One must merely observe, note patterns, and carefully generalize the data into predictive axioms.

Bacon attacks the Aristotelian intermediaries as false “idols” of knowledge. He distinguishes four kinds, one of which concerns us: “[T]here are Idols which have immigrated into men’s minds from the various dogmas of philosophies,” Bacon bemoans, “These I call Idols of the Theater.” Bacon employs the world as stage metaphor, albeit to opposite ends as Descartes. Rather than equate the world with a theatre, he argues that the inherited philosophical systems “are but so many stage plays, representing worlds of their own creation after an unreal and scenic fashion” (49). The idols of theatre are particularly insidious because they are “impressed and received into the mind from the playbooks of philosophical systems” (58). Philosophers place stories atop the stage of reality, and therefore the bare stage of nature—the proper object of science—vanishes beneath the scenery. Bacon sets his empirical method on an epistemic hierarchy that implicates theatre and philosophy as compatriots in a pernicious scheme of falsehoods. The worlds of philosophy are like panes of stained glass, which obfuscate the stage but claim transparency. The more intricate the glass, fashioned by concepts, the less light passes through it. This metaphor hits its natural limit with quantum mechanics. Without an

apparatus constructing the space of quantum theory, its stage would be entirely beyond our senses. Moreover, as Chapter 2 examines, contemporary cognitive science suggests that our cognitive apparatuses filter our perceptions before presenting them to our awareness. Nonetheless, Bacon's strict empiricism set the stage for centuries of attenuated empirical approaches.

The subsequent empirical tradition borrows more from the theatre than angry metaphors. By the mid-eighteenth century, Pannill Camp argues in *The First Frame: Theatre Space in Enlightenment France,* science and theatre became locked "in a dynamic process of mutual articulation" as both practices rapidly absorbed the empiricists' terminology (18). Across Europe, the exploratory and repeatable experiments "came to serve as proof for statements about the natural world, and their performance before discerning observers became a medium of persuasion amongst natural philosophers" (104). Where Descartes's hypothetico-deductive model encouraged fireside meditation, the empiricists' method required an audience, a sensible event, and reproducibility. Live theatre, of course, always had these elements. Scientists adapted techniques from the theatre to spectacularize public experiments; dramatists mobilized new optical theories to transform their audiences into scientific observers.

If the Cartesian stage was Bacon's false mirror, this empiricism-inflected stage was "a transparent field through which light physically moved" (Camp 5). As Camp demonstrates, the architecture of newly constructed theatres reflected the empiricist requirement for discerning, controlled observation. Oblong spaces, better disposed to engage the optics of the human eye, replaced the rectangular theatres of Cartesian optics. Artificial flats and vanishing points fell to historically accurate furniture. Le Brun's stage codes were replaced by natural blocking. And the proscenium arch widened to offer a broad view of the actor's bodies from multiple angles. These

theatremakers encouraged their spectators to treat the stage as "an actual segment of contemporary reality," placed under the theatre's strict laboratory conditions (16). On stage, declares Denis Diderot in *De la Poésie dramatique* (*On Dramatic Poetry* [1758]), playwrights and actors should now feign ignorance of their observers: "imagine a large wall separating you from the orchestra; act as if the curtain did not rise."[17] Where Descartes-inspired dramaturgs sought to stabilize the stage image as a distant substance, the empirical dramaturgs stabilized the stage as a continuous (but partitioned) slice of reality.

But the Cartesian partition still lurks beneath the empirical approach. A demonstration requires a discerning observer, and discernment begs distance. Thus, as Camp notes, Louis-Sébastien Mercier writes in 1770 that every spectator "judges as a public man, not as a private individual; he forgets his interest and prejudices" (qtd. in Camp 22). The audience remains separate from the performance, its objectivity protected by a transparent shield. These empiricists relied on Descartes's methodological advances but lost the justification for his metaphysical divide. Brecht's dramaturgy interrogates this rift, and many aspects of *Galilei* echo the empirical approach. But Brecht does not present the drama as if it were some reality spied through a one-way mirror. Instead, he lays bare the stage's spatial continuity with the auditorium. Placards announce scene changes, exposed lighting equipment reminds us of the technical work, and narration reinforces the fictionality of the dramatic events. The actor who plays Andrea in one moment may introduce the title of an episode the next. Like Mercier's audience, Brecht's regards the stage activity as reality. The Brechtian "public man," however, does not forget his imperative to judge the performance. Instead, this audience is reminded of itself and its place in the same world that houses the performance. After all, the stage is undeniably continuous with the

auditorium and, by extension, the spectator's world. By exposing the experimental device alongside the experiment, Brecht's dramaturgy prefigures the aesthetics of quantum theory.

Brechtian dramaturgy reflects both the empirical and Cartesian relationships with materiality. However, the playwright excises the project of image stabilization from both trends by oscillating between them. Historically, theatremakers stabilized the stage for objective spectatorship, and the method matched the paradigm. In Aristotle's picture, the form of the stage image (e.g., human suffering) impresses upon the matter of the spectators' sense organs. The same form impresses upon the matter many times, and thus the spectators retain a permanent image of universal humankind within themselves (*On the Soul* 424a-425b). Stabilization, in this case, is guaranteed by the structure of the human animal. Cartesian optics, however, implicate the viewer in the actualization of the viewed. According to Descartes, luminous objects radiate potential movement, which generates a mechanical pressure that travels through the air. If that potential hits an eye, it becomes actualized in concert with the soul's awareness of the sight (*Dioptrique* 81-88). God designed us to know the world, but that same design means we actualize the objects of our vision. If those objects are immoral, then we are complicit. It follows that theatremakers should stabilize the stage to safeguard ethical actualizations. In the eighteenth century, most empiricists treated light as a bombardment of luminous molecules, which crash into bodies and agitate the ether whether or not they enter the retina. The stage image interacts with the spectator no matter where they look, and, therefore, spectators must be trained to look correctly. Like the empirical audience, Brecht's has the freedom to look. Like the Cartesian audience, it also recognizes the inferiority of the stage picture. The interplay of freedom, judgement, and artificiality encourages the audience to extrapolate from staged activity to underlying reality—a cognitive *katharsis*, reminiscent of Bohr and Heisenberg's atomic theory.

This tight interplay of ocular paradigms proliferates on the quantum stage. Rather than reject any prior optical approach to staging, elements of each enter the dramaturgical space as complementary possibilities. The optics of the quantum stage thus track quantum theory's understanding of the measuring apparatus, which at once admits a shade of subjectivity, an openness to potentiality, and confidence in human understanding. In Chapter 2, I theorize stage space using contemporary cognitive science. Many modern cognitive scientists understand our perceptions as pre-interpreted images, which are filtered through counterfactual tests before they reach our awareness. Quantum mechanics and theatre share this reliance on counterfactual thinking, complementarity, and contingency. In *Cognitive Biology: Dealing with Information from Bacteria to Minds,* Gennaro Auletta argues that, because we are ultimately subject to atomic laws, the informational structure of atomic phenomena informs the counterfactual structure of cognition, perception, and semiotics (see 33-63). Before I can address contemporary staged worlds, however, I must first introduce the basic formulation of quantum mechanics.

2. Quantum theory and theatre

Extending the lessons of atomic science to human affairs, Bohr reminds us of "our position as spectators and actors in the great drama of existence" (20). Throughout *Physics and Philosophy,* Heisenberg repeats the metaphor. More than an offhand remark, the aphorism consciously inverts Descartes's spectatorship metaphor from the *Discours.* Heisenberg spies Descartes's shadow in the "eminent" Einstein's rejection of the Copenhagen interpretation, complaining that "[t]his partition has penetrated [so] deeply into the human mind during the three centuries following Descartes . . . [that] it will take a long time for it to be replaced by a really different attitude toward the problem of reality" (*Physics* 55). He commends Descartes for

recognizing "the indisputable necessity of the connection" between mind and body but regrets how "natural science in the following period developed on the basis of the polarity between the 'res cogitans' and 'res extensa,' and natural science concentrated its interest on the 'res extensa'" (53). The resulting physical theories, which culminated in Newtonian or classical mechanics, are "just that idealization in which we can speak about parts of the world without any reference to ourselves" (*Physics* 29). However, atomic experiments "make the sharp separation between the world and the I impossible" and the Cartesian subject unsustainable (*Physics* 55). In short, quantum mechanics requires a radical epistemological departure.

Heisenberg clarifies the Cartesian error with the notion of *objectivation*. Succinctly put, "we 'objectivate' a statement if we claim that its content does not depend on the conditions under which it can be verified" (*Physics* 55–56). When a Cartesian subject objectivates something, he recuses himself from the world and exposes nature's structure to his unerring rationality. When the quantum subject objectivates something, she admits that her choice of object and the act of choosing are parts of the world. Reality would exist without her measurement, but she acknowledges that she spectates and acts on the world stage. Instead of dividing the world into the subjective *res extensa* and objective *res cogitans,* atomic experiments require us to objectivate a part of the world—act *as if* it were independent—but recognize that objectivation is a nonarbitrary process. Moreover, we must acknowledge our complicity in acting *as if*. This new subject, like Brecht's spectator, accepts a systemic limit to objectivity, watches, and performs.

Newtonian idealism describes a world of strict physical determinism—given complete information now, one can accurately predict the future. As Thomasina describes in Tom Stoppard's *Arcadia*: "if you could stop every atom in its position and direction, and if your mind could comprehend all the actions thus suspended, then if you were really, *really* good at algebra

you could write the formula for all the future; and although nobody can be so clever as to do it, the formula must exist just as if one could" (13). If she could stop every atom in its position and direction, Thomasina would find that, with the universe so suspended, she could never derive an equation that would precisely predict the future of atomic events. The mathematical formalism of quantum mechanics (i.e., its set of axioms and formulas) does not assign definite values to each physical property simultaneously. Complete data only offers the probability of various outcomes, given the starting conditions. Thomasina's clever formula could predict the boundary conditions of possibility—the set of possible outcomes—but not the actual result. This shift is subtle but far-reaching: nature lacks perfect predictability and absolute values. Moreover, this fuzziness is not an epistemological problem; it rises directly from the mathematical formalism.

The following overview of quantum theory intentionally aims for accuracy and simplicity, not technical nuances. As such, it keeps scientific vocabulary to a minimum. As a theatre scholar, I focus on the founding experts' description of quantum mechanics in plain language and the resultant conceptual difficulties. I examine two sets of problems: first, indeterminacy, complementarity, and observational choice; second, the measurement problem and scientific realism. Contemporary theatre practice traces the anxieties that underlie both sets of issues. The subject/object distinction destabilizes, and the worlds onstage follow suit. On the contemporary stage, the kinds of instability are shot through with different interpretations of quantum mechanics.

2.1. Indeterminacy, complementarity, and choice

The popular understanding of quantum mechanics centres on the uncertainty principle, according to which some of a particle's physical properties inherently lack simultaneous fixity.

This uncertainty does not stem from imprecise machines or indecisive scientist. Rather, it arises before any observation or experimental design. The uncertainty principle derives from mathematical inequalities that, in turn, stem from the fact that everything in quantum mechanics, even objects traditionally understood as particles, behaves somewhat like a wave. These inequalities force certain *observables* (measurable properties of an entity) into quirky relations with one another. If one such observable exhibits an increasingly precise value, its partner observable undergoes a proportional loss of precision. Thus, if we increase the precision with which we measure an electron's momentum, then its position becomes inherently fuzzier. Observables bound in these mathematical relations are *complementary.*

This starting point may sound innocuous, but the consequences are unnerving. Theoretically, if you measure a particle's momentum with perfect precision, its possible position becomes proportionally inaccurate. In other words, if an electron has a definite momentum, it could be anywhere in the universe! A joke might help. Heisenberg is driving on the highway with Schrödinger and Einstein when he is pulled over by a police officer. The arresting officer asks Heisenberg, "do you know how fast you were going?" Heisenberg replies calmly, "Somewhere between 1 and 200 kilometres per hour, surely." The officer replies without amusement, "you were going 142 kilometres per hour!" Heisenberg throws up his arms in anger, "Great! Now we're lost!"

If we hope to avoid this absurdity, electrons must never have a precise momentum. And it follows (directly from the mathematics) that there is a fundamental limit to precision in nature. Crudely put, Heisenberg's uncertainty principle quantifies that limit. In English, the *uncertainty principle* is the common term, but it carries inaccurate connotations. *Uncertainty* suggests that one could theoretically ascertain more data, but something limits our certainty. Quantum

uncertainty is different. The limit in quantum mechanics is an ontological, systemic feature of nature. Bohr and Heisenberg test alternative terms in their writings, and each term connotes a different underlying reality. *Indeterminacy relation*, the term I find most useful, suggests that there exists a relation between observables that renders those related things indeterminant.

These ideas should sit comfortably with theatregoers. Since King Hamlet's ghost and his son's existential wavering, uncertainty has been an important theme on stage. Moreover, we face something like uncertainty whenever we watch a performance because there is a systemic limit to our ability to ascertain staged events. Some limits are epistemological: was that twitch a choice or incidental? As a choice, it might reveal the character's nature; as an incident, it reminds us theatre's embodiedness. Other limits are definitive characteristics of the art form. Each night, each performance is somewhat different despite emerging from the same scripted function. A performance traces a range of possible positions and momentums from a single pre-determined system through one measuring apparatus. Early quantum theorists recognized these similarities and, like Bohr and Heisenberg, compared quantum mechanics to live theatre (see George 172).

Perhaps the most evocative form of stage indeterminacy is the tension between the real and the fictional. The actor playing Galileo *pretends* to go blind but *actually* places a needle on water. And theatremakers have interrogated this border since the early modern stage. For example, Francis Beaumont's *Knight of the Burning Pestle* (1607) and Pierre Corneille's *L'Illusion comique* (*The Theatrical Illusion* [1634]) both blur the boundary between the real world and the world of the play. George's interjections into *Knight*'s action and Alcandre's scrying crystal suggest that the stage is another place that yet shares a porous border with our world. However, these dramatists tamed their aberrant worlds with metatheatrical conventions. Alcandre's magical device stirs worlds together, but the prologue and epilogue contain *Illusion*'s

chaos as a mere theatrical illusion. In other words, our world is the only world; the remainder is playacting. In contradistinction, the contemporary stage usually agitates its ontological confusions. As Erika Fischer-Lichte describes contemporary theatre:

> the blurring of the real and the fictional . . . resulted in transferring the spectator/visitor into a state of in-betweenness, into a state of liminality. This state not only destabilizes the order of perception but, more importantly, the self. . . . What in everyday life is neatly separated into two different worlds that can be fully grasped by a dichotomous pair of concepts becomes blurred . . . so that all certainty about whether to place oneself in a real or a fictional world is lost. (95)

Such tactics would be impossible under the previous paradigms, where the stability of the stage image was secured by the current scientific method. This instability renders the space on stage indeterminant; even a perfectly trained spectator cannot separate the real from the fictional or the purposeful from the accidental. There is a systemic, natural limit.

Indeterminacy also suggests that some aspects of a system, like the fictional and the real, abhor simultaneous viewing. A measuring apparatus offers one frame of reference, which manifests certain (e.g., particle-like) features at the expense of others (e.g., wave-like). Another device would display a complementary picture. At first glance, these pictures contradict: a single thing cannot be a wave (energy transferred through a physical medium) and a particle (a physical medium) by definition. In the Copenhagen interpretation, this contradiction is resolved (or worsened, depending on whom you ask) by the *principle of complementarity*:

> [Quantum theory] implies *the impossibility of any sharp separation between the behaviour of atomic objects and the interaction with the measuring instruments which serve to define the conditions under which the phenomena appear*. . . . [E]vidence

> obtained under different experimental conditions cannot be comprehended within a single picture, but must be regarded as *complementary* in the sense that only the totality of the phenomena exhausts the possible information about the objects. (Bohr 39–40)

When a scientist designs an experiment, she selects (or invents) an instrument for measuring a specific observable. This choice determines which facets of the phenomenon will manifest. It also introduces new counterfactuals into the description of physics, as the next chapter explores. Under the principle of complementarity, that instrument must now enter the scientific explanation as a frame. According to Bohr, she should not say "the electron *is* a wave," only "the electron, under conditions which measure wave-like behaviours, manifests . . ." By removing the *is* from our statements about the world, we avoid contradiction and honestly frame our object. Only "[b]y playing with [multiple] pictures, by going from the one picture to the other and back again," Heisenberg explains, can "we finally get the right impression of the strange kind of reality behind our atomic experiments" (*Physics* 23). The Cartesian subjects adopt an objective position from within *res cogitans,* where one can stake metaphysical claims about material reality. Quantum mechanics, in both its rational (i.e., mathematical) and empirical (i.e., experimental) forms, rejects the plausibility of such a position.

Transitioning between frames is not unlike translating between languages or even idioms: things are irrevocably lost. This situation is also true of performance. When we watch the action on stage left, we have only a fuzzy image of stage right; when we are absorbed in the fiction, we are less aware of the stagecraft. Renaissance theatremakers seemed aware of this fact. Descartes-inspired dramatists recognized that framing was a potent metaphysical and ethical problem, as the medieval practice of mansion staging made salient. In its embrace of objectivity, however, the theatre of the enlightenment downplayed uncertainty. An unquestioned Cartesian subject

became the central episteme, and so the spectator became an objective scientist. Hans-Thies Lehmann describes the dramatic period of this era as a theatre of "ordering . . . the visible through perspective . . . [which] makes totality possible precisely because the position of the viewer, the point of view, is excluded from the visible world of the stage picture, so that the constitutive act of representation is missing in the represented" (79). By excluding the frame from the stage image—by failing to mention the optical lens in the description of the theatrical event—the theatres of early modern science hid the art form's implicit complementarity.

The case is different in contemporary theatre. When perspectival contingency first resurfaced on stage, it arrived as apprehension instead of (for example) *Knight*'s playfulness. In *Staging Place: The Geography of Modern Drama,* Una Chaudhuri argues that, in the late nineteenth century, the theatre became increasingly anxious about spatial contingency. In the works of Henrik Ibsen, for example, spaces (e.g., houses) and places (e.g., homes) decouple, exposing hidden meanings within both. Is home and its safety necessarily within the house? Does space or place constitute identity through familial, national, urban, or rural notions? Chaudhuri calls this uneasiness modern drama's *geopathology.* She writes:

> The problem of place—and place as a *problem*—informs realist drama deeply, appearing as a series of ruptures and displacements in various orders of location, from the micro- to the macrospatial, from home to nature. . . . [But] the most fundamental dislocation is . . . that between humankind and nature. . . . These dislocations are given their meaning from the geopathic paradigm underlying [modern] realist drama, which also supports a certain construction of identity: identity as a negotiation with . . . the power of place. (55-56)

Under the quantum rubric, we can approach (but never reach) the underlying reality, the fact of the matter, by treating these contradictory perspectives as complementary observables. Homes

and houses are two complementary pictures of one phenomenon, whose indescribable reality is glimpsed when we contrast the two images but never grasped. The nature of that phenomenon is unspeakable, but we can hone our intuitive sense of it.

Brecht's *Galilei* marks a more radical geopathology. Its dramatic action generates a geopathology akin to Ibsen's. Galileo's home becomes his prison but remains a bastion of intellectual resistance to Andrea and his compatriots. However, Brecht also generates spatial anxiety that treats the stage itself as a site of dislocation. *Galilei* switches between two complementary modes: a dramatic mode that represents a fictional situation and a nondramatic mode that exposes the actual workings. Likewise, the spectator must oscillate between two complementary pictures of the play. Fischer-Lichte calls these two modes *representation* and *presence.* Like Lehmann, she correlates representation with the well-made play and the goals of eighteenth-century dramaturgy: a stable stage image for objective viewership. She defines presence as the spectator's awareness of the actors' bodies and the stagecraft's materiality: an unstable stage image. The interplay of representation and presence fuels *Galileo*.

In scene 10 of Brecht's English-language version, Galileo restarts his research into celestial bodies after the ascendency of a new pope. The spectator may wish to empathize with Galileo's scientific redemption after years of squandered intellect. This compulsion is dashed, however, when a title-card introduces the episode as: "6. GALILEO'S YOUNG DAUGHTER IS THE FIRST VICTIM OF HIS DECISION" (*Leben* 182). Realizing that her father's decision will terminate her engagement, Virginia faints. Galileo's redemption and Virginia's collapse are representational: both moments signal activity in a fictional world, which the spectator watches from a position without. Here, "the constitutive act of representation is missing in the represented," as Lehmann says. The title-card, however, asserts presence: the performance's

materiality emerges, and the spectator recognizes the stage activity as a part of the play's externally directed social commentary. Heisenberg demands that we must flip back and forth between two complementary pictures to get "the right impression of the strange kind of reality" beneath our experiments. *Galilei*'s stage works similarly: the spectators flit between two frames, and each transition forces them to re-evaluate both modes. They identify with Galileo's representation as a hero, but then a placard brings the performance's materiality forward and nullifies that identification. When the spectators re-enter the staged world of the drama, the placard has exposed the boundaries of Galileo's effect on the world: his victory is now Virginia's plight. The flight into presence destabilizes the return of representation, and a sense of *Galilei*'s totality emerges only from the switching between these complementary pictures.

The material condition of theatre engenders another form of complementarity that is nearly impossible to occlude. For spectators, the stage is a space to *watch*; for actors, it is a space to *be watched* (see Woodruff 18-22). When Brecht alienates the spectators from the dramatic representation, the objects on stage (the actors and their bodies) assert their subjectivity. After all, actors are people too, who could watch a play or measure an event. The Brechtian spatial arrangement, with its shifting frames, destabilizes our expectations for the event and the spectators lose their ability to locate themselves as subjects, the actors as objects, or, indeed, the world on display in *Galilei*. Is it a fictional Italy*,* a representation of historical Italy, or the stage space? In *Spatiality,* Robert Tally characterizes the modern experience through this sort of inability to self-locate. As our notions of subject, object, reality, and observation destabilize, we grow unable to position ourselves in numerous contexts (67-74). In the representational frame, Galileo does not know if he is a fighter or an obsessive. In the presence frame, the spectators do not know how to spectate an object that asserts its indeterminant subjectivity. By exposing

objectivation as a process, Brecht stages a world that is fundamentally indeterminant, glimpsed in complementary pictures.

2.2. The measurement problem and realism

So far, my description of quantum mechanics has danced around the question of reality. What is this fundamentally indeterminant stuff, slumbering beneath the complementary pictures? According to the mathematical formalism, all quantum systems undergo continuous evolution via the Schrödinger equation: a mathematical description of the system as a linear wave function. When two quantum systems interact, they obey a new, combined function. This wave-like description of an atomic entity outlines the boundaries of its possible attributes, the potential values of its observables. Consider Schrödinger's celebrated cat. Some cruel person places a cat inside a locked, impregnable box, alongside a device which may or may not kill the cat with a 50% probability.[18] The wave function that describes the cat's quantum state becomes entangled with the device's. Eventually, their mixed state evolves into a *superposition* of two superposed outcomes: $1/\sqrt{2}$ (Cat=Alive) + $1/\sqrt{2}$ (Cat=Dead). To quote Schrödinger, the wave function "of the entire system would express this by having in it the living and dead cat (pardon the expression) mixed or smeared out in equal parts" ("Present Situation" 328). But when we open the box, we never see matter smeared out in this fashion. We see an alive cat or a dead cat. To continue the joke about the disastrous road trip: the disgruntled officer then moves around the car to inspect the trunk. He opens it and finds a dead cat. "Why is there a dead cat in the trunk?" the officer asks, bewildered. "Sure, it's dead now," Schrödinger moans.

A quantum system must eventually interact with something that is not a quantum system: the measuring apparatus, which we can perceive at our everyday scale. Otherwise, we could

never read the results. But, when the quantum entity interacts with the measuring device, its wave function of smeared matter disappears. In the jargon, it *collapses*: a single outcome (within the boundary of possibility permitted by the wave function) jumps into being, and the others disappear. The result emerges discontinuously at the moment of measurement—nothing c*auses* a particle (or cat) to undergo this quantum leap (Dirac 10-17). Via a mathematical operation (the Born rule), we can calculate the probability of different outcomes; the likelihood of finding the particle in different points is decided by the magnitude of the wave function's crests and troughs. But no mechanism *causes* a particular result. This issue, central to quantum theory, is known as the *measurement problem*: why does the act of measurement erase the quantum state and replace it with a semi-classical one?[19] We never see a quantum state, so it seems unreal. Before the collapse, however, an entity in a quantum state entangles with other quantum entities as if every possible outcome were actual (as their wave functions combine). And the mathematical description of the quantum state allows us to calculate real experimental outcomes with unmatched success. In short, the whole probability space of the wave function has tangible effects, but whenever something at our scale tries to see the quantum state, it disappears.

The contentious interpretations of quantum mechanics are proposed solutions to the measurement problem. The Copenhagen interpretation solves the question pragmatically by ignoring it. Heisenberg opines that quantum states do "not describe a certain event but, at least during the process of observation, a whole ensemble of possible events." Observation then discontinuously (i.e., acausally) "selects of all possible events the actual one that has taken place" (*Physics* 28). He does not theorize the ontology of "a whole ensemble" of simultaneous possible events; nor does he propose a selection mechanism. Bohr and Heisenberg envision the wave function and the observed result as complementary pictures, one of which is mathematical

and the other of which is perceptual. Both relate to reality, but neither captures it. Thus, Hilary Putnam refers to the Copenhagen position as not an interpretation but "a *rejection* of the possibility of a scientific realist interpretation" ("Philosopher" 620). Most interpreters, however, desire scientific realism.

As Anjan Chakravartty describes, scientific realism is an "epistemically positive attitude toward the outputs of scientific investigation, regarding both observable [with the naked eye] and unobservable aspects of the world." But none of the objects of atomic experiments—atoms, quarks, electrons, and so on—are observable with the unaided senses. As the cat exemplifies, they disappear in observation! Heisenberg approaches the issues by shifting the epistemology of science. From Aristotle to Descartes, philosophers maintained what Heisenberg calls dogmatic realism. Instead, he advocates practical realism, which he contrasts with the other traditions:

> Practical realism assumes that there are statements that can be objectivated and that in fact the largest part of our experience in daily life consists of such statements. Dogmatic realism claims that there are no statements concerning the material world that cannot be objectivated. . . . Metaphysical realism goes one step further than dogmatic realism by saying "the things really exist." (*Physics*, 56-57)

The atomic world, according to Heisenberg, rebuffs the epistemology of dogmatic realism and the ontology of metaphysical realism. Science requires us to assume that some of our statements relate to objective reality, but we cannot know, even in principle, which ones. This *operationalist* posture, where scientific operations take precedence over questions of reality, threatens the unchallenged metaphysical realism beneath classical physics (56). It spurs the question: if classical physics was incorrect, then what is the target of scientific inquiry?

Of course, philosophy and theatre have always faced similar puzzles. Plato described humanity as imprisoned in a cave. In everyday life, he posits, we are chained spectators, compelled to gaze upon a shadow play on a cavern wall. We are born into this position, and thus erroneously believe that the shadows are real. And our chains prevent us from pivoting and glimpsing the actual reality, which lies beyond the cave mouth. At best, the shadow play is a distraction; at worst, it is a lie. Plato analyzes the same sort of problem that the physicists now face. Do we spy reality through our methods, or are we gazing at the shadow play of our devices? Heisenberg forges ahead by attenuating Plato's skepticism. The future may expose an experiment as misguided, and the theories that depended upon that experiment may falter. Nonetheless, we must assume that some of our experiments catch a glint of the sky beyond the cave because science is still the most successful tool for organizing reality.

As every theatre scholar knows, Plato's metaphor implicates theatre. The art presents an epistemic disaster, an attempt to make perceptible the already perceivable and thus drive audiences further from the truth. Brecht's response resonates with Heisenberg's. He too treats aesthetic tools as a means to an end, an instrument of social change. Heisenberg understood the atomic event as a "whole ensemble of events," and Brecht instructed his actors to fix an ensemble of outcomes so that the spectator may see them. Actors were to begin one action, stop it, and then perform its opposite. He sought to communicate an ensemble of possibilities within one tale, beyond those "actualized in a performance" (Silbermann 106). Brecht writes:

> When they appear on the stage, besides what the actors actually are doing they will at all essential points discover, specify, imply what they are not doing; that is to say, they will act in such a way that the alternative emerges as clearly as possible, that their acting allows the other possibilities to be inferred and only represents one out of the possible

> variants. . . . Whatever he does *not* do must be contained and conserved in what he does. In this way every sentence and every gesture signifies a decision; the character remains under observation and is tested. (*Brecht* 185)

The focus on decisions recalls Aristotle's *Poetics,* where choices reveal necessity and probability. Rather than nature, Brecht's *katharsis* illuminates the ensemble of possible attitudes, comportments, and social realities. The action a character takes is a choice, motivated by her place in the machinations of humankind. The other possibilities are ways it could be, were the character to change her ethical attitude. Brecht calls this process fixing the not-but. The actor captures possibilities never actualized, smearing them across the performance space.

Brecht and Heisenberg also gesture toward renewed tensions around counterfactual reasoning in science and performance. A counterfactual is a way the world could have been, which is logically and physically plausible but not the case in reality. For example: had I skipped breakfast this morning, I would have arrived at school sooner. Counterfactuals are a mainstay of logic (Chapter 2), and interpretations of quantum mechanics grapple with the counterfactual results embedded in the notion of complementarity (Chapters 3 and 4). When an experimenter measures one facet of a system (e.g., wave-like), she forever selects another aspect (e.g., particle-like) to languish as an unactualized outcome. The information about that unactualized outcome, which influenced other quantum state entities moments ago, disappears from the formalism. Two kinds of counterfactuals sneak into the Copenhagen worldview. First, the indeterminacy relation states that the unmeasured facet is as fuzzy as the measured aspect was sharp. But what does that physically mean? Does the unmeasured observable have a value, forever hidden from view (as some early theorists hoped)? Or is its nature inherently vague (as the formalism implies)? Or does it amass an ensemble of values, one per possible outcome? In other words, if there are

alternative faces of a phenomenon, then we should be able to discuss the counterfactual results consistently. Second, quantum discontinuity perplexes our intuitions about counterfactual states of affairs. When Schrödinger's cat is discovered alive, how definite is the dead cat? How definite was it before the discovery? By fixing the not-but, Brechtian actors also embody a counterfactual situation and define it as a valid alternative that could occupy the stage space. Quantum theory's counterfactuality frustrates the boundaries between epistemology and ontology, and I return to this question throughout the dissertation. Suffice to say, complementarity and collapse both problematize our notions of counterfactual outcomes (see de Muynck et. al 1642-57).

But this is the point on which Brecht deviates from what I identify as the quantum theatre. Contemporary theatre's celebration of artifice, which has Brecht's conscious theatricality as its seed-box, does not merely trace the operationalist move in early twentieth-century science. Since the Copenhagen interpretation was first advanced, it has garnered detractors: most famously, Einstein and Schrödinger. Some opponents, like philosopher Nancy Cartwright, argue that quantum mechanics requires no interpretation at all (197-201). But most theorists seek to explain how the situation outlined above could describe a robust reality, where indeterminacy, counterfactual outcomes, and collapse (or not) knit together. These thinkers offer scientifically realistic interpretations of atomic events, which are irreconcilable attempts to weave together quantum theory's many unintuitive threads. Most realist explanations of quantum theory strive to explain the situation between set-up and measurement. Putnam proposes two routes toward a realist interpretation. Either you think the wave function collapses, and thus you must explain why it does so; or you think the wave function does not collapse, and you need to detail how there can be both the predictive wave function and classical reality ("Philosopher" 622–23). In other words, you must expand the world to contain either new rules or new kinds of things.

If you think that the wave function never collapses, then something must choreograph the relationship between the world as it appears and the predictive mathematical models. Putnam identifies two solutions: either there is a guiding force whose variables are beyond our scope, or we exist in a plurality of worlds, where the wave function represents the total sum of all possible worlds. Following Putnam, I call these *collapse-free theories.* These interpretations describe a universe wherein the wave function inhabits a distinct mode of being, separate from everyday experience. These theorists eliminate those strange jumps and dualities and thus restore a classic, cause-and-effect picture of reality. However, the truth now lies beyond Plato's cave, and (as sensory creatures) we are doomed only to watch a shadow play on the cavern wall.

If you instead believe that the wave function does collapse, then either something makes it collapse, or collapse is stochastic, chaotic, or random. This approach is *collapse theory*, and it treats quantum mechanical discontinuity as proof that real space brims with Aristotelian potential. These theorists accept discontinuity and embrace a worldview filled with quantum leaps, when the atomic entity jumps into classical existence. This approach rescues the intuition that our world is uniquely real, but it weakens causality. These two vastly different approaches respect the scientific results and offer coherent, testable pictures. They also are entirely incompatible with one another, as two attempts to describe one underlying reality.

The quantum theatre (I demonstrate) performs a role similar to these two paths. After Brecht's political agitations, subsequent playwrights interpret how living bodies in space can navigate or otherwise dwell in bizarre worlds. Brecht's approach to theatre reflected the sort of pragmatic program championed by the Copenhagen interpretation. As the century progressed, playwrights advanced on Brecht's dramaturgy in ways that mirror subsequent interpretational developments in physics. Rather than accept complementarity as a mere tool, contemporary

theatremakers try to solve the cat paradox in performance. Where the physicists have the measuring apparatus and collapse, the theatremakers have the theatrical device and performance's ephemerality. And, where the quantum interpreter proposes a fundamental ontology to account for atomic oddities, the quantum theatremaker embraces a new performance ontology to make perceptible the unspeakable worlds we now inhabit. In their distinct spheres, theatremakers, philosophers of science, and scientists developed eerily similar solutions to the problems of quantum reality. Because theatre sets its worlds in real space on stage, however, theatremakers grapple with the experiential implications of worldviews that would otherwise remain theoretical. These plays rarely confront quantum mechanics directly, but they contribute to the conversation surrounding the macroscale implications of the atomic situation.

Furthermore, these plays introduce new themes that stand firmly on dramatic tradition. Where the cross-torrents of free will and fate tore the eponymous heroine apart in Jean Racine's *Phèdre*, quantum protagonists experience fate and free will as complementary interpretations of their existence. As subsequent chapters demonstrate, some staged worlds emphasize free will. These worlds mirror the collapse interpretations of quantum mechanics, replete with the discontinuity of character and quantum "leaps" in the plot. Others emphasize the determinism of the collapse-free interpretations, where the characters' sense of free will derives from their failure to see the vaster ontological landscape (which the spectators, as scientists, see). In both cases, the protagonists glimpse free will and determinism, as each interpretation must explain the apparent validity of the others. As physicists battle over competing intuitions about reality, the quantum protagonists are battered by competing intuitions regarding their subjective position in the world. Where the free-willed character cannot discover her essential self and thus falls to option paralysis, the predetermined character cannot determine which trajectory (of many)

contains his particular experience. Choice and fate co-exist, just as actors can choose to cross the stage or modify their performances but are bound to recite the script.

By maintaining the complementary nature of theatre (the dual descriptions of presence and representation), the quantum theatre uses its formal similarity to the atomic situation to explore what that situation might mean to our everyday lives. Theatre reflects the two interpretive paths with divergent aesthetic principles. *Collapse plays* imbricate possible outcomes on stage and exploit the dramatic tension between the fictional and the real. They are characterized by contradictory actions, lives, statements, and episodes playing out in a single (often confusing) spacetime. *Collapse-free plays* instead soothe our anxieties by separating different trajectories into spatially segregated realms. They are characterized by short, quick scenes that switch between different worlds. Furthermore, they maintain a forward timeline across worlds, returning to a handful of crisis moments to explore how counterfactuals branch from a single incident. Collapse plays exploit the materiality of theatre, but collapse-free plays often struggle against it. However, plays from both paradigms are anxious about our ability to self-locate in the spatial milieu of this new reality. As characters are caught between free will and fate, the actors are caught between a shifting, amorphous fictional space or the rapidly shifting sands of isolated scenes. In collapse-free plays, protagonists cannot determine their location because myriad possibilities extend around them, like an infinitely vast and unfamiliar landscape. If infinite possible histories could have led to this moment, and countless possible futures branch out before me, how can I pluck my life from the chaos of timelines? In collapse plays, the protagonists instead cannot locate their inner selves among their superposed possibilities: if I can act as a wave or act as a particle, what am I, beneath those performances? In their distinct aesthetic projects, both follow Brecht and merge classical, neoclassical, and

realistic optical paradigms. Possibility, uncertainty, and measurement are exposed as operating features of our very cognitive apparatus, our activities, and the structure of our worlds.

3. Subsequent chapters

The remaining chapters argue that contemporary theatre stages worlds that embody the sort of worlds described by the interpretations of quantum mechanics. Just as interpretations of quantum mechanics explore the nature of reality and the role of science, these plays examine the nature of individual experience and the role of performance. Each chapter balances several goals: (1) develop an accessible description of the interpretive issues that surround quantum mechanics for theatre and literary scholars; (2) establish how a theatre of quantum theory advances the history of scientifically inflected theatre and theatrically minded science; (3) situate both contemporary theatre and science within the broader framework of counterfactual thought in philosophy. However, the theatre of quantum theory is historically unique: it independently converges upon the same divergent paths to interpretation that characterize quantum mechanics.

The second chapter concerns the shift from experiment to counterfactual world construction. Recent developments in cognitive science suggest that cognition relies on a process of counterfactual speculation: our cognitive apparatuses compare a constant stream of electrical impulses to prior interactions after similar impulse patterns. Through a series of counterfactual arguments—*if* this impulse had come from *that, then* . . .—our brain estimates the most reasonable interpretation of these signals and then presents it to our awareness. I argue that this understanding of cognition harmonizes with the experience of theatre spectatorship. Furthermore, I propose that live performance stages a world by hijacking this natural process.

Counterfactuals also play a fundamental role in quantum theory and philosophy. Scientific experiments proceed counterfactually: *if* the world works like *this*, *then* our tests should return *that*. In quantum mechanics, counterfactuals linger even after an experiment concludes: the electron could have acted as a particle, but instead it acted as a wave. Many of the interpretations of quantum mechanics embed counterfactuality into the structure of the world. Furthermore, since Bohr's psychological writings, some scholars have sought to utilize quantum mechanics (and its counterfactual structure) as the general framework for cognitive science (see Auletta 1-8). Contemporary philosophy faces similar issues in modal logic. Logicians speak of counterfactuals as *possible worlds*, and arguments about possible worlds semantics share generative similarities with interpretations of quantum mechanics. The two interpretive threads correlate to understandings of possible worlds: *actualism* and *possibilism*. I argue that the staged worlds of contemporary theatre converge upon these approaches, and I demonstrate these developments with Caryl Churchill's *Traps* (1978) and Yasmina Reza's *Trois Versions de la vie* (*Life x 3* [2000]).

With the theoretical groundwork in place, the remaining chapters concern these two threads in depth. Chapter 3 considers the collapse-free interpretations of quantum theory and the possibilist approach to possible worlds. These interpretations seek to retain both a deterministic, mechanical universe and a meaningful sense of counterfactuality. The two exemplars of this strategy, the infamous many-worlds interpretation and pilot wave theory, salvage their competing intuitions by banishing counterfactuality into a real but distant (and inaccessible to the senses) realm. In the many-worlds interpretation, that realm is a multiverse of equally real worlds; for pilot wave advocates, it is a dynamical function that guides the universe as a super-universal law. In either case, the counterfactual ways an experiment could have gone are

understood as the echoes of distant worlds, occupied or empty. Things could not have gone otherwise in our world: if the electron acted as a wave, the electron would have always acted as a wave. But there are other worlds where things did, in fact, go otherwise.

On the contemporary stage, playwrights have staged similar worlds to explore how our lives are predetermined but also contain a trace of chance. Jennifer Haley's *The Nether*, John Mighton's *Possible Worlds* (1990), and Nick Payne's *Constellations* (2012) echo the ontological implications of these interpretations. Each play stages multiple worlds, and each world has unique dynamics. But these dynamically isolated worlds must ultimately share a super-reality: the space on stage. This chapter also explores the first of two kinds of failures to self-locate. The protagonists of these plays have the solidity of individual identity, but they are unable to locate their positions. Amid a sea of worlds, all of which follow the dictates of dramatic probability, they cannot decipher which world is theirs. This self-locating ignorance leaves the future open for chance, confusion, despair, and hope. Yet cynicism also festers in the knowledge that, in principle, their lives are predetermined and immutable. If they fail, they could never have succeeded; however, there exists another world where someone like them indeed triumphed.

The fourth and final chapter concerns the collapse interpretations of quantum theory and actualist staged worlds. These interpretations seek to retain a single-world framework and a meaningful counterfactuality, but, to do so, they must weaken determinism. Collapse theories conserve most of the implications from the Copenhagen interpretation but add metaphysical weight to the operationalist approach. In subjective collapse interpretations, the strangeness of quantum mechanics collapses into our tangible reality whenever a (poorly defined) subject interacts with a quantum object. The most infamous versions of this approach argue that human minds are required for reality to exist. Otherwise, quantum *potentia* never actualizes into

concrete reality. Alternatively, some physicists promote an objective collapse theory, where objects in the quantum realm spontaneously snap into classical forms. This latter option ejects the subject from the description of reality but embraces extreme discontinuity.

Contemporary playwrights occasionally ape the mysticism that collapse interpretations permit. These plays suggest that free agents exist amid a swirl of live possibilities, and their actions collapse those possibilities into a singular, actualized outcome. Such protagonists are agents of change, but emergent patterns suggest that their range of options is dishearteningly narrow. The proliferating worlds of Chapter 3 permit luck, but Chapter 4's plays take place in worlds that oppress their protagonists with a glut of choices. Martin Crimp's *Play with Repeats* (1990), Odin Teatret's *Kaosmos* (1993), and Roland Schimmelpfennig's *Idomeneus* (2008) trace the implications of collapse theory. These plays examine the tension between systemic limits and agential desires. This chapter defines the second kind of failure to self-locate. The protagonists of these plays fail to find and delimit their essential selves. They recognize proliferating possibilities within their lives and subsequently fail to understand how their natures shape or limit those possibilities. Option paralysis, nostalgia, and ennui fill the caesura. In the end, commitment to action becomes the only way out.

§

When Galileo performs that floating needle experiment, the audience is reminded that theatre and science share many traits. Both require observers, something to observe, and a place (and time) of observation. The conditions of performance and scientific demonstration are of a similar type, albeit of very different kinds. The experiments in *Galilei* are real events. Actor

Charles Laughton, Galileo in the play's premiere American production, set a needle on water. The audience—assuming truly superhuman eyesight—saw that needle float. At the same time, the border between the audience and the action—the stage—reminds us that the experiment is *staged.* It is staged in three senses. First, it performs aesthetic and narrative functions in the unfolding drama. Second, the real demonstrations share a stage with dramatic fiction. Third, it may be fake. Theoretically, we could see the needle float, but did we, practically, from the balcony? The needle vexes Galileo's students precisely because it is so small that it seems like it should float! There may be a border between audience and spectacle, but nothing distinguishes Galileo's speech from Laughton's demonstration. In other words, there is no sharp boundary between the fictional world of the play, the possible world of Galileo's scientific paradigm, or the actual world of the demonstration. It all dwells in a single measuring apparatus.

Before the experiment, Galileo promises us that science will set *eine Grenze* to infinite error. At the beginning of this chapter, I translate *eine Grenze* as "a limit," but the words carry somewhat different connotations. Limit implies a maximum or perhaps a litmus test: some hard line that cannot be extended or passed. Science, in this sense, caps error at a manageable level. *Grenze* brings connotations similar to the English word *border*. *Galilei*'s action is replete with borders. The play closes with Andrea crossing the Italian border, the Catholic church and its infinite errors behind him. We cannot forget that Brecht and the physicists were fleeing across the German border as he wrote. Galileo demonstrates the border between rational and empirical thought, but Brecht gestures toward that perforated border between stage and audience. *Border* suggests that the errors are contained but present and effuse: still visible across an unmarked threshold. And the theatre's threshold is particularly indeterminant. There is a devious contradiction in the very act of setting a border around an infinite error. The infinite abhors

boundaries by definition, as Heisenberg's electron similarly rejects a precise position. We do not know how Brecht would translate *Grenze* because his own English translation of the play lacks this speech. In fact, this speech is also omitted from the play's final German-language version. After the atomic bomb, Brecht could no longer feign that science has any *Grenze* at all.

Galileo extols intellectual borders in a play about thought experiments and live experiments. Thought experiments complicate those borders between empiricism and rationalism, science and philosophy, fiction and reality. The scene performs the failure of the *Grenze* its protagonist extols: is the experiment real or fake? Where Aristotle's thought experiment resides in the imagination, theatre practitioners must *stage* their findings. Brecht's choice of experiment seems deliberate: given the optics of a theatre, it is an indemonstrable demonstration. The whole of quantum theatre follows, demonstrating ramifications that are, strictly speaking, beyond human observational capacity. The rest of this dissertation examines just how that practice of staging establishes theatre as an essential interlocutor in the new scientific situation. In staging quantum mechanics, theatre embodies the ramifications of the strange findings coming out of laboratory experiments and notebooks riddled with mathematics. It does not set a limit to scientific error but tries to make sense of the borders of quantum mechanics: those between complementary pictures, the classical and quantum worlds, and determinism and free will.

Notes

[1] "Es ist nicht das Ziel der Wissenschaft, der unendlichen Weisheit eine Tür zu öffnen, sondern eine Grenze zu setzen dem unendlichen Irrtum" (Brecht, *Leben* 81).

[2] "ANDREA: Eis ist schwerer [als das Wasser] . . . aber es schwimmt nicht, weil es leichter als Wasser ist, sondern weil es breit und flach ist, so daß es das Wasser nicht zu zerteilen vermag . . .
GALILEI: . . . [W]oher kommt es dann, daß . . . eine Nadel . . . untersinkt? Ihr wißt, das ist das Argument des Aristoteles" (*Leben* 81-82).

[3] "Aber das stimmt nicht . . . daß eine breite und flache Eisscheibe das Wasser nicht zu zerteilen vermag. Drücke eine solche Scheibe gewaltsam auf den Boden des Gefäßes, und sie steigt sofort wieder in die Höhe, also überwindet sie beim Emporsteigen den Widerstand, den das Wasser der Zerteilung entgegensetzt" (*Leben* 82).

[4] "Ich will jetzt etwas machen, was seit langer Zeit nicht gemacht worden zu sein scheint. Ich will die Nadel auf das Wasser legen" (*Leben* 82).

[5] "*Gelächter* . . . Sie sinkt nicht und das ist ein Fakt" (*Leben* 82).

[6] "The classic," Wekwerth quotes Brecht as saying, "is by no means perfection within a genre . . . [but] the attempt to make certain proposals . . . permanent and to lend them something final and conclusive" ("'Klassik,' sagt Brecht, 'ist keineswegs . . . eine besonders hohe Stufe der Vollkommenheit innerhalb einer eigengesetzlichen Kunstgattung . . . [aber d]er Versuch, bestimmte Vorschläge . . . Art dauerhaft zu gestalten und ihnen etwas Endgültiges, Abschließendes zu verleihen'"; 304).

[7] "Auch auf dem Felde der Ethik waren Sie uns um Jahrhunderte voraus" (*Leben* 372).

[8] Catherine Gallagher's *Telling it Like it Wasn't: The Counterfactual Imagination in History and Fiction* posits that "[q]uantum physicists . . . seem to have had an influence on how fiction writers imagine the relation between their alternative worlds and our own," especially when they tackle counterfactuals directly (318).

[9] An example from Galilei (and Aristotle's *On the Heavens*) might help clarify matters:

(1) all things that take up little surface are things that sink
(2) all things that are thin are things that take up little surface
Therefore, (3) all things that are thin are things that sink

And we can add:

(3) all things that are thin are things that sink
(4) all needles are things that are thin
Therefore, (5) all needles are things that sink

You can continue this chain of reasoning, and use (5) as the major premise in a new syllogism.

[10] Famously, the philosopher never defines *katharsis*. For now, I focus on the "clarification" interpretation of the term (what R. Darren Gobert has called *cognitive catharsis*) because it fits best with his scientific project.

[11] "Sie fliegt nachts durch die Luft . . . sie nirgends in der Stadt auch nur einen Topf Milch . . . Das hat der Teufel hier hingestellt. Es ist eine Kiste" "(376–77).

[12] "Auf einem Stock kann man nicht durch die Luft fliegen. Er müßte zumindest eine Maschine dran haben. Aber eine solche Maschine gibt es noch nicht. Vielleicht wird es sie nie geben, da der Mensch zu schwer ist. Aber natürlich, man kann es nicht wissen. Wir wissen bei weitem nicht genug, Giuseppe. Wir stehen wirklich erst am Beginn" (378).

[13] "une substance dont toute l'essence ou la nature n'est que de penser, & qui, pour être, n'a besoin d'aucun lieu ny ne dépend d'aucune chose matérielle. En sorte que ce Moi, c'est à dire, l'Âme par laquelle je suis ce que je suis, est entièrement distincte du cors . . ." (*Discours* 33).

[14] "tâchant d'y être spectateur plutôt qu'acteur, en toutes les Comédies qui s'y jouent . . ." (*Discours* 28).

[15] Gobert shows how Descartes encourages intersubjectivity. He advocates reaching the precipice of the sort of engagement described by Aristotle, but then resisting it rather than falling into it. This process hones your skills of self-control. Such an activated spectator, facing drama but using it to learn, prefigures some of Brecht's theory (see *Mind-Body Stage* 97).

[16] "*Lächelnd zieht er ein Taschentuch heraus und wischt, mit bedeutsamem Blick auf Galilei, die obere Linse ab*" (59).

[17] "Imaginez, sur le bord du théâtre, un grand mur qui vous sépare du parterre; jouez comme si la toile ne se levait pas" (231).

[18] This is a quantum mechanical probability, and the device relies on a half-silvered mirror and a photon. The specifics are unimportant, but this situation is not like a coin toss, where probability represents a failure of knowledge. This probability correlates with the natural potential in quantum systems for a range of solutions.

[19] It is semi-classical in that it still conforms to the degree of accuracy permitted by the indeterminacy relation.

Chapter 2: Counterfactuals as Worlds in Theatre, Cognition, and Physics

In the opening scenes of Caryl Churchill's *Traps* (1978), Albert and Syl struggle with their roles as new parents. After their baby daughter falls asleep and their flatmate, Jack, retires to his bedroom, the couple steals a rare moment alone. A malaise exudes from the working-class pair. Syl frets that motherhood diminishes her potential, and she wistfully speculates "what if" she simply abandoned her home and infant. Albert dismisses her woes: it might be unfair, he opines, but the obligations of motherhood are "[j]ust a fact" of their world (76). He considers swapping roles, but his empathy dissolves into a tirade about darts, cards, and politics. He seems as fickle as Syl is miserable. The apartment on stage visually reflects their precarious state. Unfinished projects and half-forgotten chores burden the playing space with "*plenty of clutter*: *large jigsaw half done on the floor, large pot plant, newspapers in various languages, oil lamp, cards, airgun, cake, pile of clothes washed but not ironed, ironing board and iron, towels, broken bowl, guitar, suitcase, picture, carrycot* . . ." (73). The set invites the audience to approach the play as a kitchen sink drama, as the weight of social expectations and institutions threatens to crush the impoverished Britons. Before Syl can finish her next line, a knock on the door interrupts their solitude. Ever paranoid, Albert "*gestures*" to stop Syl from saying, "[*c*]*ome in*" (75). Albert, fearing surveillance, has "bang[ed]" the door shut before the play's first line (73). But his confidence in his fortress is misplaced. The interloper "puts his head round the door" (without opening it) and breaches its supposed security (75). The couple acts as if the door is locked and they are secure. But their visitor reveals the door on stage is rarely actually locked.

The odd moment might erode the dramatic tension, but the play weathers the breach as if it were a sight gag. Perhaps the latch is defective, and the door drifted ajar. The intruder interrogates Albert. He seeks their flatmate Jack, he announces, or at least "the other one . . .

[w]ho's looking for Jack herself" (77). The audience had seen Jack retire to his room moments ago, but Albert insists that Jack "[m]oved to the country for a healthier life" (77). Unconvinced, the intruder crosses the stage. Looming over Syl, he states: "if someone else turns up looking for Jack, if you tell her Reg was here and I'm in the pub, I'd be very grateful. No need to let her get you into conversation" (77). Reg, we learn, is Jack's brother-in-law; Christie, his wife and Jack's sister, absconded the night before. His declarative utterances and dominance of the space, Syl's retreat to the floor, and Albert's desperation imbue Reg with a sense of subdued violence. Spectators may wonder: what abuses prompted Christie's flight?

When Reg "*is about to go, Jack comes in*" through the same door (78). Reg disarmed Albert with ease, but Jack is a bulwark. He announces that he expects Christie soon because "I was willing Christie to come. I got you. It's a near miss. And maybe she's on her way." The abrupt "religious performance . . . Mumbo jumbo" stuns Reg, and he begs of Jack what he demanded of Syl: "[i]f Christie comes I'd be most grateful if you'd tell her I was here. To collect her. Do explain properly will you?" He tries to flee, but "*Jack locks the door and puts the key in his pocket*" (80). That door, which Reg had treated as a mere inconvenience, now traps him. Perhaps the latch is broken, but now the deadbolt holds.

As Jack and Reg spar, Syl and Albert return to their marital bickering, as if adrift in their own world. Syl complains that Albert is "getting to be impossible to live with," and he retorts with accusations of marital infidelity. Syl elaborates her problem:

> ALBERT: What do you mean I'm impossible to live with?
>
> SYL: I'm thirty next week. I think 'Where am I getting?' I'm not that good a dancer. If I haven't had a child in the next five years, I'm not likely to have one at all. That's okay.
>
> ALBERT: Five years is a long time. (78, 81–82)

Suddenly, Syl insists that she is childless, a declaration refuted by the set's carrycot and baby clothes. But Albert does not challenge it. He merely acts *as if* she never had a child. He announces that he is "happy to be a father any time" (82). The baby, like Jack and Reg, disappears from their marital world. But the clutter of things associated with the baby, Jack, and Reg linger in the visual field.

Albert exits through the locked door, and it effortlessly opens as if Jack had never locked it. Reg watches Albert leave and "*tries for the door*" himself, but he finds it "*locked*." When Reg first peeked through the (supposedly) secure door, the dramatic situation integrated the breach. Now no fictional explanation can. These contradictions proliferate. Jack and Syl embrace as lovers and discuss moving to the countryside. Reg struggles with the door and pleads, "[i]s it some kind of joke? Christie and I are expected to dinner with our likely future managing director" (83). In eight pages, the stage erases Syl and Albert's baby; swaps Syl's relationship with Albert for one with Jack; demotes Reg from threat to prisoner; and abandons realism for bold metatheatre. Can we expect an audience to comprehend such a performance, or is it—like quantum theory's worlds—hopelessly obscure? Spectators cannot reconcile these events into a single, consistent state of affairs.

In a prefatory note, Churchill warns her readers that *Traps* is "an impossible object . . . [which] can exist like that on paper, but would be impossible in life" (71). Her claim rings somewhat disingenuous: she breathes life into this impossible object by staging it. Watching *Traps,* spectators perceive real people interacting in real space, and the "impossible" object is live to their senses. The kitchen sink realism lures spectators into viewing the stage as if it were a real apartment elsewhere. Then, Churchill rewards those spectators who embrace the theatrical illusion with an intoxicating dramatic situation. When Reg enters and withholds his identity for

nineteen lines, the danger is palpable. When Syl withdraws, spectators are more likely to ponder her history with Reg than (in the premiere production at the Royal Court in 1977) actress Catherine Kessler's decision to cross the stage. The illusion of another world, summoned by the theatre, set, and actors, defines the realistic or traditional drama. And *Traps* presents another world on stage and asks spectators to partake in the make-believe of fiction.

However, Churchill refuses to let this other world settle. Reg hounds Syl and Albert, but he also threatens the cohesion of the fiction itself. He immediately finds the door locked after Albert exits through it, drawing attention to the materiality of the stage. That door is a stage property, whose lock functions through the *as if* of the dramatic illusion. Albert's actor acts as if it were unlocked, Reg's acts as if it were barred, and Jack's acts as if he were locking it. Drama's twin realities underpin *Traps*'s extreme world bleeding. Reg and Albert, at different times, ignore the *as if* of the door because their actors (Tim Pigott-Smith and Anthony Milner in the 1977 premiere) can. And, if they can ignore the rules of the door, they can shift the rules of playacting on the stage. The frame of reference often vanishes behind the *as if* of realistic drama, but Churchill thrusts it into view. Spectators must adjust how they see the space on stage because the moment requires them to cognize one body as multiple things—a character and an actor. The identity we attach to that body depends upon the current frame of reference.

Jack's entrance exposes the brittleness of the theatrical frame. He enters through the same stage door as Reg, but he comes from his bedroom, not outside. Spectators must recognize that a door on stage can be many possible doors: an exterior door, an interior door, a stage property, and so on. Churchill reveals the possible lives that dwell in actual things. Jack disrupts the continuity of the door's signification, and Syl and Albert undermine the continuity of the space. The pair argue as if they were alone one line after Syl speaks to Reg. Even space, devoid of

observable boundaries, contains multiple, distinct, possibilities. *Traps*'s spectators must accept the notion that material things possess possibilities beyond the scope of everyday experience. Otherwise, they drown in the play's mess of contradictions.

Churchill demands more from her audience yet. As the couple argues, Syl irons clothes and Albert fixes a broken bowl. On stage, Kessler ironed real clothes, and Milner mixed real glue (and some future actors iron and mix). Actual activities match the play's fictional actions. Thus, Churchill intimates that this web of possibility, which she locates in the space, people, and things on stage, extends to daily life. We too situate objects and people into frames of relation, or worlds, every day. Her decision to ground her experiment in the trappings of kitchen sink realism is no accident. The multiplicity of worlds in *Traps* is more potent because we at first expect it to act like our world. Realism encourages a transfer by analogy from the actors' activity to the characters' lives to our own. But she destabilizes these threads and uncovers the potential beneath our expectations. Churchill coaxes us into accepting the reality of her characters; then, she reveals the pluralistic lives of the bodies and things on stage; finally, she reminds us that these imbricated possibilities exist in our daily lives of entrances and exits. We cognize the stage space as a swirl of counterfactuals, an arena of potentiality, a machine for staging worlds.

Traps exposes how swiftly and arbitrarily theatre inscribes worlds into space. The very fact that (some) audiences follow *Traps*'s shifting situations speaks to our cognitive flexibility. In social environments like the theatre, we readily revise our understanding of spaces and places in complex ways (see Lefebvre 61-65). This chapter theorizes how the theatre constructs those worlds on stage. First, I propose a cognitive account of how spectators perceive the activity on stage as a distinct world. To do so, I use the Bayesian Brain theory of perception, advocated by Anil Seth, Karl Friston, and Chris Frith. According to Seth, our beliefs about the sources of our

sense data "are updated as new evidence comes in . . . incoming sensory data are combined with 'prior beliefs' to determine their most probable causes, which correspond to perceptions" ("Bayesian Brain" 50). These neuroscientists treat brains as machines for counterfactuals: scenarios that follow an *if*/*then* structure. Our brains explore possible scenarios until they land on one that most plausibly accounts for perceptual signals. My reading of cognitive studies concentrates on their discussion of counterfactuals, which resonates with theatre and, finally, complementarity in quantum mechanics. I do not (nor could not) comment on biological or neurological claims.[1]

To bridge the gap between cognitive science and staged worlds, I use the language of *possible worlds*. In modal logic, possible worlds are tools for discussing possible, impossible, and counterfactual statements. In theatre, the spectators' moment-by-moment perceptions, which are incited by staged activity and fictional action, offer an analogue. I argue that these components of theatre stage a world via a process analogous to (though very different from) how statements construct a possible world. I call the fictional worlds of theatre *staged worlds* because their position in our ontology relies on our understanding of staging (as objectivation [Chapter 1]), fiction, and the materiality of the stage or implied materiality of the text.

My dissertation explores the resonance between the staged worlds of contemporary theatre and the bizarre reality of quantum mechanics. Because modality appears embedded into atomic events (e.g., an electron could have acted as if it were a particle, but it acted as if it were a wave), most interpretations of quantum mechanics treat possibility as something that belongs in the fundamental ontology. The twentieth century saw two divergent approaches to the ontology of possibility: *actualism*, which grounds the ontology of possibility in everyday objects, and *possibilism,* which shunts possibility into an isolated realm. As the first chapter outlines, the

interpretations of quantum theory trace the same trajectories as competing explanations of the mathematical and experimental outcomes. In this chapter, I demonstrate these explanations as I read two plays: *Traps* and Yasmina Reza's *Trois Versions de la vie* (*Life x 3* [2001]). I mobilize cognitive science and possible worlds to theorize staged worlds as objects of cognition. Then, I unpack the ontological commitments of possible worlds, which link the performance ontologies of contemporary theatre to the fundamental ontologies of quantum mechanics.

1. Staged worlds as cognitive counterfactuals

Staged worlds are, first and foremost, things that are perceived by audiences. Allow me to rewind my description of *Traps*. How do spectators see the stage and set before the performance even begins? We arrive at the theatre with a set of expectations, carved out by our cultural context and personal history of theatregoing. When the public sits, faces the stage, and views the set under houselights, the audience members receive the stage, the seats, the exit signs, the aisles, and people milling around the auditorium as a single sensation. The foreground sights, sounds, and smells draw immediate attention because other human bodies inhabit them. Space seems thicker wherever bodies transit because movement proves that we could also move through that space. However, in many cases, the auditorium is designed to ensure that looking at the stage is more comfortable. Spectators, for the most part, are acculturated to expect *something* from the space on stage. Yet, even from the orchestra, the stage may appear far away and dark. While viewing the inactive stage, spectators can still intuit that each thing on the stage is a thing, which can be manipulated, circumscribed, and touched. They can distinguish between the stage's unfinished activities (e.g., the wrinkled laundry), dishevelled decorations (e.g., the large pot plant), and the strange remnants of past events (e.g., the broken bowl). The house lights bounce

off the edges of the carrycot, their reflection marking it as a distinct object, separate from its surroundings. But the spectators cannot glean all the information they want: is that plant made of plastic? Is that cake edible? Curiosities nibble away. Among their many jobs, our perceptual faculties separate our sensory field into distinct things, draw attention to elements that need more investigation, and prime our bodies to move through space. This activity precedes any conscious awareness.

1.1. Perception as counterfactual inference

According to Bayesian Brain theory, perception requires a series of counterfactual tests. Seth and Friston explain that, in each moment, our cognitive faculties develop voluminous models of the world. In turn, these models emphasize "the beholder's share" in generating the world we perceive. The Bayesian Brain framework

> offers exactly the right set of concepts to talk about the body and mind in terms of beliefs about the body (and oneself). On this view, the brain is . . . a statistical organ that actively generates explanations for the stimuli it encounters—in terms of hypotheses that are tested against sensory evidence. . . . [The unconscious brain engages in] Bayesian inference—about the hidden causes of our sensations—and . . . these inferences induce beliefs and behaviour. "Explanations," "hypotheses" and "beliefs" should in this context be understood not as consciously held mental states, but as neuronally encoded probability distributions (i.e., Bayesian beliefs) over the hidden causes of sensory signals.

Our brains never present an accurate "stimulus-response" picture of our environment. Rather, to borrow Frith's phrase, our conscious minds witness a *controlled hallucination*, an "explanation" pre-filtered through a meshwork of counterfactual "hypotheses." Light stimulates sensory

receptors, and fluctuations in air pressure press our eardrums, but our brains receive everything as an undifferentiated stream.[2] Our brains compare the raw input to neuronally encoded *if/then* scenarios to determine which signals relate to which phenomena. Imagine seeing a bright light. *If* that light *had* come from the sun, *then* it *would have had* a bluish hue, cast sharp shadows, and accompanied a sensation of heat. However, *if* it *had* come from a stage lamp, *then* it *would have had* a redder hue, softer shadows, and less heat. Our brains compare these hypotheticals to the sensations to determine which hypothesis most plausibly explains the sensation. After extensive computation, our perceptual faculties present the likeliest scenario to awareness. In other words, our cognitive faculties imbue a sensation (e.g., the light) with an explanation (e.g., a stage light acting *as if* it were daylight) before it is presented as reality. After a painstaking rehearsal, our unconscious systems stage the world we experience.

Our perceptual faculties' first job is to distinguish actionable objects from transitable space. As Seth and Friston describe, this "counterfactual or conditional aspect" of cognition "may underlie basic properties [of] perceptual experience, such as 'presence' or 'objecthood'" (see also Auletta 115-20). For example, our brains speculate about a percept's manipulability (e.g., can I act with this?) and circumscribability (e.g., can I walk around this?) to determine if it represents a distinct object. Comparing all the possible sources of a (e.g., carrycot shaped) light reflection, our perceptual faculties predict that the source of the sensation is a free-standing thing (e.g., a carrycot). It then arrives to our awareness as an object that we could manipulate—circumscribe, move, rock, and so on. Our previous interactions with similar objects determine the scope of possible manipulations. Our brains inventory possible future situations by encoding our current interactions alongside a signature of the relevant percepts. We then form (Bayesian) beliefs about the proper responses to relevant stimuli. These beliefs are not conscious mental

states, but probability distributions over what sort of thing the carrycot-like percept plausibly is, and what kind of response it deserves. Cultural knowledge shapes this possibility space. For example, the carrycot might come to awareness as a vessel for babies, and thus prime you to seek (or worry about) an infant. The context surrounding *Traps*—the Royal Court premiere—prompts a dread response in routine theatregoers. After all, Edward Bond's *Saved* (1965), in which a baby is stoned to death, premiered on the same stage.

At first, the auditorium, where bodies move, demands attention more than the stage. But everything soon changes: the performance activates what Constantin Stanislavski famously dubbed the *magic if* of theatre (59). It begins with a lighting change. In the foreground, the lights dim, other members of the audience settle, and they reorient themselves toward the stage as the focus of attention. We are acculturated to turn to the stage and hush conversation, as our knowledge of theatrical convention shapes our response to the changing sense data. The stage space brightens, and new bodies enter and activate it instead. Spectators' perceptual faculties instantly note a transformation in the visual and auditory fields: new shadows, new tricks of light, new interactions between bodies and objects. Suddenly, the stage alone permits movement. In everyday life, our pre-aware perceptions anticipate our interactions with the world. For example, when our perceptual faculties determine the presence of a carrycot, they await feedback on the accuracy of that hypothesis. Is there a baby in it? Our brains need feedback to update predictions and develop a more accurate model. But the cultural institution of theatre throws a wrench into this machinery. We believe (in the Bayesian sense) that the various stage properties would be circumscribable and manipulatable. But we cannot gather feedback about these predictions. At the very instant the stage space becomes the arena for possible action, we sit in distant chairs, ignoring our perceptual faculties' need for an investigation. Perception adapts; our

brains decipher the situation on stage from afar through a secondary system of tests. Bayesian Brain theory suggests an answer that echoes Aristotle's in *Poetics*: cognitive empathy.

Bayesian Brain theory implies that spectators rely on empathy (of a different sort) to grasp performance. In "Interoceptive inference, emotion, and the embodied self," Seth suggests that our "predictive inference" engages a special kind of "empathy" as a component of the inferential feedback system. We are perceptually biased: we assume that agents who are similar to us will interact with the environment in a manner that matches our possibility space. Because we view the stage from afar, we cannot confirm our beliefs about it. Instead, we rely on our perceptions of other bodies to judge the accuracy of our hypotheses. The cultural institution of theatre encourages spectators to trust the actors and their interactions in space. In realistic dramas, as *Traps* appears at first blush, the actors act *as if* they were their characters and their actions conform to our expectations. Syl places a baby in the carrycot and carries her offstage. But soon, the actors rebuff our prior beliefs. The paranoid Albert enthusiastically slams the door shut. Then, he and Syl act *as if* the door bars Reg from the space. Reg knocks on the door, which lends credence the accumulated predictions—knocking implies a closed door, a barrier to movement. When Reg enters without resistance, however, he breaches those beliefs. When our expectations are undermined, empathy overtakes our predictions. Our cognitive faculties take cues from the movement of other bodies and treat their successful action as a more accurate model of the space. Because theatre holds its spectators at a distance, their predictive inferences must accept the actor's actions as a temporary, provisional reality. The rules governing the stage become the new controlled hallucination.

This illusion succeeds because our brains learn from predictive mistakes. When a belief about a percept is proven wrong by our interactions (for example, if we try to pass through space

and find an invisible glass barrier), our brains "updat[e our] beliefs about the world based on [these new] sensory samples." Each new percept becomes another *if/then* against which future sensations are compared, and these new "expectations shape behavioural and neuronal signatures of perception" (Seth and Friston). A great lighting design may trick our perceptual faculties into perceiving the stage light as daylight. Looking up, we can confirm that a lamp hangs on a grid above. From that moment forward, our future perceptions of sunlight in similar conditions will include a stage light as a marginal counterfactual possibility. We store an increasingly massive database of possibilities, and so our prior beliefs grow increasingly accurate. When Albert, Syl, and Reg act as if the door were locked (when Reg knocks), our perceptual faculties learn to erase the possibility of entering from the ledger of possible actions in this peculiar context. The *as if* activity of actors on stage alters the very possibilities which the spectators perceive in that space. Temporarily—likely for mere seconds—potential actions disappear from awareness. In *Traps*, our expectations of realistic theatre reinforce the illusion. As any theatregoer can attest, our brains are skeptics. The set's presence as a three-dimensional object (a set, not the place it represents) routinely resurfaces. Percepts demand re-evaluation. Nonetheless, the actors' bodies carve out a provisional set of relationships and interactions that becomes the limit of possibility in that space. During acutely empathetic moments, this provisional world overtakes the spectators' unconscious beliefs about how things ought to act. This process generates the staged world of theatre: staged by the playwrights, actors, directors and by the spectators' capacity for cognitive empathy.

In summary, the staged worlds of theatre are generated by the provisional relationship between actors and objects, embedded in space by the actors' activities, perceived by the spectators as the limits of possibility. When actors maintain unusual orientations in space, they

coax the audience members' cognitive faculties toward erasing certain possibilities from the scope of potential activity. As reader response theory intimates, "informed" spectators (who attend theatre frequently) will find that their perceptual faculties adjust the ledger of plausible interactions more quickly (Fish 86-89). Spectators become increasingly comfortable with the conventions of theatregoing, which attenuate our Bayesian beliefs about objects under staged conditions. The theatrical event piggybacks on the general counterfactual feature of perception. When a performance stages a world, it imbricates the world generated by our perceptual systems with the world produced by the *as if* activities of the actor's bodies to create a unique perceptual experience. Through this cognitive understanding of theatre, *Traps* unveils theatre's ontological potency: staged worlds may present counterintuitive relations between bodies and objects (like those theorized in quantum theory) and make them temporarily perceivable. When a performance ends, the ephemeral world generated by the actors' bodies falls to applause, and a lighting shift reactivates the auditorium. Everyday relations resurface, but the two events lack a sharp boundary, and beliefs bleed both ways.

This account of staged worlds continues the tradition of understanding theatre through its contemporaneous optical paradigm (Chapter 1). Prior models (e.g., Aristotelean form impression) engendered different theories of spectatorship. Cognitive science adds a link to this chain, which synthesizes empirical science and phenomenological experience. Of course, phenomenology infiltrated theatre studies long before cognitive science. In *Bodied Spaces: Phenomenology and Performance in Contemporary Drama,* Stanton B. Garner, Jr. defines performance as a process that exposes opposing orientations toward the stage space. Spectators orient their perspectives around the fictional representation: for instance, Reg struggling to open the apartment door. Actors instead orient themselves around the space that they must navigate:

for example, Pigott-Smith manipulated the stage door as if it were locked. Thus, spectators are forced to cognize "an autonomous, differently oriented world within [their own] perceptual boundaries" (47). In other words, theatregoing makes salient the fact that other people reside in their own oriented worlds. Spectators confront the limits of their own subjectivity.

Garner's theory expands upon a half-century of phenomenological philosophy. Like Seth and Friston, the phenomenologists posit that we experience individually oriented worlds that are structured by our beliefs. As Maurice Merleau-Ponty reminds us, these oriented worlds participate in a shared reality. In everyday life, he suggests, we are not aware of the limits of our own perspective because our bodies "give" the world to us *as if* we had witnessed it from an indefinite number of perspectival views. We must assume that a shared reality exists beyond our subjective worlds, but we can only capture the "universal style of all possible perceptions," not reality itself (16). His stance fits nicely into the Bayesian account, which qualifies realism as the interplay between pre-aware and aware processes.[3] However, I turn to cognitive science and not phenomenology because, as Bruce McConachie argues, it offers firmer epistemic grounds. Because it theorizes the interplay of subjectivity and intersubjectivity while retaining realism, cognitive studies unites subject and object in a shared world (52–60). Quantum theory and contemporary theatre request the same balancing act.

1.2. Cognitive linguistics and the theatre

Of course, the theatrical event is not solely perceptual. The worlds of plays are also conceptual and linguistic. We do not merely watch *Traps*; we also think about it and reflect on its themes of motivation, choice, and performance itself. When Reg fails to open a door that someone else used freely, Churchill interferes with the processes that stage worlds. The play

rejects the relationships already drawn by the actors' bodies. The spectators' empathetic inferences fail too. The incursion draws attention away from the empathetic *as if* relations and back toward space and its objects. From this moment on, any actor might disregard the prior activities, reigniting our ordinary cognitive beliefs and discounting the reliability of the entire ensemble. As *Traps*'s stage accumulates baggage, the clutter fails to accrue a consistent history. However, even when the relations on stage are undermined, the staged world remains. It cannot vanish: it is generated by the actors' bodies and their relations to objects, however well these interactions correlate with our beliefs. These metatheatrical moments challenge and interrogate the line between *as if* and *is*, but the sensory field retains its physical continuity. When a performance rebuffs our expectations wholesale, we are invited to conceptualize the activity on stage. We always reflect on plays, but *Traps* asks us to reflect mid-performance.

Concepts, like percepts, are constrained by our prior experiences. As Seth describes, our brains encode perceptual signatures and then return to those signatures when evaluating new signals. These signatures include spatial information, such as circumscribability. According to George Lakoff and Mark Johnson, these same spatial relations coalesce into concepts. In their introduction to *Performance and Cognition: Theatre Studies and the Cognitive Turn,* F. Elizabeth Hart and McConachie explain:

> [M]ental concepts arise, fundamentally, from the experience of the body in the world. As "neural beings," humans must make meaning within certain "spatial relations" and "bodily action" schemas along with other mental constructs arising from the interplay of experience and patterning in the brain. "Primary metaphors" flesh out the skeletal possibilities of many of these foundational schemas. (2)

Their argument follows a similar trajectory to Seth's. Our conceptual faculties develop concepts by comparing sensations and thoughts to historical patterns.[4] When our brains neuronally encode spatial information for subsequent tests, they collect common spatial arrangements together. Emergent patterns then offer metaphorical models for more complex ideas. For example, our historical experience of crawling as infants leads to the concept PATH.[5] Lakoff and Johnson call these patterns "spatial-relations concepts" or image schemas (16). Key image schemas include BLOCKAGE, CONTAINMENT, PATH/SOURCE-PATH-GOAL, NEAR-FAR, and so on (Hampe 2). When we reflect on our situations, our cognitive apparatus builds an analogy between an encoded spatial relation (e.g., BLOCKAGE) and a relevant notion (e.g., writer's block). These conceptual building blocks are metaphorical, before language, and "largely unconscious," like the prior beliefs that fuel perception (McConachie and Hart 2).

As we tackle increasingly sophisticated notions, we expand the meanings that we ascribe to image schemas. For example, PATH anchors more sophisticated metaphors including

> *life* (we typically conceive of life as movement along a path or more complexly as a journey), *death* (conceived of as the destination on that path or journey), and *causation* (things that happen to us along that path or journey seem linked sequentially owing to the linear trajectory of PATH). (Hart 38)

Where our perceptual systems strive for an accurate ledger of possible actions, our conceptual systems grapple with a complex conceptual space. For example, PATH permits an understanding of *causation,* which leads to *purpose, forced movement*, and so on. From this unconscious process, we develop a roster of metaphors for conceptualizing our experiences. This embodied unity between percepts and concepts lends staged worlds theoretical coherence: as the space on

stage brings certain spatial relations to the foreground of cognitive activity, spectators are more likely to turn to notions fueled by their attendant spatial-relations concepts.

In *Traps*, the door first accumulates the spatial relations that we expect of a kitchen sink drama. Early on, the activity on stage primes spectators to see the door as the blocked path into or out of an apartment. After Albert emphatically slams the door shut, the play primes the BLOCKAGE schema, which interrupts PATHS into and out of CONTAINERS. He and Syl act *as if* this set of spatial relations rules the stage. Then, Reg enters through the supposedly secure door. He ignores the blockage and privileges the door *as if* it were a path. This contradiction spurs a cognitive move to reflection and conceptualization, which requires a new relational concept. At this juncture, however, we can still salvage the world under a consistent set of rules. We can assume, for example, that the latch stuck, luring Albert and Syl into a false sense of security. Even so, Reg unsettles the stage's constitution as a container—the space on stage becomes permeable, unsealed.

When Jack later locks the door, Churchill strains the conceptual interplay further. Jack strengthens the BLOCKAGE schema, and Reg reinforces it (and the apartment-as-container, despite his previous incursion) when he fails to open the door. As Jack re-establishes the CONTAINER schema within the fiction, however, he destabilizes the CONTAINER schema of the play. A play is a container for fictional action, maintained by consistent rules. However, the door behaves inconsistently. The lock does and does not work. It leads to both Jack's room and the apartment hallway. Reg finally succumbs to containment within the apartment as a prisoner and submits to the expectations of drama, but spectators simultaneously learn that the relations on stage are irrecoverably artificial. And now the artifice rules Reg. He *can* ignore the blockage schema—we have seen him do so—but he is trapped by convention. This tension sows the first

seeds of *Traps*' primary theme. Our relational, social, and institutional contexts contain us, even though our potential extends far beyond those traps.

Churchill then celebrates space's ability to contain infinite possibilities. Albert exits through the same door without unlocking it. The rules are not only artificial, but they apply to different agents differently. Once more, we must re-conceptualize the space. As in perception, we monitor the other agents for clues. Jack locked the door with *purpose,* which is a metaphor derived from the PATH image schema. His goal was to block Reg's path, so Reg could not complete his goal (reclaim Christie). When Albert uses the same physical path freely, he exposes the relational nature of Jack's purposeful action. Jack does not lock the door; he strengthens the door's BLOCKAGE relation to Reg. When Jack successfully blocks Reg, he foregrounds the door's role as a path: not a physical path, but a causal node in a series of actions. The door is in a PATH relation with a GOAL—namely, contain Reg. Albert then freely uses the door, because his path is not Reg's.

Language also primes schemas and spatial-relations concepts. Cognitive linguists treat language as a sophisticated set of spatial metaphors, derived from those same encoded spatial relations. As Hart explains,

> the utterance, via semiotic signs . . . serves to cue or highlight within an audience member's mind an image schema . . . even if only for the flicker of time it takes for the brain's neurons to fire. Then, once foregrounded in this way, [the schema] may remain prominent within the audience member's continuing processes of interpretation[,] . . . thereby creating structural coherence . . . between many if not most audience members' perception of the performance. (43)

For example, Churchill uses the word "if" over a dozen times on the eight-page scene I highlight above: "What if I went out? . . . If you don't want to take care of it . . . if someone else turns up looking for Jack, if you tell her . . . If she's here all along . . . If you're waiting for Christie . . . If Christie comes . . . If you'd tell her . . . If I haven't had a child," and so on (76–83). The preponderance of counterfactual and subjunctive language in *Traps* primes spectators to focus on comparisons (paths) between exclusive *or*s (containers) with contradictory contents (A and not-A). As the characters' utterances refer to the containers that they inhabit linguistically, the door transitions between different places that it could contain physically, and the action shifts between different lives their bodies could inhabit. As speakers and agents, the actors interrogate the limits of this containment and bridge linguistic, conceptual, and perceptual features of spatial navigation. *Traps* produces paths through space, paths through identity, and paths between containers. In doing so, the play stages a world where the potential to be, the path between possibilities, is a perceptually present within the world.

The occasional metatheatrical breaches indicate how the staged world itself—and all worlds beyond those in *Traps*—are also paths. Staged worlds are trajectories that lead from sources (such as scripts) to goals (such as productions). The spectator, contained in the same venue as the actors, engages *Traps* on the only immutable path it presents: forward-moving time, the course of the scripted performance. Time still eludes physicists, but cognitive linguists treat time as a facet of the *causality* metaphor, itself an application of the PATH schema. As a path, time appears linear, but *Traps* folds its narrative time in on itself and rejects causality. The action lacks forward momentum: characters storm out and come back with pep, Albert dies offstage and then returns without fanfare, and so on. But it is no accident that a "clock showing real time" is set upon the stage (73). The action may be anachronous, but the activity of theatre occurs in time.

Traps exposes the myriad possibilities that co-inhabit space, but it also foregrounds the vitality of the current moment. Our decisions, the lives we actualize, contain our existence. We cleave one possibility from many, but time is always running out. Unlike Syl and Albert, we only ever experience one actualization. If we never breach containment, then our potential languishes.

In summary, staged worlds result from the interplay of our perceptual, conceptual, and linguistic functions. At first, spectators perceive the stage as they perceive anything else—a space containing objects. They unconsciously extrapolate from historical data to map the spatial relations on stage. In theatre, the spectators cannot confirm these predictions. Instead, they rely on the actors/characters' bodies. When the agents undermine the spectators' expectations, the spectators adjust their beliefs and adopt the *as if* relations that the actors are carving into the stage's possibility space. This process generates the convincing *as if* world associated with realistic dramaturgy. However, inconsistencies among the actors' activities frustrate the spectators' perceptual apparatus. For example, *Traps* forces us to decelerate and focus on multiple counterfactual trajectories. The play trains us to abandon the consistent history we expect of an object and instead trust the moment-to-moment relationships between bodies. This immediacy foregrounds the stage as a space of agents, who struggle against the stage and society, two containers that squash their potential. This shift, however, requires conceptualization, and our concepts are indebted to the same encoded spatial beliefs as perception. Thus, spatial arrangements, concepts, and language work together to prime the spectator to cognize the performance as an organic entity. Because actors and spectators exist in the same continuous space, the spatial relations presented on stage become another neuronally encoded possibility: another counterfactual test for all future perceptions.

In every play in this dissertation, the stage imbricates multiple counterfactual worlds. In *Traps*, the trappings of our containers restrict our capacity for flourishing. The expectations of society, self, and time erode our freedom of choice. Theatre's mimetic flexibility (i.e., its ability to inscribe many possibilities into one actual space) motions toward the real potentialities that we often overlook in daily life. By highlighting the stage space's inherent modality, theatre exposes the arbitrariness of the limits on our potential. Infinite potential can liberate, but it can also loom with horrid sublimity.

2. Counterfactuals as possible worlds

Contemporary cognitive and atomic science paint their pictures of reality with kindred brushes. In *Physics and Philosophy,* Heisenberg claims that even our most steadfast concepts (e.g., spacetime, causality, objecthood) "have been formed . . . through the interplay between the world and ourselves . . . [and] we do not know exactly how far they will help us in finding our way" (*Physics* 64–66). Atomic physics, Heisenberg determines, exposes our concepts and percepts as definitively limited by the things "that we can connect to the experiences of daily life, where we never observe isolated atoms."[6] Atomic reality dwells beyond our capacity to imagine, and we creep toward the atom's nature by juxtaposing its complementary appearances. It is not quite a wave, but not quite a particle, but not quite matter, but . . . Thus, Heisenberg advocates a worldview of "practical realism": we must assume that aspects of the world do "not depend on the conditions under which [they] can be verified," but we must admit that our discoveries are conditioned by our biology (*Physics* 55–56). This stance presages the last few decades of cognitive science. Seth's work uncovers perception's dependence on imagination and imagination's reliance on past perception. In other words, everyday experience is limited by our

mental pictures, and our mental pictures are derived from everyday experience. What Heisenberg calls practical realism, neuroscientists such as Edelman and Tononi call "*qualified realism*" (207). Reality exists beyond us, but our faculties qualify the world that we see. Our understanding of quantum mechanics and our cognitive processes are intimately entwined. Bohr was vocally interested in this extension, and he spent his late career folding atomic physics and psychology together. In many ways, Gennaro Auletta's *Cognitive Biology* attempts to complete Bohr's project. As Frith describes Auletta's work in its foreword, he bridges "quantum physics and information theory; information theory and perception [e.g., Bayesian inference]; perception and semiotics [e.g., image schemas]; semiotics and behaviour" (vii).

Moreover, physics and cognitive science share a preoccupation with counterfactual thinking. Seth describes the human brain as a counterfactual machine, which runs sensations against counterfactual scenarios and then logs our interactions for future tests. Kuhn's divisive scientific revolutions replace one account of reality with another. Each new scientific paradigm states: if the world were to act per this theory, then these consequents would be derived from an experiment. Our current model limits the sort of counterfactuals we can imagine ("Possible Worlds" 9–14). Quantum theory fascinates us because its various interpretations describe incompatible but equally plausible realities. *If* the wave function were real, *if* it were to collapse when an apparatus interacts with it, *then* the universe would be teeming with bizarre fundamental entities. *If*, however, the wave function were to represent our inability to locate ourselves within a system, *then* our multiverse would be deterministic. These counterfactual explanations, like the hypotheses in Bayesian cognition, try to offer a consistent interpretation of reality. Staged worlds, *as if* counterfactuals themselves, make such realities salient on stage.

In a certain sense, cognitive science and quantum theory both treat counterfactuals as real. For cognitive science, counterfactuals are embodied in the brain's neurons and synapses. These neurons, in turn, qualify our access to reality. Many atomic physicists, however, embed conditionals in the very structure of the universe. Statements like, "had I set up the experiment in a different manner, the electron would have manifested particle-like behaviour" are accurate descriptions of the world, our best interpretation of the evidence. But what does that mean? *Traps* tackles similar questions. Churchill imbues a real door with many possible lives and asks what that means for her characters and spectators. Theatre matches the counterfactual nature of all perception to the conditional *as if* of theatrical presentation. A cognitive theory of staged worlds clarifies how theatre is well-positioned to interrogate the realities of contemporary physics. As Churchill exposes, the *as if* of theatre permits malleable staged worlds, where relations that we could never experience in daily life are concretized. These staged worlds permit us to explore the sorts of ontologies that quantum theorists often assume.

Since the early twentieth century, philosophers have explored the ontology of counterfactuals under the umbrella of modal logic: the logic of qualifiers, much like cognitive science's qualified realism and quantum theory's practical realism. Of course, possibility evades easy conceptualization. However, if possible things are real in some sense or another, then an ontology of possibility might help us find our way in puzzling through atomic physics and theatre. The following section examines the *as if* of theatre as a counterfactual and, moreover, a possible world.

The nature of the conditionals has haunted philosophers since Aristotle, and his Organon launches the tradition of analyzing these entities through modal logic. Arguments in classical logic adjudicate between what *is* and what *is not*. For example, I can evaluate a statement such as

"all electrons always act as particles" with a basic syllogism (see Chapter 1). Ultimately, if a single electron fails to act like a particle once, it is false—it is not the case that all electrons always act as particles. Elsewise, it is true—it is the case. However, classical logic buckles when premises include modal adjectives or adverbs. Consider the statement, "if I had set up the experiment differently, then the electrons would have manifested wave-like features." Those subjunctive terms (*if I had, then . . . would have*) qualify the statement with a conditional (or counterfactual) mood. Such statements fail to assert that something is or is not the case in the world: instead, they claim that something might be the case, given the right conditions. Of course, even classical logic assumes some degree of modality. For example, one reads the arrow of material implication (⇒) as "implies." Thus, "A⇒C" reads as "A implies C," and, like subjunctive verbs or the suffix *-able,* the verb *implies* packs an implicit conditional.[7] "A implies C" means "if A is true, then C is true." However, the conditionals of classical logic represent an epistemic fault and not a metaphysical claim. I do not know if A is in the world, and the *if* of material implication indicates my insufficient knowledge.

However, no empirical evidence can prove a modal premise. Try as one might, one cannot observe an *if I had*. When a premise lacks evidence, most logicians treat it as undecidable or, even worse, false. When that premise contains a modal qualifier, however, this solution clashes with our intuitions. It does not feel false to claim that "If I had set up the experiment differently, then the electron would have manifested wave-like features." It cannot be found out there, so it is hard to say it is true, but it feels wrong to call it false. It also seems unintuitive to call it undecidable: we are reasonably sure it would have been the case. Such statements are *possible*. Modal logicians handle counterfactual statements by replacing the *is* and *is not* distinction with a fourfold case: is necessary, is actual, is possible, and is contingent. If

something could be true, it is possible. If something must be true in every coherent scenario, it is necessary. If something is true in the real world, it is actual. If something could be or not be true, it is contingent. For philosophers and scientists both, modal logic presents a system that appeases and formalizes our intuitions about possibility.

Modal logic helps us parse the implications of counterfactual statements, but, as a framework, it remains agnostic on matters of ontology. It clarifies what a modal situation means, but not what it is. For example, philosopher Gunnar Olsson interprets all modal statements as nothing more than speech acts, which convince an interlocutor to imagine a given counterfactual as plausible. In logic, he opines, "[t]here is indeed no description without performance . . . Telling truth is not enough. Being convincing is equally necessary" (76). A logical symbol (e.g., ◊P) refers to a possible thing (e.g., Possibly-P) without defending its reality. We reason about Possibly-P with unchallenged confidence, but it lacks a referent. However, most logicians hope to treat true premises as statements that interface with the world. Otherwise, how can we know that the discoveries of science and mathematics describe reality? It follows that many philosophers are convinced that it would be foolhardy to ignore the being of Possibly-P.[8] Since the middle of the last century, logicians began treating modal statements as references to a *possible world*.

Possible worlds are semantic models that describe one of many self-consistent states of affairs. As David Lewis describes in his influential study *Counterfactuals*:

> I believe, and so do you . . . [that] there are many ways things could have been besides the way they actually are. . . . [This implies] there exist many entities of a certain description, to wit "ways things could have been." . . . I therefore believe in the existence

> of entities that might be called "ways things could have been." I prefer to call them "possible worlds." (84)

Alternatively, as Lubomír Doležel defines them, "possible worlds of logical semantics are interpretive models providing the domain of reference necessary for the semantic interpretation of counterfactual statements" (14). A possible world accounts for all objects, properties, and the relations between them within a given domain. For example, consider the following statement: "if the door had been unlocked, then Reg would not have been trapped." According to the rules of modal inference, we can separate that statement into three contingent states of affairs:

> (world 1) The door is locked, and Reg is trapped (the origin state)
>
> (world 2) The door is unlocked, and Reg is not trapped (the asserted counterfactual)
>
> (world 3) The door is unlocked, and Reg is trapped (an alternative counterfactual)

We can conceive of these scenarios as three possible worlds, which are contingent and mutually incompatible. If each world is coherent, then the statement is valid and sound. Furthermore, if the difference between the origin world (world 1) and the asserted world (world 2) is suitably limited, then Lewis would call those worlds *close* (*On* 20–26). We have a third option: the door could have been unlocked, and yet Reg could have been nonetheless trapped (world 3). Perhaps he was drugged, restrained, or otherwise unconscious. However, any plausible scenario that completes the description of world 3 requires extra adjustments to the state of affairs on world 1. Because world 2 requires the fewest changes, world 2 is *closer* to world 1. It follows that the statement above is *true*: if the door had been unlocked, then Reg would not have been trapped.

As Jaakko Hintikka describes, possible worlds semantics "began its life as a theory of logical (conceptual) necessity and possibility," but throughout the twentieth century it grew into "a general theory of meaning," an explication of "knowledge, belief, [and] perception" (52).

Most disciplines take the actual world as an origin world, across from which their theories present a counterfactual. Thus,

> possible worlds of philosophy are coherent cosmologies derived from some axioms. . . . Possible worlds of natural science are alternative designs of the universe constructed by varying the basic physical constants. . . . Possible worlds of historiography are counterfactual scenarios which help us understand actual-world history. (Doležel 14)

Per Seth, we could add to Doležel's inventory that the possible worlds of perception are neuronal hypotheses constructed by experience and inference.

We also face a swirl of counterfactual staging opportunities whenever we read a script: the possible worlds of production. Yasmina Reza's *Trois Versions de la vie* helps demonstrate how contemporary theatre directly explores possible worlds within the staged worlds of performance. In doing so, it also clarifies how possible worlds relate to theatre aesthetics. When the play begins, Henri, an astrophysicist, verges on publishing new research for the first time in three years. He has developed a convincing proof that the dark matter halos surrounding galaxies are "ten times as thin as they're wide" (*Life* 217).[9] Approaching a mid-life crisis, he hopes that this research will advance his mediocre career. To this end, he invites Hubert, a key player in his research institute, to dinner. However, a scheduling error undermines his plan: Hubert and his wife Inès arrive an evening earlier than expected. Lacking a proper dinner spread, Henri and his wife Sonia desperately cobble together a piecemeal platter of biscuits and booze. As the underfed night of drinking progresses, Henri learns that his stratagem was doomed from the start. Hubert has no interest in promoting Henri, and he gleefully reveals that a team of Mexican physicists beat Henri to publication. He spends the night basking in Schadenfreude. This initial state of

affairs forms the necessary features of *Trois Versions*'s possible worlds. Reza's characters could react to this syzygy of professional and social disruption in different ways.

Reza does not develop a single plot from this inciting condition, however. Instead, each act develops a different counterfactual *if/then* into a staged world. Acts 1 and 2 both begin with Henri putting their son, Arnaud, to bed as Sonia mulls over work-related files. The first two lines are identical:

HENRI. He wants a cookie.

SONIA. He just brushed his teeth. (*Life* 203, 236)

In act 1, Henri "[does not] know there were no cookies in bed," so he tells Arnaud that he might have one. Sonia, perturbed by Henri's weak will, halts her work and storms offstage to deny Arnaud's snack; soon after, Sonia enters as her "disgustingly temperamental" child cries offstage (*Life* 204–05). Henri rushes to offer Arnaud an apple, despite Sonia's disapproval. The disharmony escalates until Sonia shouts, "shut the fuck up, Arnaud!" and Henri "grapple[s]" with her to protect the boy (*Life* 208-09). When she cries, "you're suffocating me," spectators know that their union cannot weather Henri's servility and Sonia's fury. The same weakness infects Henri's career: once Hubert arrives, he spends the evening demeaning himself before his boss. When Hubert reveals the Mexican research, Henri sinks into pleading and despair.

In act 2, Reza presents an alternative counterfactual scenario: if Sonia were less high-strung and less invested in Henri's career, then . . . In other words, Reza stages the possible world that would exist if Sonia were a slightly different person. The scuffle that opens act 1 is now avoided. Henri gives Arnaud a cookie before asking permission, but Sonia continues her work despite knowing that Henri defied her. She seems disappointed, but resignation replaces vitriol. At first, the pair seem happier for it: they plan dinner and jest about the invited couple.

After Hubert and Inès arrive, however, we learn the price of Sonia's happiness. Halfway through act 2, "fifteen seconds . . . is more than enough" for Hubert to seduce Sonia while Henri and Inès are offstage (*Life* 242). Sonia and Hubert, we learn, have had an ongoing affair. Detachment and infidelity are the antecedents that lead to the consequent of a genial Sonia. The closest world that contains a less furious Sonia, Reza suggests, is a world in which she has already abandoned her family emotionally. Furthermore, Henri needs Sonia's vitriol to function. Without act 1's spat, act 2's Henri responds to Hubert's news with nihilistic fury. He tells Hubert to "fuck off," destroys what little career he had, and interrogates Sonia about her shiftiness (*Life* 254). *If* Henri had not released his anger against Sonia (as he does in act 1), *then* he would have had a row with his superior and destroyed his career (as he does in act 2).

In act 3, Reza offers a third version: if Henri were more competent, then . . . This world offers a stark contrast. An unspoiled Arnaud replaces the bratty child who fought his parents in acts 1 and 2. His previous behavioural issues, it seems, derive from Henri's servility. Sonia too seems content in this version. And, because Henri is confident, he has friends, who warn him about the Mexican research in advance. This Henri repositions his research to compensate for the other publication, and he extracts Hubert's endorsement before the evening's end. Success, however, fails to generate a joyous finale. Despite deft navigation, Henri cannot escape from the infectious sense of "gloom" (*Life* 266). Furthermore, Sonia still accepts Hubert's proposition. The pair begin, rather than continue, an affair. Reza demonstrates how different *if*s lead to different *thens*, but act 3 reveals how certain necessary features persist across possible world. In particular, Reza emphasizes the "dark matter halos" of disappointment and ennui that circle her upper-middle-class intellectuals.

Despite foregrounding contingency, an uncaring determinism lingers beneath Reza's many worlds. As Chapter 3 seeks to establish, this deterministic turn is typical of a genre of quantum plays—those plays that, like Reza's, quarantine possibilities into separate scenes, acts, or spaces. Reza's engagement with counterfactuality leads her to stage three possible worlds. Those worlds adopt an *if/then* structure, where some change in the initial conditions (if) causes a new outcome (then). When a pattern repeats across the three possible worlds, it seems necessary. These essential features come to define the macrostructure of worlds. Subsequently, deviations seem contingent and inessential. In Reza's worlds, defeat, dissatisfaction, and gloom unite us. We could comport ourselves differently, but does our behaviour matter to reality? Through Henri's three failures, Reza seems to answer no.

Of course, even the worlds of realistic dramaturgy pose counterfactuals, though they (tend to) instantiate a single state of affairs. A handful of scholars have described drama in terms of possible worlds. Philosopher John Dilworth, in "The Fictionality of Plays," defines the essence of a play as the set of necessary features in its fictional world. Theatre scholars, including Veronika Ambros and Jenn Stephenson, have explicitly treated dramatic worlds through possible worlds semantics. And Michael Y. Bennett's *Analytic Philosophy and the World of the Play* represents the first book-length treatment of the topic. These projects stress the resonance between theatre and counterfactual thinking.

Bennett's work advances upon a theory of theatre proposed by Irit Degani-Raz. In "Theatrical Fictional Worlds, Counterfactuals, and Scientific Thought Experiments," she argues that theatre should be thought of as an extended counterfactual statement:

> Fictional worlds are possible worlds that provide a frame of reference whereby we characterize the qualitative nature of the actual world . . . [I]n order to understand a given

> work of art, the spectator examines it from the viewpoint of the following question: "Would I accept, in the light of my knowledge of my actual world, that if there exists in my world an initial state of affairs like that described by the theatrical text, then it is highly possible that it would evolve to the same final state of affairs as that described by the text?" (354)

She forwards logic as a dramatic world's primary feature, a conceit that she inherits from previous scholarship. Since the 1970s, a spate of narratologists adapted possible worlds semantics into a theory of literary semiotics—fiction theory. That tradition is a dissertation unto itself, but (crudely) fiction theory states that a text constructs a fictional world so long as its internal rules are self-consistent.[10] In part, I agree with Degani-Raz. Theatre explores alternative spatiotemporal arrangements and social relations as if they were a reality. If the provisional reality seems plausible, then the performance exposes the spectators' assumptions about reality. However, I disagree that spectators read performance through such a logical process. Degani-Raz's spectators decipher the performance as a series of signs that present an argument. They test the dramatic action against their "knowledge." This account does not reflect my experience as a theatregoer. When I watch a play, logic enters my experience only when the dramatic action strains credulity. Furthermore, though consistency is integral to some genres, plentiful modern plays present engaging but self-contradicting worlds.

In contrast, I treat perceivability as the staged world's prime feature. Degani-Raz's spectator asks, "would I accept, in light of my knowledge of my actual world . . .?" Instead, my spectators cognize the staged relations as a provisional world because the activity on stage is demonstrably possible. After all, it just happened, even if the theatrical illusion attenuates or re-aligns its reality. Moreover, our shared reality is a necessary component of the staged world, not

an alternative case against which a performance is tested. Our prior experiences enter the inferential chain of perception as the first beliefs we bring to bear. Thus, I argue, logical inconsistency does not render a world on stage implausible. Instead, perceptual consistency forces the spectators to cognize the stage image, whether it appears consistent or not.

We have not yet touched the question that launched this section. What *are* these "ways things could be"? The possible worlds of modal logic and the mimetic activities of actors share a fundamental puzzle: what is their object of imitation or reference? An actor imitates some non-existent character, and the arrow of material implication likewise bursts with "mimetic desire" for some non-tangible possibility (Olsson 76). Theatre and logic are materially dissimilar. Theatre is composed of human bodies and scenic objects in spacetime. Henri is not a real person, and so Richard Berry's performance in the premiere production did not imitate a real person but something else. Logic deals with written symbols, where the relation between sign and referent is comparably abstract. Aristotle would say that Berry imitates the capacity for servility (universal to all human beings) when he plays Henri. Modal logicians would say that modal statements imitate possible worlds. But these answers delay the question: what are universals and possible worlds?

This dissertation concerns staged worlds that evince the same sorts of ontological commitments as those underlying quantum theory. If an electron honestly *could have been* a wave-like or particle-like actor in the experiment, then we should know what it means to *could be*. The plays in this chapter both forward an ontology of possibility through the nature of their content. Churchill renders possibility vivid by focusing on the endless succession of paths, available to every object, body, and space itself. Reza offers three separate complementary pictures, distinct acts that are small plays themselves (note the title). In other words, *Traps*

situates possibility and potential within the immediate reality of the material objects onstage; *Trois Versions* instead situates potential without the immediate reality, in a broader structure that contains the whole event. These two approaches reflect the prevailing interpretations of modality in philosophy and physics: *actualism* and *possibilism*.

3. The ontologies of possible worlds

Like the nature of atoms, the nature of modality lies beyond intuition. For philosophers, there are two conventional approaches to possible worlds: actualism, in which possible worlds are understood as arrangements of the possibilities latent within actual things; and possibilism, in which possibilities exist in distinct spatiotemporalities. These two competing explanations salvage opposing intuitions at different costs (see Loux 28–36). Actualism rescues the intuition that nothing exists beyond actual things, forces, and their interrelations. Everything real is actual and vice versa. To explain modality, however, modal actualists discard the strictest determinism because actual things could have been otherwise.[11] This potential-to-be-otherwise exists within the actual objects of reality. Possibilism instead rescues strict determinism from the cliff's edge. According to possibilism, there exists a realm of entities beyond those things that are actual. Actual events proceed deterministically. Things could not have gone otherwise. But, in another distinct world or realm, which is real but not actual, things did go otherwise. Put another way, actualism situates potential within objects, so the universe contains everything, and those things contain myriad possibilities. Possibilism situates potential at a super-universal scale, and the set of actually existing things in our world is strictly deterministic. Chapters 3 and 4 explore how these two strategies resonate with the varying interpretations of quantum theory. Like actualism, collapse theories treat the universe as a fundamentally uncertain, nondeterministic, discontinuous

place. Like possibilism, collapse-free theories understand the wave function as the echo of a multiverse or a lonely branch in an otherwise empty reality.

Traps and *Trois Versions* stage worlds that fall into the same two categories. *Traps* stages an actualist world in which potential is physically embodied within the actors. In *Trois Versions*, Reza stages a possibilist world in which possibilities are divided into unique spatiotemporal contexts. On stage, actualism and possibilism engender different themes, both of which relate to anxieties about personal identity (as essence), free will, and fate. In the actualist worlds of *Traps*, myriad possibilities bury the self, while systemic relations obfuscate its potential and desires. In the possibilist worlds of *Trois Versions,* a strict determinism exposes our belief in possibility as an illusion, a by-product of our insignificance. The following discussion of actualism and possibilism is necessarily scant—Chapters 3 and 4 expand both. Here, I aim for a general outline of the sorts of worlds suggested by modality and, ultimately, quantum theory and contemporary theatre.

3.1. Caryl Churchill's *Traps* and actualism

Churchill begins *Traps* by warning that

> [i]n the play, the time, place, the characters' motives and relationships cannot all be reconciled—they can happen on stage, but there is no other reality for them. . . . [T]he characters can be thought of as living many of their possibilities at once. There is no flashback, no fantasy, everything that happens is a real and solid as everything else within the play. (71)

In realistic dramatic performances, actors (generally) embody a single version of their characters at a time: one Hamlet for one production, derived from a reading of the script, honed in

rehearsal. Churchill asks her characters (and actors) to live many possibilities at once. Her vocabulary—*their* possibilities—hands each character ownership of his or her potential. But these "possibilities" are not complete lives. Rather, characters summon their field of possibilities from a potential within themselves. Each possibility emerges from the potential of the actor's body, before it recedes, and another crests. In her influential study of the play, Elin Diamond describes *Traps* as a play where "[c]haracters are completely recognizable; what they do is not surprising, narrativity seems absolutely appropriate, yet nothing coheres" (87). Moment-to-moment, the characters are legible as realistic people. But the activity onstage grows incoherent as contradicting possibilities lay equal claims on actual space. One could easily mistake Churchill's warning or Diamond's summary for a description of actualism.

Actualism situates modality inside actual beings. "The only things that exist are objects that exist in the actual world," describes Michael J. Loux, "[therefore] possible worlds can be identified with actually existing object or with constructions out of actually existing objects" (38). The actualist universe contains only actual things. However, one needs a wide-ranging definition of *thing* to corral all of our modal intuitions. Think of actualism's possible worlds as floorplans, which outlines one possible way to arrange furniture in space. Reality's furniture is already laid out one way, and these floorplans are limited to the furniture we have. But you could rearrange that furniture (at least in theory). These floorplans, or possible worlds, systematize the fact that the sofa against the north wall *could have been on the south wall*, or *could have been a different colour*. These possibilities exist within that sofa: it has the *potential* to be on the south wall or green. However, those possible attributes could never exist in isolation. They emerge only in complete floorplans that relate the sofa to the rest of the world. Were the sofa on the south wall, for example, the potted plant would necessarily relocate. The possible worlds of

actualism describe one non-contradictory arrangement for all of actuality's contents. Subsequently, they consist of relational networks of actual things. Because a possible world must (by definition) present a maximal floorplan, some objects may possess potential that is strictly impossible without massive relational changes. For example, say the sofa has the potential to be on the ceiling. After all, we could draw it there. Such a relocation would require a massive adjustment to matter's relationship to gravity. That world would not be close to ours.

In the actualist worldview, we can discuss possible worlds because these floorplans *actually exist*. However, they exist only as *abstract objects*: mind-independent entities (such as numbers) that are "non-spatial and causally inefficacious" (Rosen). Actualism requires us to admit abstract objects (and, depending on the theorist, a host of other properties) into the ontology. For example, we might need to accept states of affairs, properties, roles, and causal relations as actual things in some sense. The specific issues that arise from this approach are addressed in Chapter 4. To differentiate between the actual world (i.e., the actual arrangement of reality's furniture) and possible worlds (i.e., the floorplans), philosopher Alvin Plantinga coins the term *obtainment*. All possible arrangements of the world exist (e.g., as objects' potential), but everyday actuality is the sole world that *obtains* concreteness. Because every possible world is supported by actual world entities, the actual world and possible worlds co-inhabit a single spacetime. Thus, actualism offers a neatly bordered stage—actuality. However, a messy ontology, peopled by strange players, dances atop its slats.

The actualist universe coincides neatly with the experience of theatregoing. A given actor's body could be Hamlet, Reg, Sherlock Holmes, or cast cross-gender. These possibilities dwell within an actual body. When we see an actor perform a role, his or her past performances linger like possible lives that no longer obtain on the stage (see Carlson 6–12). Actors and

directors often struggle to erase these traces, and acting methods have developed to obfuscate the actual body from which these characters emerge. By analogy, a performance stages one world, but the bodies and props on stage could have been arranged otherwise. The performance obtains, but other performances are still actually in the space on stage.

Churchill brazenly explores the performativity of the actual stage in *Traps*. The set offers a striking metaphor for actualism's cluttered ontology. The jigsaw puzzle, fragmented into possible pictures; a broken guitar, which could have been played, had it been in working condition; a shattered bowl, which gets fixed on stage but might never have been broken; washed but wrinkled clothes, an activity abandoned halfway. The objects onstage teem with *could have beens*. Furthermore, the space on stage could be—and often is—different possible places. Early in the play, a dog barks downstairs and Albert sends Reg to the pub on the corner: the original venue, the Royal Court Theatre Upstairs, is similarly upstairs and near public houses. The space could be (and actually is) the theatre. Act 2 inexplicably relocates the action to a countryside cottage, yet another possibility. The layout of their apartment also shifts. As already discussed, the door offers a path to different rooms to suit a character's goal. *Traps*'s shifting sands leave the play always haunted by the previous scene, as if fragments of unfinished plays stick to the set and actors. But actuality—the real stage space—persists, foregrounded by the fact that no other world obtains for long. The shifts encourage us to seek stable patterns.

Dramatic plots and stories obtain on stage and then fade without justification. The play focuses on the possible relationships among six adults who are sometimes lovers, sometimes roommates, and sometimes enemies. We first discover Jack and Syl on stage, and each subsequent entrance weaves new webs of possible relations among the six bodies. At first, Syl and Jack seem to be an impoverished couple: Syl tries to put her baby daughter to sleep, and Jack

sleeps in a chair. After Albert enters, however, he seems to be Syl's lover and the father of her daughter, while Jack is their roommate; after Albert exits, Syl and Jack embrace and plan to abscond to the country, as if Albert does not exist. Later still, Albert and Jack are lovers, and Syl is childless. The first adjustments to the action are bewildering but non-contradictory. For example, spectators could have misread the relationship between Syl and Jack; Syl and Jack's subsequent embrace could be a sign of her infidelity toward Albert. But Churchill does not imply polyamory, succession, or affairs: instead, the relationships shift along with the locations, allowing new constellations of possible attributes to obtain onstage. *Traps*'s possibilities are fundamentally embodied. Actors signal new provisional relations—these floorplans for their bodies—by inscribing them into the stage space. New worlds are signalled by an unexpected entrance, embrace, whisper, or chore.

Traps does not demarcate its counterfactuals with scenes or acts. There are no lighting cues, and transitions between possible worlds can occur midline. Characters often inhabit contradictory relational networks onstage simultaneously, and old arrangements resurface. One moment, Syl sets her baby down to sleep; next, she wonders if she will ever have a child; later, she worries where the baby has gone; later still, she is pregnant. When Albert and Jack embrace, Syl's prior relationships with Albert and Jack, and her possible child with both, linger as possible lives. The morphing possibilities, however, do not trivialize the dramatic stakes. Instead, Churchill teases meaning from the emergent patterns in her characters' possible lives. Perhaps the most striking example is Syl, whose baby haunts her for most of the performance. The play begins with the baby physically on stage, but Syl carts her offstage after the first line. The baby never reappears. At some unmarked point in act 1, she disappears from an adjacent room (never actualized in the space). Syl asks the others for her child's whereabouts, and Christie replies that

it is “in the garden” (101). The apartment’s garden was never mentioned before, and it is never mentioned again. Infants have a disquieting history on the contemporary stage, and Bond’s *Saved* haunts the scene as a possible outcome for Syl’s child. In act 2, the missing baby re-emerges; Syl is pregnant for the first time (108). She names the unborn baby Albert, who committed suicide between acts. Fret not: Albert returns within a few scenes, without comment.

Across every possible world, motherhood gnaws at Syl. The infant sticks to Syl as an abstract property; her potential *to be a mother* is an ever-present quality. Spectators face a similar stickiness: the play opens with Syl swaddling the baby, and thus her motherhood primes all subsequent perceptions of her. Churchill motions toward a constant feature of human experience. As individuals, we are awash with choice and potential. But we define each other and ourselves through a limited set of concepts, choreographed by our first impressions. Moreover, Churchill intimates the ontological puzzle at the heart of actualism. Does motherhood limit all possible Syls? Is motherhood an *essential* element of Syl’s character?

Traps is preoccupied with essences, and anxiety about essences befits the worldview of actualism. Plantinga (masquerading as a fictional interlocutor), summarizes the problem:

> [i]f Socrates exists in several worlds . . . there must at any rate be some property or other that he and only he has in each world in which he exists. Let us say that such a property is an essence of Socrates. Such an essence meets two conditions: (1) Socrates has it in every world he graces, and (2) nothing distinct from him has it in any world. (154)

For example, when I speculate “what if Syl hadn’t had a child?”, I must pick out Syl, the being around whom my hypothetical centres. But Syl contains infinite obtained and unobtained possibilities—she *could be Albert’s lover*, *could be baby Albert’s mother*, and so on. If these possibilities are mutable, they are not integral to her and, therefore, they are inessential. But, if I

can track Syl in different possible worlds, then I seem to assume some persistent, essential Syl-ness across the permutations. Otherwise, she would break a slew of logical laws, and the actualist account would fail to offer a consistent ontology.[12] When we propose a possible world, it must be accessible from the materials of reality. But when we pick out some element of reality to speculate about, we hold some feature of that object as inviolable.

Churchill dares her spectators to read behavioural patterns as her characters' essences. Del is the second last to enter. He bursts through the door and announces his plan to "tell you bastards what I think of you!" (86). His erratic behaviour leads to his eviction from the commune. Moments later, Del's entrance replays itself identically. The repetition cements a relationship between Del entering and the threat of violence, an association that persists throughout the play. His outbursts culminate in act 2's opening scene, where he unapologetically recounts raping and murdering a woman to Christie (herself a victim of sexual violence). "I hated her because I was raping her," he explains (103). In every possible world, he obtains the property *could be violent*. When Del announces that he is a "[k]iller deep down" (102), Churchill tempts her spectators to see this violence as Del's essential feature.

In the play's finale, however, she rejects this definition. The performance culminates in a ritualistic bathing sequence, during which each character strips naked, washes in a communal tub, and then emerges to eat dinner. As Diamond opines, the sequence foregrounds the performative body over the character or fiction. "[The tub's] material reality asserted by the fact that naked actors climb into it, get wet, climb out, and dry themselves," she explains, "the one-by-one bathing ritual injects, for the first time, an impression of temporality and focused space" (87). The world on stage and the spectators' perceptive faculties briefly find correlation in the material facts of reality—this sequence feels undoubtedly real. Addressing his nudity in *Traps*,

Pigott-Smith writes, "[N]udity can distract . . . [because] nudity is real. [It] cross[es] some line of convention" (281). Justified or not, spectators tend to cognize nudity as more essential than the represented action. Churchill's staging exploits this trend. Purging the trappings of prior relations, each actor emerges from the bath with only his or her essence remaining: the body. Del bathes first:

> ALBERT: Jigsaw's getting on
>
> *DEL comes back with a bucket of cold water and tips half of it into the bath*.
>
> SYL: Somebody try that.
>
> DEL: I'm going first and then I'll get supper. (120)

He washes away the worlds of violence, and his actor becomes stubbornly present. After his bath, he prepares real food for the others—which the spectators can see and smell—as they bathe in turn. Del inhabits the vilest possible worlds in the play. Yet even his violence was inessential, a result of the relations that our world permits him to obtain. In other words, peace, care, and nourishment are potentials for Del, but the prior relations only allowed him to obtain violence.

Moreover, the dirt that he sheds muddies the basin. Each character soaks in that water. Then, each actor emerges. By cleansing their bodies, the characters also stain themselves with the dirt of those who bathed before. Even during this ritual bathing sequence, the relational nature of objects in a possible world persists, scum on the water's surface. Each performer joins the dinner table to eat real food afterward. Churchill presents her characters as collections of inessential (and often regrettable) properties, which emerge because of the diseased arrangement of the world beyond. *Traps*'s puzzle—the jigsaw of performance—"gets on": Churchill allows so many awful possibilities to obtain on stage so that she might wash them in a ritualistic *katharsis*, purifying the actors and spectators of toxic social relations. Cleansed, Hugh Fraser (or

some future actor) builds new, nourishing relations. He feeds the other actors' bodies with real food. The only essence, it seems, is the performative body. The resolution is no uncomplicated purging, however. It is still scripted. The bodies, the food, and the table may be actual, but the arrangement remains *staged*. Churchill presents the physical body as an essence that possesses untold potential for care and nourishment. But it never escapes its trappings. Churchill's own restrictions on the actors' freedom, like the dirt on the water, remains even after purification. An actualist object cannot exist in isolation: it requires a world, an account of all objects and their interrelations.

Churchill, of course, recognizes the body's embeddedness. In actualism, one considers a world *accessible* from another when a series of *if/thens* can bridge from the latter to the former. Syl and Christie only access worlds of oppression. Syl obtains motherhood, expectant motherhood, and discussions about motherhood. On a handful of occasions, she finds herself in a world where she is a dancer, but, in these worlds, the men chastise her because she *should be a mother*. She becomes defined by motherhood because of her body, despite motherhood being inessential to that body. Likewise, Christie is defined by her abuse. The entrances reinforce the difference between the men and women. Reg, Albert, and Del enter the scene with violent energy. Spectators discover Syl swaddling her child, and Christie sneaks on stage with an apology. These limits come to define the women, but constraints are not essences. Rather, the systemic relations of the spectators' actuality reduce their potential into a limited set of sexist possibilities. In other words, every *close, accessible* world limits them. When Del serves Syl food, spectators glimpse an arrangement where relations are ejected: a utopic potential, possible through a *kathartic* purging of our world.

Diamond and R. Darren Gobert posit that the play's final moment cements its thesis. After the actors are cleansed of their trappings, "*each separately, they start to smile*" (125). According to Diamond, the cleansing ritual proves that the "'body' we see is perceivable not only because of its presence, but because the water which 'frames' the body has taken on a character, a narrative of its own" (87). Bodies are intractably defined by the relations that space permits, and the mutual bathing becomes a new relational network. Syl and Del escape their social roles only because the water redefines them, and spectators instead see the naked body because Churchill's theatrics has framed it. Gobert focuses on the potential that the ritual recovers, concluding that "we too [as spectators] might join Reg as he laughs and smiles, experiencing . . . 'feelings of possibility, hope, and political agency'" (177). Diamond's reading emphasizes the world that contains the closing image. Gobert instead foregrounds the transworld subject, whose potential extends beyond the limited possibilities permitted by the present context. In either case, the potential of theatre surpasses the limited possibilities of society. Theatre exposes the potential, latent in our actual bodies, oppressed by social relations.

Interpreting *Traps* as an actualist performance, the play's unmarked and amorphous exploration of possibility warns us about the limits of our containers. Through the *as if* pretense of theatre, actors take on characters; stage doors become external and internal doors; tangible objects temporarily obtain new lives. But these actors and objects reside in real space—a fact reiterated by the clock telling "real time" on stage (73). The clock is the stubbornly real object *par excellence,* binding fictional possibility to actual space and motioning toward the essence of theatre: real people, doing real things (States 30-31). *Traps*'s worlds are contained within the possibility space of dramatic representation. But, no matter how tyrannical the rules of a staged world appear, they are subservient to the potential to undo those rules. On the one hand,

Churchill demonstrates that our bodies possess potential beyond those possibilities that seem obtainable. On the other hand, she reminds us that social relations trap that potential in a narrow set of social possibilities, smothering our essences in the process.

3.2. Yasmina Reza's *Trois Versions de la vie* and possibilism

Compared to *Traps*'s set, Reza offers a minimalist stage for *Trois Versions*: "*Evening. / A living room. / As abstract as possible. No walls or doors; as if open to the sky. / What matters is the idea of a living room. / Sonia is sitting in her dressing gown. She's reading a file. / Henri appears*."[13] Both plays explore counterfactuals, but their staged worlds stand diametrically opposed. Where Churchill stuffs her stage to present the potential within things and bodies, Reza reduces her set to abstraction, with all the artifice of perspectival staging. Where Churchill forces her characters to file through a single shifting door, Reza banishes doors from the playing space, leaving her characters without a visible exit. Where Churchill emphasizes the actuality of the performing body, Reza emphasizes the "idea" as "what matters." Finally, where Churchill's characters enter the playing space from offstage, Henri just "appears." Reza's and Churchill's missions could not diverge further. As *Traps* presents the cluttered reality of actualism's possible worlds, *Trois Versions* offers the alienation of possibilism's possible worlds.

Where actualism locates possibility within actual things, possibilism situates possibility at a higher level: the set of worlds itself. Actual things are physical, well defined, deterministic, and *could not* have been otherwise. And they are contained within the actual world. However, there is a realm of other entities, mere *possibilia*, which exist in their own right. Returning to the examples from above, the possibilist interpretation of the statement "had the measuring apparatus been prepared otherwise, the electron would have acted like a particle" departs from

the actualist response. For the possibilist, that statement refers to four distinct entities: that measuring apparatus and that electron in the actual world, and a possible measuring apparatus and a possible electron in another possible world. There really exists a possible world in which the measuring apparatus *was* set up differently. The statement in question compares our world to that possible world, which is a real (and spatiotemporal, according to some) realm that contains its own beings.[14] Looking over the floorplan of reality, the furniture of actuality could not have been arranged any other way: it is predetermined, placed by the machinations of the deterministic universe. Other possible floorplans refer to other actualities, where the furniture *is* differently arranged. The messiness of actualism—with its unobtained but actual possibilities—falls to a crisper picture. There are only real objects, and we do not need to include states of affairs, properties, or other abstractions in the ontology.

According to Lewis's possibilism, which is both idiosyncratic and dominant, all things are real in the same manner. Every possible world is actual from its own perspective, and our world is a possible world from the viewpoint of the others. He explains:

> "actual" and its cognates should be analyzed as indexical terms: terms whose reference varies, depending on relevant features of the context of utterance. The relevant feature of context, for the term "actual," is the world at which a given utterance occurs. . . ."Actual" is analogous also to "here," "I," "you," "this," and "aforementioned"—indexical terms depending for their reference respectively on the place, the speaker, the intended audience, the speaker's acts of pointing, and the foregoing discourse. ("Anselm" 184–85)

Despite the deterministic nature of our actuality, our modal intuitions grasp the fact that we have infinite doubles across infinite worlds, who live lives very similar to ours with minor variations. These beings are our *counterparts* (Lewis, *Counterfactuals* 39-40). Thus, possibilism simplifies a

messy ontology and rescues strict determinism from actualism's potential-to-be-otherwise, which implies some choice or randomness. In exchange, the multiverse becomes infinite. But its vastness is invisible. Where actualism's possible worlds are layered atop one another, the worlds of possibilism are lonely and inaccessible.

Despite performance's actualist underpinnings, dramatists are drawn to the scriptedness of possibilist worlds. *Trois Versions* reflects a possibilist understanding of modality. Rather than explore characters and *their* possibilities, Reza presents three versions of a single evening. These variations are separated into distinct acts, unique temporal contexts with no causal interrelations. At first blush, the set primes spectators to view the worlds as unrelated. *Traps* recreates a messy apartment in London, wherein things accrue meaning through real time. Instead, *Trois Versions* only gestures toward its generous Parisian flat. In the premiere production in 2000 at the Théâtre Antoine in Paris, minimalist furniture and an anemic potted plant completed the set. Edouard Lang's design left the sparse furnishings grouped at centre stage. As a result, the set was dwarfed by the emptiness surrounding it. Rather than leave the walls bare or draw black curtains, the entire stage space was encircled by a backdrop depicting an evening sky, punctured by bright star lights and a dull, full moon. The same night sky propels the dramatic action: Henri and Hubert are astrophysicists, and their research prompts the central dinner. Henri studies the stars without passion or direction, and he focuses on his career when his home life is in shambles. Likewise, the backdrop in the premiere production drew spectators' eyes beyond the players and set, toward the back of the space: not unlike perspectival flats, which coax the eye toward the vanishing point of the universe. As a result, the actual objects on stage lacked the context to accrue meaning or a sense of potentiality. Rather, the space appeared entirely representational, and its distant worlds were easily cleaved from our own and each other.

This design made perceivable the play's fundamental tension. The alien cosmos of *possibilia*—the distant stars on the backdrop and across the astrophysicists' sky—seems ineffectual and unimportant from the here and now of one's actuality. Inès, played by Reza in the premiere, questions the value of astrophysics when the stars are so disinterested in our world:

> INÈS: Is it important for [dark matter] halos to be flat? . . .
>
> HENRI: Well, I have serious reasons to suppose that the distribution of dark matter which surrounds it is more or less as flat as the visible matter . . .
>
> INÈS: And what difference does it make if the halo's not round anymore?
>
> HENRI: To our everyday life, none. . . . It's a modification of presumed reality. A new entry in the encyclopedia of mankind. (*Life* 221–22)

Henri tries to explain why our "presumed reality" may be important. Before he can elucidate how distant worlds relate to our own, however, the immediate surroundings intrude. Sonia (who wrestles with a bratty Arnaud) and Hubert (who mocks Inès's lack of expertise) interrupt Henri's lecture. The actual specificities, Reza implies, demand more attention than lofty speculation. Inès, the playwright herself, wordlessly abandons her conversation with Henri and instead entertains the young child. One must make a choice, it seems, between the cosmos of possibility and the tangible actuality of other people and our future generations.

Where *Traps* emphasizes the actual space of performance, *Trois Versions* minimizes it. The lack of continuity between acts, spatial jumps, or entrances disconnects space from place. To this end, the abstract set allows the space to read as many different places and no place in particular. In *Traps*, the door becomes a compelling locus of activity, because new possibilities enter the space from offstage, activating the stage space and connecting it to the nooks beyond view. Reza eliminates the door, virtually locking her characters in the stage arrangement. She

banishes entrances almost entirely, save for sojourns just offstage to Arnaud's bedroom. At the beginning of the play, Henri "appears": he does not enter nor begin on stage. Likewise, when the action cuts to Hubert and Inès before their arrival, Reza asks that the transition be performed "with brutal speed, cutting the action."[15] A rapid lighting change refocuses the spectator's gaze onto the new location. Later, when the guests arrive, the lights blink, and the act of entering is skipped. The play shifts from Henri announcing "I'll get the door" to "*Inès, Hubert, Sonia and Henri in the living room. The two guests pick at the cold snacks . . . on a platter*."[16] On the one hand, the stage space is an isolated world that one cannot enter, even from the wings! On the other, the abstract set prevents the accumulation of connotations. Her characters are torn between the tangible and the possible, yet even tangible existence teeters on the edge of abstraction. Actuality, which demands more attention, offers effective action (like caring for Arnaud), but it fails to provide joy. Soon, act 2 replaces act 1 add renders the previous action irrelevant. Possibilism makes sensible a deep pessimism: we cannot obtain other possibilities, because we are trapped in our singular actuality. But our actuality is nonspecial, one adrift among many.

As the play continues, the play's cosmic backdrop implies an increasingly sinister theme. We can gaze at the stars and even study them, as Henri and Hubert do, but we are hopelessly bound to our limited actuality. Possibility taunts the characters and spectators both because their actual lives proceed deterministically. In act 1, Henri lacks confidence, Sonia wishes she never traded her career for a floundering husband and a snotty child, and Arnaud relies entirely on his parents. From these initial conditions, the evening proceeds with Aristotelian efficiency: Sonia begrudgingly deals with her unruly child, Hubert toys with Henri's hopes, and Henri descends into deplorable sycophancy. As the act ends, Henri pleads with Hubert to tell him that he pleads too much. He might be able to map the invisible regions of space mathematically, but he cannot

navigate his own life. Arnaud's whining and Sonia's rage hinder more than help. Act 2, however, does not continue Henri's tragedy. It presents a new spatiotemporal context.

The act break and subsequent re-submergence into the perceptual context of performance primes spectators to view act 2 as a new play. They re-enter the container of the event, which visually resets between acts, and the opening lines repeat. At first, one additional stage direction distinguishes act 2 from 1: Reza requests a "sweetness of tone."[17] The stage direction is not attached to an individual line or character, but it ranges over the whole scene and its participants. In other words, it describes the atmosphere of act 2's world, not a previously unobtained possibility newly expressed by a particular character. As act 2 progresses, spectators meet Sonia's counterpart, who fully exhibits this sweetness of tone. She lacks act 1's anger, but she also seems less concerned with her family. Where act 1's Sonia interrupts her filing to discipline Arnaud, act 2's Sonia dismisses her family and focuses on work. However, Henri's counterpart is the same sort of meek person, and Arnaud's is still spoiled by his father. As Reza follows the thread of this "sweeter" Sonia, she exposes a necessary precondition to the tonal shift: her ongoing affair with Hubert. Act 1's Sonia's counterpart, who is not exasperated by her Henri, is a Sonia who is no longer invested in the family. Hubert, in turn, has less cause to embarrass Henri (another example of sweetness). Through the affair, he wounds Henri's pride already. But Henri detects the affair and melts down, destroying this artificial sweetness. Act 2, like act 1, proceeds dramatically. Given the characters' personalities and the initial state of affairs, events continue as necessary. If Henri thinks Sonia *could be sweeter*, he is wrong; that would be a different Sonia, in a different world, following different dictates of fate.

The differences between these two acts indicate a fundamental divide between two levels of necessity. There is that which is necessary in the world of a given act, and that which is

cosmologically necessary. Though act 1's and act 2's Henris search the same cosmos for a brighter future, both are inescapably worldbound. Arnaud's behaviour connects the notion of boundedness to a character's birth. Born to a father like Henri, both Arnauds are the only way they could be. Everything within an act is deterministic, and the potential of the distant cosmos is merely theoretical. As Inès leads Henri to admit, cosmological concerns have no impact on our daily lives (*Life* 222). Act 1 could not have been act 2 and could not have been act 3; rather, these acts are counterparts of one another. And knowledge of other possibilities, as possibilism suggests, has no bearing on the progress of each separate actuality.

By the end of act 3, Reza sifts the necessities, which unite all possible Henris and Sonias (as contained by their names), from the contingencies. A necessary truth is something true in all possible worlds. In Reza's play, each version of the evening is drawn into the black matter of ennui, regret, or abiding dissatisfaction. This situation, Reza opines, is fundamental. For example, after learning that another team has beaten him to publication, act 1's Henri pleads with Hubert and act 2's Henri erupts. Act 3's Henri integrates this research into his own, but his project still leaves him dissatisfied because it remains intangible and disconnected from the immediate. Reza posits several black holes that draw her characters toward their inevitable dissatisfactions: France and its institutions, academia, and marriage. These forces (like her script) necessitate each act's plummet into darkness. Her characters are firmly locked in the spatiotemporal limits of the stage, yet joy seems to exist somewhere far without. The only trace of potentiality is the night sky, which unites each act's stargazers and spectators. But ennui emerges from the pursuit of stargazing. The cosmos only demonstrates our insignificance.

By separating her possible trajectories into distinct acts, Reza formalizes her possible worlds as contingent and mutually incompatible. Furthermore, she teases out the tensions

between possible and necessary "ways things could be" by alternating between recognizable patterns of repetition and stark divergences. Physics and ennui loom as necessary, but each character's comportment toward these facts is contingent on that counterpart's position in the machinery of the act. Moreover, persistence across possible worlds represents inescapable necessity, reinforced through repetition. By the end of act 3, we know how this evening will terminate, no matter its path. Because they see all three worlds, audience members observe *Trois Versions* from an ironic distance. The affairs and outbursts become logical consequences, and the activity on stage grows as universally inconsequential as Henri's dark matter halos. The stars draw Henri's attention because they signify a vast network of possibility. But that possibility is causally effete, unable to address his imminent failings. And that cosmic background supervenes over all worlds, including our own. Understanding *Trois Versions* as a possibilist play, Reza's thesis seems clear: the actual is pre-determined, the possible faraway, and change illusory. The vast emptiness of space reminds us that we will never find our place.

In summary, actualism places potential within actual things, and possibilism displaces potential into distinct spatiotemporal contexts. Actualism purchases freedom but loses determinism; possibilism makes the opposite exchange. *Traps* and *Trois Versions* pair these understandings of modality with divergent theatrical practices. For *Traps*, the embodied nature of actualism matches the embodiment of performance. Embracing the potential of the performative body, however, requires Churchill to abandon the dictates of plot and story. Churchill's characters are freer, but spectators must struggle to follow the messy threads. For *Trois Versions*, the distant nature of possibilism extends to three disjoined worlds, which reinforce a bleak fatalism. If all possibilities are equally real, then everything that could happen does happen somewhere. Reza's characters are pushed by the dictates of the universe, but the cosmos beyond

bursts with infinite possibility. What does any choice or success matter, if every outcome exists equally? Both plays complicate an ancient theatrical puzzle: are we free, or do we follow the dictates of fate? In *Traps*, individuals are free but trapped by the limited relations that have obtained. *Trois Versions* demonstrates the opposite: individual characters are bound by dramatic logic, but the multitude of worlds guarantees every possible outcome occurs somewhere. Only happiness, it seems, remains impossible.

§

In *Novum Organum*, Bacon lobs a grievous insult at western philosophy: he likens the philosophers' metaphysical systems to the "staged worlds" of theatre (see Chapter 1). When Plato posits ideal forms or Aristotle talks of universals, Bacon opines, they obscure the stage of reality by placing a conceptual scheme atop it. These staged worlds are pernicious conceptual and perceptual errors, which turn the viewer away from the true object of intellectual pursuit: the bare stage of reality. Bacon's ideal observer ignores speculative ontologies altogether, but cognitive science rebukes the strict Baconian empiricism. Every perception arrives pre-interpreted, and those interpretive metrics are generated through a lifetime of experience and acculturation. On this, the qualified realism of quantum mechanics agrees. We simply cannot grasp the bare stage of the atomic world, inaccessible as it is without an apparatus.

As Heisenberg intuits when he borrows the term *potentia* from Aristotle, quantum theory requires a more sophisticated notion of possibility. The experiments and mathematics beg explicitly modal terms. Thus, quantum theory opens the door for competing understandings of reality, most of which integrate live counterfactuals into fundamental physics. As plays like

Traps and *Trois Versions* demonstrate, contemporary theatre confronts the same concerns. These plays stage worlds that point to the *as if* nature of those worlds staged by natural, political, and social philosophy. Moreover, they expose our reality as fundamentally contingent and open to (re)conceptualization. They direct our awareness toward a worldview that is otherwise inaccessible to sensible experience. Dramaturgs have explicitly described plays as small worlds since (at least) the eighteenth century, but these contemporary plays interrogate the worlds as they stage them and question our place as human beings in such strange lands.

The remaining chapters examine two types of staged worlds in contemporary theatre, with distinct ontological commitments. These plays demonstrate different failures to self-locate in our new reality. Chapter 3 analyzes plays where the self is delineated as a particular subject, but the world in which the subject dwells cannot be determined. In other words, these characters grasp an essential self but cannot determine which possible world is theirs. The indexical nature of such a reality renders the value of self-knowledge suspect. Moreover, these worlds are fundamentally deterministic; all stochasticity and choice are delusional by-products of ignorance. In *Trois Versions,* Henri and Sonia's descent into ennui represents such a case. Their self-certainty and direction have little value in an uncaring cosmos. Success leaves them hollow. These plays stage possibilist worlds and, moreover, echo the developments of collapse-free interpretations of quantum mechanics. These interpretations reclaim strict determinism from the clutches of the Copenhagen interpretation, but they reduce our world to one of many. Scientists strive to salvage strict determinism, and these playwrights redeem more traditional realistic dramatic structures. But those realistic dramas are fragmented small plays, displayed in a gradient across many scenes. Our reality is definitively nonspecial, and an avalanche of worlds suffocates free will beneath infinity.

Chapter 4 then analyzes plays where characters struggle to define their transworld self across multitudinous embodied possibilities. As with Syl and Del in *Traps*, these characters dwell in actualist worlds, where possible properties are entangled in imbricated networks of relations. But the contradictions on stage undermine their supposed essences. As Syl exposes, one cannot locate the self's broader potential within the systemic limits of society. This erasure of the self, however, engenders metaphysical hunger. These plays mirror those interpretations of quantum theory that posit a collapse of the wave function and represent a thrilling convergence of post-Brechtian aesthetics and post-Heisenberg physics. For theatremakers and scientists both, these ontologies carve out a space for chance and choice, but at a great cognitive cost: spectators and characters alike may lose direction, purpose, narrativity, and (often) hope.

These parallel paths between theatre and physics represent the two enterprises arriving at remarkably similar conclusions about the nature of our reality via radically different practices. Chapters 3 and 4 do not inventory every play that fits these patterns. Rather, I listen for and identity echoes between theatre and physics through the six case studies. The plays elucidate a trend that extends far beyond their particular examples. Moreover, the above method of analyzing staged worlds as cognitive counterfactuals can be applied to performances and plays of any description.

Notes

[1] Cognitive science is a hotly contested domain, and mutually exclusive theories of cognition and perception still compete. The Bayesian account has empirical evidence, finds support among a large and vocal group of scientists, and parallels elements of quantum theory, modal logic, and theatre aesthetics. But other approaches—including those advocated by Gerald Edelman, Antonio Damasio, and Daniel Dennett—are available.

[2] Our brains also receive electronic signals from proprioceptive and interoceptive systems throughout the body, and this information about the external and internal environment arrive together. Our brains must infer which signals come from without and which come from within. This mixing has interesting implications for *katharsis*.

[3] According to Merleau-Ponty, whenever a subject perceives an object, the percept is always "given" to awareness "as the infinite sum of an indefinite series of perspectival views in each of which the object is given but in none of which it is given exhaustively" (15).

[4] Lakoff and Johnson focus on our body's history in space, such as being under things, instead of perception. However, Seth's recent work suggests that perception, proprioception, and interoception comprise a single inferential system derived from the same mass of signals.

[5] Cognitive scientists and linguists offer competing accounts of the process with which our brains categorize these schemas—the Bayesian account may render an additional explanation of categorization unnecessary—but these explanations share key features. Regardless, the theory of image schemas (as presented by Lakoff, Johnson, McConachie, and Hart) is agnostic as to which account of basic-level categorization is correct.

[6] "gehen auf die Erfahrungen des täglichen Lebens zurück, in denen wir . . . nie einzelne Atome beobachten" (*Physikalischen Prinzipen* 7).

[7] Our ability to discuss modality is qualified by the same neuronal embodiment that qualifies all of our concepts. For example, in my discussion of *Traps* I use the word *circumscribable,* which the OED defines as "that may be circumscribed." The auxiliary verb *may* includes an implicit counterfactuality: if one tries to circumscribe this object, then he or she will be successful. Indeed, every word with the *-able* suffix reflects our intuition that things, like the electron in an atomic experiment, could be otherwise (see Loux 58–59). Auletta's *Cognitive Biology* argues that the structure of our neuronal encodings is, in turn, shaped by quantum information (423-38).

[8] The basic idea of a syllogism or any other logical apparatus, for philosophers, is to reason about metaphysical truths through a chain of irrefutable deductions. If these deductions never hook into reality, then they can only prove the consistency of an abstract system. This, in turn, would drain logic of much of its practicability.

[9] My engagement with *Trois Versions* relies on the original French text and Christopher Hampton's translation, titled *Life x 3.* In both cases, I use the character's names from the original French text. Hampton's translation of the dialogue captures the French very well, but I opted to turn to Reza's original stage directions.

[10] I lack the space to address the literary approach to possible worlds in this dissertation. Umberto Eco, Thomas Pavel, Lubomír Doležel, and Marie-Laure Ryan developed a modal semantics for literary texts from the possible worlds framework. Like Olsson, they treat literary texts as speech acts. However, books, like modal statements, are comprised of written signs. Thus, both dwell in conceptual, not perceptual, cognition (see Mancing 196-99). Materially, the modal argument "$\Diamond\exists x Wx \,\&\, ([Wx \text{ or } Px] \,\&\, \neg[Wx \,\&\, Px]) \Rightarrow \Diamond\exists x \neg Px$" and a sentence from *Hamlet* have more in common than the same argument and a minute of *Hamlet* in performance. Ambros and Stephenson rightfully abandon most of the narratological baggage as incompatible with performance.

[11] I am ignoring strict actualism, where modality has no real relationship to the actual state of affairs. After all, this dissertation concerns modal ontologies and not their negation.

[12] Particularly, the indiscernibility of identicals and the rule of transitivity are sundered unless there is some essential characteristic of Syl (or an alternative mechanism). For the purposes of this dissertation, I focus on solutions with an essence, because they relate most readily to theatre (see Loux 36–47).

[13] "*Soir. / Un salon. / Le plus abstrait possible. Ni murs ni portes; comme à ciel ouvert. / Ce qui compte, c'est l'idée du salon. / Sonia est assise, en robe de chambre. Elle lit un dossier. / Henri apparaît*" (*Trois Versions* 11; my translation).

[14] This description ignores a key difference in two prevailing understandings of possibilism, which is addressed instead in Chapter 3. Simply put, some possibilists see other worlds as distinct realms (i.e., modal realism); others treat possible worlds as a separate domain within a single realm (i.e., classical possibilism).

[15] "On les quitte brutalement, en pleine action" (*Trois Versions* 20).

[16] "HENRI: J'ouvre.

Inès, Hubert, Sonia et Henri dans la salon. Les deux invités picorent divers met froid . . . posés sur un plateau" (*Trois Versions* 25).

[17] "Douceur du ton" (*Trois Versions* 59).

Chapter 3: Possibilist Staged Worlds and Collapse-Free Interpretations

John Mighton's *Possible Worlds* is equal parts murder mystery and metaphysical puzzle. The play opens after the murder of George Barber, whose assailant absconded with his brain. The lead detective, Berkley, launches his investigation with the gusto of a pulp fiction gumshoe. His theory? Someone at the university clinic stole George's brain for an experiment. The detective tours the neuroscience research lab at the local university, headed by Dr. Penfield. As Penfield expounds upon his theory of consciousness, he flaunts his many animal brains, each of which is suspended in a jar and bedecked with diodes. Despite Penfield's flourish of mad science eccentricity, Berkley finds no proof of wrongdoing. Still, his gut tells him to take a rat's brain (jar and all) as potential evidence (26). His partner, Williams, charts a stranger course: he registers for a cognitive improvement class, The Consciousness Revolution, to enhance his imaginative faculties and thereby visualize the murder (34). But George's case inaugurates a rash of similarly grim executions, whose crime scenes baffle the detectives. There are no signs of intrusion, the craniotomies leave no "abrasions" on the skulls, the victims' homes "were locked from the inside," and so on (12, 47). The body count climbs, and the investigations falter.

George dies before scene 1, but half of the play's action follows him. His scenes are not in analepsis, however: instead, we witness a handful of the other lives that George could have lived. In each, he meets Joyce, who is his wife in the world of his murder. In one world, he is a shy insurance analyst, and she is a cold neuroscientist; in another, he is an overconfident stock analyst, and she is a hotblooded day trader. These two Joyces (of several) lead unrelated lives with incompatible birthplaces and histories. George's history changes scene to scene as well, but (unlike Joyce) he remains cognizant of his alternate lives. In fact, he experiences continuity of awareness as his consciousness shifts between an "infinite number of possible worlds" (23).

Without provocation, George explains, “I feel my properties melting, everything I’ve ever known or felt . . . but after a few moments, I become adjusted . . . I take on [a] new life” (40). His experiential continuity inspires him to seek behavioural continuity, and thus he searches for Joyce in each new world. However, Penfield routinely interrupts this quest. In scene 9, the doctor guides George to a strange, alien world and explains:

> [PENFIELD:] Some biologists believe that mental processes create a field of information. . . . I’m going to kill you. In every world.
>
> GEORGE: But I haven’t done anything.
>
> [PENFIELD:] You will. (43)

Thus, the play presents additional detective work for its audience: what will George do in every world? Each story culminates in either violence (e.g., “*George puts his hand over [Joyce’s] mouth”* [65]) or the implication of violence to come (e.g., “*George moves towards [Joyce]”* in anger [59]). Early in the police investigation, Williams reveals that his George “and his wife had a big fight minutes before the murder. . . . She walked out on him” (32). At the moment of his death in that world, George was livid. Does Penfield slay every George to protect the Joyces? After George assaults an unfamiliar Joyce, he is placed under psychiatric care and waits for another world shift. In his intake interview, he confesses to Penfield: “when I believed I had a soul, I was imprisoned in myself, I felt I had to be consistent among my lives. But now I realize they’re all different. . . . If there’s a unity that makes them all me, I don’t know what it is” (66-67). After George accepts his discontinuity, Penfield releases his quarry. In George’s next and final scene, he finds himself on a peaceful beach with his perfect, passive Joyce.

As George struggles to decipher his existential lot, Berkley declares the investigation hopeless. Their foe walks through walls and steals brains through wizardry. His and his partner’s

plight is like that of the rat's, he opines, which cannot "foresee what its enemy [is] going to do" because it is "limited by the structure of its brain" (60). However, Williams refuses to relent. He travels to Penfield's lab to return the rat's brain and ask for guidance. There, Berkley's original hunch bears unexpected fruit. Williams stumbles into the lab as Penfield lies suspended in a sensory deprivation tank. A rat's nest of wires tethers him to George's brain. Through this science fiction apparatus, he shocks George's brain, and that current generates hallucinatory moments of consciousness. George's many worlds are nothing more than his subjective experience of electrical impulses. Penfield's deprivation permits him to entangle his brainwaves with the "field of information" surrounding George's and enter his worlds (43). George's metaphysical quest, the pattern of violence, and the Consciousness Revolution are nonfactors in the case's solution. Williams causes the climactic reveal by happy accident. Had he continued his old-fashioned investigation, Berkley would have solved the case.

The detectives close the book on the case, but the play's mysteries remain. George's scenes contain a cornucopia of red herrings. In each scene, someone refers to a duration of three days, weeks, months, or years (statistics and survivalists both have well-known rules of three); Penfield guides George to an earlier human experiment, yet George was the first victim; George tells Joyce that he has shifted between worlds since he was a child; and so on. Stranger still, Penfield's arrest fails to explain the incredible crime scenes in the detective's world. How did he pass through walls, steal brains, freeze a man to death at room temperature, and so on? There are clues in George's scenes that point toward the play's conclusion, but they only introduce more complications. For example, George's worlds repeat a motif of rainfall, beaches, and glass (in dialogue, props, and sound effects). As one Joyce jests, a glass bowl "could have been a beach" had the sand remained sand (56). By the same reasoning, it could have been a jar. In her analysis,

Jenn Stephenson argues that these motifs reflect the components of George's brain jar at different states of composition ("Metatheatre" 85-86). But this reading abandons the detectives to the same existential mire because their world repeats the same motif. That motif compresses at the end of the play, constructing a repeating pattern across worlds: George assaults a Joyce on a beach in scene 15, Berkley returns from a beach vacation with his wife in scene 17, and George spends scene 18 on a beach with Joyce. If the rainfall, beaches, and glass allude to containment, then the detectives too may be trapped in Penfield's experiment—sufferers of an altered reality. By extension, the audience is mired as well. We are all brains in vats, and the play's entire plot is only the agitations of our brain chemistry. We never see the actual world of the play.

Of course, the audience never sees the actual world of *Possible Worlds* (or any other play) because no such thing exists. Like George's lives, the staged drama is a kind of virtual reality: a fiction induced by actors and props. George's worlds and the staged worlds enter their respective audience's brains as electrical currents (through diodes or sensory organs) and construct a provisional reality. In performance, the Georges share an actor, but the material condition of the stage does not force those Georges to share continuity. After all, an actor may play Richard III in one performance and Hamlet in another. Mighton's list of dramatis personae reinforces this fact: we are told that the "small roles can be doubled. The doubling need not be heavily disguised" (9). When Penfield blinds his own senses, he removes himself from the world and enters the space of unactualized possibilities. He lingers in that liminal place until he coaxes George to accept his position as an actor who takes on new roles in new contexts. In short, he steps outside the logic of drama and enters the guiding domain of playwrights, directors, and audiences. There he remains until he finds the right performance for George. Mighton's conclusion is rife with metatheatrical implications, and one explanation for Penfield's impossible

murders remains. He commits them because they are written in the script. Mighton is his accomplice, and he stole our brains for ninety minutes of performance.[1]

Possible Worlds displays eerie similarities to some of quantum theory's more infamous interpretations. For most agents, the play's worlds lack causal interrelations: their actions in one world do not influence the others. However, each world is causally indebted to a superior reality: the spectator's actuality, which Penfield inhabits via the sort of theatrical logic that has been exploited since the Renaissance stage.[2] In emphasizing dynamically isolated worlds, *Possible Worlds* partakes in a possibilist performance ontology. In the metaphysics of modality, possibilism is the stance that possibility represents a distinct mode of being, with its own kind of reality. In other words, anything that is possible *is* real, but it is not actual. I argue that some contemporary plays stage possibilist worlds, which separate possibilities into isolated contexts. Perhaps they utilize abrupt transitions between scenes, stage the performance throughout different physical locations, cast multiple actors for the same role, or interrogate the division between reality and fiction. Each world follows the conventions of plot and character and proceeds causally toward its conclusion, but the play's reality, as a single staged event, offers no closure. Each George loses his Joyce, but inconsistencies between Georges and Joyces rebuff our attempts find a precise meaning in the pattern. Likewise, any given George can only decipher the situation in his world. No cognitive improvement course offers salvation.

The worlds of these plays reflect those interpretations of quantum mechanics that treat the quantum state (i.e., the mathematical description of a quantum system) or more specifically its wave function (i.e., the mathematical formula that relays the evolution of the quantum state) as a superior reality. Following Hilary Putnam's lead, I collect this group as the *collapse-free interpretations of quantum mechanics* ("Philosopher" 626). As my first chapter elucidates,

quantum systems appear in two modes: first, quantum states evolve linearly (i.e., deterministically) through time, per the associated wave function; second, the wave function *collapses* (disappears) whenever we measure the system. In collapse, a (quasi) classical object discontinuously emerges somewhere within the boundaries described by the wave function. In all interpretations, the wave function collects many possible outcomes. However, according to the collapse-free theories, our world could have only experienced the outcome that did indeed occur. The particle never discontinuously emerges after collapse: beforehand, it was merely hidden. In short, these other possibilities were never possible *for us*. However, they are still real possibilities, as the mathematical formalism dictates. While few philosophers argue that collapse-free theories treat the quantum state as a possibilist entity, they certainly share possibilism's general contours.[3] Furthermore, plays like *Possible Worlds* share this structure. The worlds that house George's lives are distinct systems. Characters are bound to one world unless, as is the case with George, Penfield's supernatural and super-dramaturgical guidance shows them the superior reality. Possibilist worlds in performance demonstrate the sheer volume of possibilities but bind us to a single outcome.

The following chapter navigates this convergence between contemporary theatre and a branch of atomic physics. It begins with a history of dyadic ontologies in theatre and physics (i.e., ontologies with two modes of being). I treat two scientific paradigms and theatre practices: Platonism and Cartesian dualism. In both cases, a dyadic worldview influences theatre criticism and making. Neither of these histories is explicitly possibilist, but Platonism and Cartesianism are possibilism's antecedents. Here, the methodological concerns of Chapter 1 are extended into questions of ontology. This chapter then outlines the ontological commitments that follow these collapse-free theories. The *many-worlds interpretation* suggests that the wave function of the

quantum state represents the true reality, which collects myriad actual worlds. Quantum strangeness reflects our inability to determine which branch of the wave function (which world) is ours. *Pilot wave theory* instead argues that a single branch of the wave function represents the world, but the empty branches are still real (if anemic). I examine these paradigms through two plays: Nick Payne's *Constellations* (2012) and Jennifer Haley's *The Nether* (2015).

1. Possibilism

As Timothy Williamson explains in "Bare *Possibilia*," possibilism is the stance that "if there *could have been* something that *was* such-and-such, then there *is* something that *could have been* such-and-such" (257, emphasis added). In other words, if we agree that something could have existed (but does not), then that thing must have some kind of *being.* As Bertrand Russell summarizes, this stance distinguishes between "*Being* . . . which belongs to every conceivable term, to every possible object of thought . . . [including] Numbers, the Homeric gods, relations, chimeras" and "*Existence.* . . [which] is the prerogative of only some amongst beings" (449). Succinctly, everything that is concrete (that which is actual) exists, but "being" extends beyond existence. The set of beings includes all of actuality *and* the near-infinite other entities that could have been but failed to obtain concreteness.

As a modal ontology, possibilism simplifies the actual world by exiling everything that could have been into another realm. Modal statements refer to the realm of *possibilia*, but our experience concerns only *actualia*: simple, concrete, material things. For example, consider the counterfactual statement "there could have been unicorns." My intuitions say this statement is true: given a different evolutionary story, we could have had horse-like, one-horned creatures. If I want to explain this intuition without *possibilia*, I might need to find some actual being that

could have been a unicorn and then say, "this could have been a unicorn" (see Chapter 4). However, if I accept *mere possibilia* as beings, my intuitions latch onto a new target: the set of real entities called *possible unicorns.* If we grant the reality of *mere possibilia* and distinguish them from *actualia*, then we have a simple foundation for our modal intuitions.

Thus, possibilism divides reality into two categories: actual things and possible things. Only the former is sensible, but the latter remains reasonable. The different possibilisms share this picture, but there are two divergent ontologies. Classical possibilism (which has roots in Plato) argues that possible entities only possess an anemic mode of being. A unicorn *is* but does not *exist*, as Russell outlines. This stance attracts numerous detractors and few contemporary defenders. Willard V.O. Quine's criticism is most influential: in "On What There Is," he dismisses the distinction between *being* and *existence* as wordplay. The second version of possibilism arises as a solution to Quine's charge: David Lewis's idiosyncratic extreme possibilism.[4] At first blush, Lewis agrees with Quine. *Being* and *existence* are obtuse linguistic categories. Where Quine dismisses *possibilia* through this argument, Lewis avers that possible and actual entities partake in the same mode of being—actual existence. However, the pair dwell in spatiotemporally isolated realms, or possible worlds.[5] To be clear, the term *actual* retains its ontological heft in Lewis's picture. But his *actual* is an indexical term, like *here* or *there*. When we say that an object is actual, we are stating that it exists in our world (i.e., it is here). Other possible worlds are actual from their indexical perspectives. They are vibrant places that exist exactly as we do, just over there (*On* 1-5). We could never visit these worlds, but they are real and, therefore, we can reason about them. Many thinkers reject Lewis's radical ontology, but his approach has undeniable advantages. It accounts for modal reasoning without introducing new modes of being, and it reduces modal reference to a case of indexical language (*On* 69-86; 92).

Few contemporary logicians dispute possibilism's utility. It explains contingency and counterfactuality without abandoning strict determinism at the macroscale. If the universe is absolutely deterministic, then the statement "there could have been unicorns" seems to be false. Chemical reactions have dutifully followed clockwork laws since the Big Bang, and that causal chain led to this unicorn-free world. Modal actualists deviate from determinism (ever-so-slightly) to explain how there could have been unicorns, but possibilists can retain total mechanicalism. The actual world could never have had unicorns because it is deterministic, but unicorns still *could have existed* because they live in an extended reality (in other worlds or as *possibilia*). This approach salvages two opposing intuitions: the world is deterministic, and things could have been otherwise. However, it clashes with a third. According to possibilism, my life could not have gone otherwise. For example, if I intuit that I could have skipped breakfast this morning, I am wrong. Strictly speaking, my breakfast was ordained by fate. But there exists another version of me, who did skip breakfast. My modal reasoning is sound, but I am not reasoning about myself. Rather, I am referring to one of my *counterparts:* a distinct entity who is nearly identical to me but lives elsewhere (*On* 192-209). Whenever we explore counterfactuals from a possibilist perspective, we speculate about something's counterparts and never its actual version.

Both the indexical theory of actuality and counterpart theory have influenced literary studies. Lewis often turns to fiction to expound his ideas, especially in "Truth in Fiction." Moreover, a spate of narratologists transformed the possibilist approach into a system of literary semantics (e.g., see Ryan 646). Yet theatre seems resistant to possibilist accounts. Perhaps something essential to the artform resists this kind of plurality.[6] Romantic dramatists may think of playwrights as Lewisian explorers: like Dr. Baliardo in Aphra Behn's *Emperor of the Moon*, the intrepid dramatist spies another world through a magical telescope. And theatre scholars are

familiar with the semiotic notion that actors represent fictional individuals in performance. They stand in for their fictional counterparts, and their bodies function like logical variables. But, unlike a written name or logical note, theatre's vivacity in performance resists any attempt to erase its materiality. Perhaps a skilled actor could disappear into Lady Macbeth, but that would be a short-lived exception, not a rule. Spectators cannot help but recognize the actor as a real person occupying space, just as the spectator could (see Chapter 2). Unsurprisingly, the history of possibilist theatre is fraught, populated by dramaturgs who struggle to force a rift between the dramatic world and reality. On stage, possibilism walks hand-in-hand with illusion and artifice.

Possible Worlds exemplifies and exploits the tensions between a possibilist ontology and the liveness of theatre. Mighton's dramatic career reflects his MA in philosophy and PhD in mathematics: his plays investigate the history of astronomy (*A Short History of Night* [1992]), chauvinism in science (*The Little Years* [2013]), counterfactuality in memory (*Half Life* [2005]), and the boundaries of identity in math and language (*Body and Soul* [1994]). As Stephenson notes, *Possible Worlds* weaves together his myriad interests by combining René Descartes's evil demon in Dr. Penfield, George Berkeley's immaterialism in George's experience, and Lewis's possible worlds to examine "how worlds . . . are constructed in perception" (74). She concludes that *Possible Worlds*'s metatheatrical touches expose theatre as an extension of our brains' metonymic, world-modelling biases (74-78). In short, *Possible Worlds* explores the limits of cognition and the boundaries of personal identity.

The play separates its six (or more) worlds into distinct threads, relayed through short scenes. Spectators have two primary means of distinguishing between worlds. First, Joyce's disposition signals the world of a scene. The first Joyce is an antisocial scientist; the second is a gregarious day-trader; another is a married swimmer; and so on. Furthermore, each Joyce was

born in a different city to different parents, and thus they evince incompatible histories. Clearly, they do not represent possible ways a singular entity's history could have gone, but they are distinct individuals, bound by a counterpart relation. In Lewis's system, we affix a provisional essence to an entity to test if subsequent entities are its counterpart. In other words, we pick and define a core feature and then search for beings that share it. This essence is not metaphysical but conventional. In the script, Joyce has a traditional variable: a name, which immediately indicates that a being is Joyce. However, George (more theatrically) defines Joyce through her present body, not her history, personality, or career. Spectators, of course, will likely follow George's tactic. This choice is more than a material necessity of live performance: it advances the plot. In scene 15, George assaults a woman on a beach to expose the "mole on [her] shoulder" and thereby prove she is Joyce (65). The woman is certainly Joyce-bodied because she shares an actress with every other Joyce. Thus, George (and likely the audience) accepts her as Joyce's counterpart without further proof. George fixates on Joyce's body as if it were a variable, regardless of its value (e.g., her personality). The lack of consistent values for this variable leads George to recognize his variability and embrace his discontinuity.

Second, spectators are able to distinguish between worlds because Joyce's scenes are separated by scenes in which she is absent. The oscillation forces spectators to regularly re-acquaint themselves with the pair. The plot parallels this process, and spectators watch George and Joyce meet for the first time again and again. The first four George-Joyce scenes open with a meeting. The motif (which lasts until scene 15 of 18) encourages the spectators to stage the world anew each time the pair appear. For example, scene 2 opens with:

> *JOYCE sits readings a paper in a crowded restaurant. GEORGE enters . . .*
>
> GEORGE: Do you mind if I sit here?

JOYCE: No, go ahead.

GEORGE: There's no place else. (13; stage directions omitted)

Scene 4 inverts the same general dialogue:

GEORGE is drinking in a crowded bar. JOYCE enters . . .

JOYCE: Can I sit here?

GEORGE: Sure.

JOYCE: This place has gotten pretty popular. (21; stage directions omitted)

Mighton toys with this process. By scene 6, spectators have seen multiple Georges and Joyces and are thus primed to expect a new pair. Then, George once more approaches her in a crowded restaurant, and scene 6 repeats scene 2's dialogue almost verbatim. Just as spectators are misled into misidentifying this scene as a duplicate, the repetition is exposed as George's awkward joke. Scene 2 and 6 share a world and a Joyce. Mighton asks spectators to embrace discontinuity and then reveals how continuity between scenes is an artifice, not a structural element of theatre.

After scene 6, worlds reappear across multiple scenes. Scene 2's George returns in Scenes 6, 9, and 11 and stays "passive–like smoke" throughout his relationship with that Joyce (45); scene 4's George returns in Scenes 9 and 13 and ultimately threatens an unfaithful Joyce. By returning to Georges and Joyces, Mighton allows these snapshots to accumulate into lives. Because each world is its own distinct context, each has its causal plot. In one world, George teaches Joyce (neuroscientist) to relax and embrace life's grey areas; in another, an obsequious George alienates Joyce (stockbroker) and repels her into an affair; and, of course, in another, two sleuths investigate George's murder. Each world has multiple scenes that lead into one another, with individual climaxes and resolutions that move forward per the dictates of drama. If we take each thread as an independent actuality, then *Possible Worlds* resolves multiple deterministic,

cause-and-effect plots. However, from the spectator's vantage, which reveals many worlds, the play as a single event fails to connect its various dots. In other words, there is indexical completeness to each staged world, but the spectators' "supernatural" viewpoint, a basic context of theatre, prompts a destabilizing experience.

Finally, *Possible Worlds* struggles against theatre's materiality. First, the play strives to convince spectators that each scene follows different characters despite the shared actors. Theatrical artifice helps differentiate between characters with costume changes, lighting shifts, voice-overs, and so on. But our cognitive faculties cannot help but interpret a body as a consistent entity. Mighton embraces this challenge and pushes his spectators to acknowledge that actors play distinct, unrelated characters throughout their careers. Penfield and his victims abandon their actual bodies to embrace that lesson, but spectators must instead confront the notion through metatheatre. In scene 9, George describes the process of "melting" between worlds to Joyce. As he details a world of monsters, "*[t]he lights fade on JOYCE, who remains upstage"* and the action shifts into his memory (41). George and Penfield converse in a strange land, and then the "*[l]ights rise on JOYCE.* [*PENFIELD*] *exits. JOYCE stretches as if waking*" (43). During the retreat into George's memory—effectively a play-within-a-play—the staged world shifts. This scene offers the only staged transition between worlds. Mighton continues the pattern of separating George-Joyce scenes with Joyce-free scenes (via the interstitial memory), but, in this instance, Joyce remains visible. The moment succinctly undermines the theatre's ability to separate levels of reality by adopting the conventions of the memory play, where unused characters fade from the action without abandoning the stage. These conventions are brazenly artificial compared to the play's otherwise realist staging, and spectators cannot help but recognize the physical presence.

However, when Joyce reactivates, her actor, playing a new Joyce, acts as if she were waking from a night's rest. The new world coincides with a new day, and this blurred boundary—day and world, artificial freeze and realistic awakening—returns to the play's realist commitments. From our conscious perspective, what is a new day but a new world, separated from the old by a strange memory? George, however, remains cognizant during the memory play and realistic drama, and this "kind of fluctuating dream state" situates him in the supernatural, liminal space between a one-world frame and the miasma of possibility (70). He dwells in the liminality of metatheatre, and Mighton embeds this metatheatrical tension at the play's heart. Penfield's name is another evocative example. When he first meets George, his name is Guide, who (according to the stage directions) is "*played by the scientist*" (41). In the detectives' world, Penfield's dialogue is attributed to the scientist (25). The name Penfield appears only in the metatextual element of the dramatis personae, nary a line attributed to him.

In summary, possibilism is the stance that possible things are real. Of course, philosophers disagree about the exact sense in which they are real. When a possibilist says that things could have been otherwise, it is a sleight of hand. In our actual world, things could not have gone otherwise. However, everything has counterparts for which things did indeed go otherwise. This move saves determinism and sets logical operations on firm ground, but it also abandons the intuition that we have freedom. Many literary scholars embrace an implicit possibilism: words on a page represent characters in another world, which is a sort of counterpart to our own. Moreover, that other world represents its own actuality, with its own counterfactual worlds around it. In theatre, possibilist staging conventions combat the stage's material presence. Because actors stand in for their counterpart, theatremakers must separate the actor's body from the continuity of the fiction. Though explicit possibilism is a more recent invention, the history

of philosophy and theatre both evince possibilist antecedents. Like many philosophical stories, it begins with Plato.

2. Possibilism and theatre history

Plato never elaborates a metaphysics of modality, possibilist or otherwise, but his work acts as a precursor to possibilism in metaphysics and theatre. Nicholas Rescher suggests that

> [t]he fountainhead of subsequent discussions of nonexistent [possible] individuals is found in the dialogues of Plato . . . [who] espoused the Parmenidean view that all meaningful discourse (*logos*) must be *about a being*. . . . [Possible beings therefore have] a mode of being that is intermediate between the actually existent and the utterly nonexistent . . . [and] Plato did not hesitate to draw this consequence. (166-67)

To be clear, contemporary possibilism is broadly incompatible with Plato's metaphysics. However, advocates still recognize a Platonic connection (see Cresswell 136; Mondadori and Morton 238; Nowak 276-82). Like some Platonists, possibilists approach the mind as a "special, albeit spooky, kind of telescope," which spies beyond the cavern walls of actuality into the heavens of possibility (O'Leary-Hawthorne 187). Similarly, many quantum physicists are taken by Platonic metaphors (e.g., Rovelli 43-44). Furthermore, Plato is a force in the history of theatre, both for his polemics against the art and his experiments within it. In the sixteenth century, René Descartes revised Platonic dualism, relocating the divide. He situates the *res cogitans* of minds on one side and the *res extensa* of matter on the other. In doing so, Descartes bridges Platonic (and Neoplatonic) thought and the possibilist metaphysics of his intellectual descendants. The next section examines this history, to demonstrate how the possibilist quantum theatre belongs to this lineage of aesthetic experimentation.

2.1. Platonic idealism and the function of theatre

An undeniable flair for the dramatic burns in the heart of the Socratic dialogues. Of course, they provoke their readers with ethical and metaphysical arguments, but they also present Athenian social life, develop nuanced characters, and trudge toward tragedy in Socrates's execution. Yet the antitheatrical tradition in Europe also begins with Plato's works: the *Symposium,* the *Republic,* and (most influentially) the *Laws.* In *The Drama of Ideas: Platonic Provocations in Theater and Philosophy*, Martin Puchner dissolves this apparent contradiction by positioning Plato as a reformer, not an opponent, of theatre. In that light, Plato's dialogues exemplify a radical new dramatic paradigm, which stands in opposition to his character's antitheatrical invectives. Plato's Socrates rejects theatre for its misleading materiality (as Chapter 4 discusses, the prevailing dramaturgy in Socrates's day was staunchly actualist). Plato's dialogues offer a vision of theatre that distances spectators from corporeality and provides tools to set higher truths before the mind's gaze. In short, the Socratic dialogues prefigure possibilist poetics. Moreover, this aesthetic project stems from his dyadic metaphysics.

Plato may not offer an explicit ontology of modality, but the *Sophist* and the *Theaetetus* both affirm the distinct reality of nonactual beings. As Plato lays out in the Sophist, "[w]hen we say something is not, it seems, we're not saying that it is the opposite of what is, we're just saying it is different" (257b1-5). If something is intelligible, it is, in some sense, real.[7] However, Plato does not seek to decipher mere *possibilia* but the Problem of Universals: what feature of reality renders similar things (e.g., two pomegranates) similar and distinguishes things from one another (e.g., oranges)? Put differently, how do two entities share qualities, and why do different entities share different qualities? After Aristotle, such qualities are known as *universals*. Everyday objects (*particulars*) seem comprised entirely of universal qualities. If we somehow

removed redness and roundness (and seediness, and so on) from a pomegranate, nothing seems to remain. What then, makes it a pomegranate?

Plato's theory of Forms defines the nature of these universals. Reality is bifurcated into two realms, one of which contains the objects of our senses, and the other contains the objects of our intellect. In daily life, we navigate the sensible realm of transient things. When we theorize about patterns and truths, however, we turn our mind's gaze toward the superior realm of universal, ideal Forms (*Republic* 508a-509a). These Forms populate a (Platonic) heaven, where they bask in the light of the Form of the Good Itself. The sensible realm, in contrast, is a puppet-show of ever-changing shadows, cast upon a cavern wall. Because we are sensitive creatures, we impulsively gaze at the shadows. Plato's metaphysics thus relies on an antitheatrical metaphor: people are spectators, condemned to watch a performance instead of reality itself. The philosopher's mind's eye gazes instead at the illuminated Forms. These Forms are not picturable but intelligible to reason alone, as mathematical laws (*Phaedo* 99e-100b). Thus, Attic tragedy presents Plato with an awful spectacle. The Good life is spent contemplating the Forms and attaining knowledge, but theatre directs the spectator's attention on the contingent, the particular, and the imagistic and thus occludes the Forms (*Republic* 606a-607c). It must: we engage with tragedy through our lower senses such as sight and hearing, whose domains are particulars. Moreover, actors are themselves composed of shadowy copies of many Forms (humanness, maleness, and so on). Theatre shadows a shadow in shadows and traps its spectators.

If we follow Puchner and embrace Plato as a dramatic reformer, then his dialogues model a new genre that addresses this ethical failing. Tragedy emphasizes a cause-and-effect plot to maximize the *katharsis* of emotional responses. The tragic protagonist's actions bring an accidental downfall, and spectators thus recognize the particular causes. Instead, Plato's

dialogues meander through looping, unfinished conversations, whose argumentative turns offer a "proliferation of reversals and recognitions." Furthermore, his dialogues lack any tragic dread because we know that Socrates dies a model of virtue. As Puchner summarizes:

> Plato thus interrupts the different dimensions of drama in order to dislodge the materiality of the theater, turning that materiality into something much more detached, removed, mediated, and unstable. . . . His dialogues [can] be used to point to . . . forms. These . . . forms, in turn, are never presented by themselves. They arise from the materiality of the theater precisely when this materiality is drained of its solidity and stability . . . (25, 33)

He thus advocates a theatre that turns spectators away from its materiality. The dialogues themselves include fictional spectators, who intrude upon the inquiry. The interlocutors imagine one of Socrates's thought experiments and extrapolate from its implications to grasp a Form. Plato's actual spectators enter the chain: they imagine the dialogue's realistic social situation, then imagine the thought experiment, and then they contemplate the Forms alongside the orator. They enter into the fictional argument and activate their reason. Because Plato places Athenian life explicitly in the same system, he encourages spectators to then turn toward the Forms in daily life. In summary, Plato utilizes detachment and mediation effects to focus spectators' attention on their rational faculties instead of their sensory experiences.

Plato's theatre thus asks an audience to consider the worlds that lie beyond our spatiotemporal context. Because the nonactual heaven of Forms is superior to actuality, he condemns mainstream theatre as infelicity's handmaiden. Plato's dramatic worlds await the spectators' rational telescopes, and, when the spectators imagine these worlds, they step closer to the more real world beyond. Thus, the Socratic dialogues prefigure a possibilist stage aesthetic.

2.2. Descartes and the world of the drama

Like Plato, Descartes advocated a dualist ontology that engendered a radical dramatic paradigm. As Stephen Buckle traces in "Descartes, Plato and the Cave," the former's ontology evinces a "broadly Platonic nature," and his metaphors and terminology are largely indebted to Plato (301). "In fact," Buckle argues, Descartes's *Meditations* is consciously "*modelled on* the allegory of the cave" and aims to modernize Platonic metaphysics (325). Like Plato, Descartes distinguishes between corporeal things, the "objects of the senses," and intellectual things, the objects of "thinking and willing" (302-05). These entities exist in separate realms, and subsequent thinkers advanced the classical model of possibilism on this division. Descartes's "broadly Platonic" system splits from Plato's, of course. His division suggests a theatrical paradigm distinct from the Socratic dialogue, though one that is equally invested in distance. The Socratic dialogues construct "detached, removed, mediated, and unstable" worlds and encourage the spectators to attend to the Forms. In contrast, Descartes-influenced playwrights sought to protect the sovereignty of spectators' "thinking and willing" souls. To this end, they treated the staged world as a separate system, whose machinations the spectators spied from afar. These distant worlds evince an explicitly possibilist performance ontology.

Following Plato, Descartes argues that, if we want to discover the true nature of things, "the mind must be turned away carefully from sensible things so that it can perceive its own [incorporeal] nature as distinctly as possible" (*Meditations* 27). At a glance, the structure of Descartes's ontology and his recommended conduct converge with Plato's, though their dynamics depart. First, the realm of Forms is an unchanging world, populated by a limited set of perfect prototypes for all universals. In contrast, the realm of *res cogitans* is populated by entities who are partially defined by their duration because they change. After all, *res cogitans* is

populated by minds, who, unlike Forms, are agential subjects. Second, the material objects of *res extensa* have no causal link to *res cogitans*. For Plato, Forms cause the properties of particulars. A pomegranate is red only because it partakes in the Form of Redness Itself. For Descartes, material things are instead defined by spatial extension and nothing so arcane. In other words, *res extensa* does not rely upon *res cogitans* for prototypes. Third, because *res extensa* and *cogitans* lack a causal relationship, they require God's unifying grace. God designed human minds so that we could capture in thought the material world's essence, via the "key to the real": mathematics (Buckle 310). Human minds, *res cogitans,* are thus coupled with an extended body, *res extensa*, by God. This structure again strikes a possibilist note. Descartes posits a realm of immaterial yet transient entities, which is available to thought alone, and a physical realm, which is an entirely mechanical collection of extended objects. Thus, Cartesian *possibilia* rest in the *res cogitans*, as a kind of object of thought. In his *Essais de Théodicée* (*Essay on the Problem of Evil*), Gottfried Wilhelm Leibniz formally extends Descartes's project into possibilist metaphysics. He imbues *possibilia* with ontological legitimacy as God's thoughts, which dwell in the infinite possible worlds He thinks but never actualizes.

Moreover, Cartesian metaphysics offered theatre's critics the vocabulary to voice long-rehearsed concerns. If the mind shares a connection with the body, and if the body influences the mind through sense-perception and imagination, then, when spectators perceive nefarious actors, it infects their minds. For example, if a spectator sees an actor cry for fictional reasons, the spectator's passions are inappropriately agitated through an intersubjective line, which runs from the actor's mind to his body, then to the spectator's body, and then to her mind. To be clear, Descartes was no enemy of the theatre himself: he extols intersubjective exchange as a formative educational experience (see Gobert, *Mind-Body Stage* 42). But moralistic playwrights promoted

a dramaturgy of detachment on the back of his concepts. They strove to construct an "entirely different world" on stage, which was grasped by the spectators' mind but did not stir their bodily passions (38). In *The Mind-Body Stage: Passion and Interaction in the Cartesian Theater*, R. Darren Gobert identifies key features of this dramaturgical style, which collectively develop a possibilist ontology of performance. First, "perspectival stagecraft . . . not only disciplined audiences into a singular perspective oriented toward a vanishing point . . . but also separated the theatrical milieu into two distinct ontological spaces, those of the play world and the real world," thus constructing the staged world as mere *possibilia* (36). Second, architects utilized fixed-direction seating to direct the spectator's gaze toward that *possibilia* and not one another, through a "vantage point [that] passed through an elaborate and visually assertive proscenium arch, which we can liken to . . . the lens of a telescope" (140). Third, directors adopted a style that treated characters as "two-dimensional textual construct[s], awaiting animation by the actor[s'] agency" and actors as "celebrit[ies] . . . [with their] own mental landscapes or interiority" (107, 87). These advancements erect an artifice between the spectator's actuality and the play's internal dynamics. They treat the stage space as a representational tool that points to a detached possible world.

This Descartes-inspired dramaturgy retains traces of Platonic poetics. The Socratic dialogues were not fully staged, so Plato's worlds formed in the "distinct ontological space" of reason and imagination. The dialogues promote thoughtful engagement instead of the tragic *katharsis* of pity and fear. As Gobert explains, Descartes-inspired playwrights offered a *katharsis* of wonder instead of such volatile emotions. Wonder inspires no bodily agitation and thus prompts no intersubjective danger. Understood as a sense of awe in the face of something new, wonder is "conditioned anew every time it is experienced": therefore, "all who feel wonder are

compelled to engage reason in order to judge whether the wondrous stimulus is beneficial or detrimental" (63-64). Wonder engages the reason, per Plato's dictates.[8] In both cases, spectators have individual, mental access to staged *possibilia*.

Mighton's *Possible Worlds*, which tackles Descartes's philosophical project directly, takes yet another possibilist path. The brain-in-a-vat thought experiment functions as a contemporary version of Descartes's deceitful demon, inserting itself between the *res cogitans* and *res extensa* and lying to the former about the contents of the latter (75; see also Putnam, *Reason* 5-21). George's mind can be dislodged from a particular corporeality, and thus he enters a series of possible *res extensae.* Surely, Descartes would balk at the notion of multiple (unrelated) realms of *res extensa*. He would likely opine that each of George's worlds is an illusion, generated by the impish Penfield. When Leibniz inaugurates the first theory of possible worlds, he concludes that God could logically only have sufficient reason to actualize one world (238-44). *Possible Worlds* also traces Platonic provocations. The detectives think that Penfield needed George's brain for his mathematical knowhow, and the play suggests that George shifted between worlds before his murder. If the magical telescope of the Socratic dialogue spies a superior reality, and the distancing telescope of the Descartes-inspired theatre safeguards individual autonomy, then *Possible Worlds* offers an unflinching possibilism where no reality within the fiction is superior. The possibilist quantum theatre situates one world as among multiple, and in doing so, it implicates the spectator's actual world in a relational chain.

3. Collapse-free interpretations and contemporary theatre

Quantum mechanics would appear alien to Plato and Descartes, but its reliance on mathematical formalisms should strike a chord with both. When Werner Heisenberg examines Plato's metaphysics in *Physics and Philosophy,* he concludes:

> The elementary particles in Plato's *Timaeus* are . . . not substance but mathematical forms. . . . In modern quantum theory there can be no doubt that the elementary particles will finally also be mathematical forms, but of a much more complicated nature. The Greek philosophers thought of static forms and found them in regular [geometric] solids. . . . [In atomic physics,] the mathematical forms that represent the elementary particles will be solutions of some eternal law[,] . . . some quantized nonlinear wave equation for a wave field[,] . . . not any specified kind of waves or particles. (45-46)

Plato's Forms are perfect, prototypical, and eternal, but the forms of atomic physics are solutions to changing, proliferating, and evolving mathematical functions. Plato's Forms reside in a superior realm, peopled by, e.g., a perfect triangle, a perfect square, a perfect chair, and so on. Quantum theory's forms instead offer probability densities in the physical world, not rational prototypes. Descartes also understood mathematics as the key to reality, but, unlike Plato, he extends mathematics to the essence of *res extensa.* In Descartes, Heisenberg sees the "complet[ion]" of Plato's project, yet he rejects Descartes's "metaphysical realism" about physical objects (52, 57). Descartes equates matter with spatial extension, but quantum theory categorizes spatial extension as a special mathematical solution. Compared to Cartesian certitude, quantum theory allows only practical realism: our picture of reality is contingent on our vantage. Ultimately, "we cannot disregard the fact that natural science is formed by men. Natural science does not simply describe and explain nature; it is a part of the interplay between

nature and ourselves" (55). Our method of questioning presupposes what sort of results constitute an answer. Experiments glimpse a sliver of the real, but science cannot describe reality with Descartes's divinely granted certitude.

The various interpretations of quantum theory reach beyond Heisenberg's cynicism and try to offer a more robust metaphysics. As I tackle in the first chapter, two mathematical rules lay at the centre of quantum theory. First, there is the Schrödinger equation, or wave function: a linear (i.e., deterministic) equation that describes how a system in a quantum state evolves through time. Second, there is the Born rule, which assigns probabilities to outcomes based on the amplitude (crudely, troughs and crests) of that wave function. Thus, quantum theory concerns entities in a quantum state, and it describes these entities as a sort of wave that evolves through time. As an entity's quantum state evolves, the matter associated with that particle seems to smear through space[9] along those crests and troughs, where (perhaps?) we ought to find more and less matter. The situation seems unimaginable. Indeed, Heisenberg agrees with Plato and Descartes—the fundamental reality of the quantum state is impossible to picture. Our perceptual apparatuses have evolved to decipher matters on our scale, at which the observable features of reality never "smear." Because our perceptual capabilities limit our cognitive ones, mathematics offers our only inroad into this situation (*Physikalischen Prinzipien* 7; see Chapter 2). By way of metaphor, quantum mechanics thus suggests that the fundamental form of matter looks more like an electromagnetic field than an object.[10]

Consider a man who stands at a crossroads, who may continue east or west. In ordinary quantum theory, we say he exists in a *superposition* of possibly heading east and possibly heading west. If we describe his state with a wave function, then he goes both directions, and he collects more branching options at each subsequent fork in the road through time. Thus, our

quantum traveller's matter smears across an expanding set of trajectories through time (west-west-west, west-west-east, west-east-west, and so on), as dictated by the wave function. Eventually, this system could encompass the entire universe, fork by fork. According to the formalism, this description of our traveller is genuine and accurate. If another quantum state journeyer meets our traveller, she will act as if the first traveller inhabited every possible path within his superposition from every possible path in her superposition. The two will become entangled, and their combined wave function will evolve together. In daily life, we never meet anything in a quantum state. I do not appear smeared through space; rather, I appear localized at some place and time. Were I to meet this hypothetical quantum traveller, he too would snap into place at a single locale. More formally, when we measure an observable of a particle, its quantum state disappears the instant the measuring device enters the boundaries described by the wave function. A familiar entity instantly and discontinuously appears: a localized, physical particle. This quantum leap generates some very odd effects. Were I to interact with the smeared traveller's wave function at the point west-west-west, he may localize at a completely different crossroads east-east-east. I would have no indication we ever met.

This issue is known as the *measurement problem*: why does a particle's wave function "collapse" when we measure it? The measurement problem represents quantum theory's interpretive battleground. Throughout the twentieth century, thinkers have proposed myriad solutions, the most tantalizing of which are realist. Per my first chapter, scientific realism is the position that our observations and measurements connect to reality in some sense. In other words, our measurements are not mere artifacts of our operations but are measurements *of* something else.[11] A scientific realist interpretation of quantum mechanics must (1) account for the reality of the wave function; and (2) explain why everyday life is devoid of superpositions,

despite their reality. Thus, quantum theories must commit to: either an *actual* wave of smeared matter that extends through space and then collapses into a particle; or a wave entity that is distinct from the localized particles. The former explanation, *collapse theory*, correlates to actualist performance ontologies and takes centre stage in Chapter 4. The second explanation, *collapse-free theory*, understands collapse as an illusion generated by our ignorance of the quantum state's true ontology. Defenders might balk at any charge of Platonism, but collapse-free theories have a Platonic and possibilist character.[12] The following section examines two distinct interpretations: the many-worlds interpretation and pilot wave theory. Both suggest that the wave function represents a real entity, to which we have access through rationality alone.

3.1. Nick Payne's *Constellations* and the many-worlds interpretation

The many-worlds interpretation of quantum mechanics is perhaps the most evocative interpretation of atomic data. In *Making Sense of Quantum Mechanics*, Jean Bricmont inventories four incompatible versions of the many-worlds interpretation (200-12). I focus mostly on the "naïve Many-Worlds interpretation" because it is the most widespread in popular culture (200). The basic structure of many-worlds interpretation is quite elegant. If the wave function is "truly fundamental" to reality, then it must be "physically real" and "ultimately apply to the entire universe" (Saunders 1). Thus, as Simon Saunders explains in "Many Worlds? An Introduction":

> without making any additional hypotheses, there follows a conservative picture of the small macroscopic, consistent with standard applications of quantum mechanics to the special sciences, a picture that extends to the biological sciences, to people, planets,

> galaxies, and ultimately the entire universe, but only insofar as this universe is one of *countlessly many others, constantly branching in time, all of which are real.* (1-2)

Where other interpretations of quantum mechanics add entities (such as particles), rules (such as collapse), or features (such as spontaneity) to the universe, the many-worlds interpretation posits that quantum theory already represents a complete description of reality. The wave function is a purely mathematical, god's eye view of absolute totality. From that position, there exists not one local actuality but an ever-branching multiverse. As co-founder Bryce Dewitt describes: "[t]he universe is constantly splitting into a stupendous number of branches . . . [and] every quantum transition taking place on every star, in every galaxy, in every remote corner of the universe is splitting our local world on earth into myriad copies of itself" (161). Thus, when our quantum traveller could go east or west, the entire universe splits into World-E, wherein he heads east, and World-W, wherein he heads west. From a god's perspective, the multiverse evolves deterministically. Everything that could happen does happen—though perhaps not in our local experience. When a scientist "sees" a wave function collapse, that collapse is merely phenomenological. At the beginning of the experiment, she does not know which world will be her own; after the experiment, she knows that she is in the world where the electron appeared there, instead of the worlds where it localized elsewhere. She moves from world-ignorant to self-located within one branch of the multiverse.

Thus, Saunders forwards, "the collapse [of the wave function] is indeed only 'effective.' . . . [It] reflects . . . the change in dynamical influence of *one part of the wave function over another*—the *decoherence* of one part from the other." Thus, the universe splits into "worlds [that are] not spatially, but *dynamically* separated" (4-5). These decohered branches are the worlds of many-worlds interpretation, which Saunders defines as "dynamically robust patterns in

the wave function, obeying approximately classical equations" (5). Once branches have decohered, they share no causal relationship with each other, but each world is actual from its perspective (and the universe's). Certainly, this description echoes Lewisian possibilism. Both theories understand reality as a set of near-infinite worlds, one per possible result, which are dynamically isolated. But the pair are not identical. Lewis's possible worlds are divided by an infinite and unbridgeable spacetime gap. They never overlap or share events, only counterparts of events. The worlds of the many-worlds interpretation, however, coinhabit a universal spacetime. The decoherent branches share universal configuration space even after they lose causal interrelationships. Nonetheless, if two things share the same spacetime but cannot influence one another, they inhabit unique spheres. On these grounds, thinkers like Saunders strive to wed the pair ("Chance" 197-98; see also Wallace 68; Hawthorne 146). The many-worlds interpretation suggests that, whenever we detect the wave form of an atomic entity, we glimpse a more fundamental reality: the quantum state that collects all worlds.

The many-worlds interpretation seems more compatible with theatre than Lewis's worlds. Staged worlds share a space (the stage) and often a time (the performance) but diverge in their dynamical relationships. In one scene, a George meets Joyce; in the next, a different George meets strange aliens; in the next, yet another George undergoes a psychiatric evaluation. These worlds share a single spacetime and wave function, *Possible Worlds* and Penfield's manipulations, but are dynamically decohered. Beyond Mighton, a spate of contemporary theatremakers explores the ramifications of this worldview. In one stage space, they offer a quick succession of dynamically distinct worlds, each of which dwells in a different branch of one system. Most often, as with *Possible Worlds,* a romantic relationship takes centre stage. These plays expose a tension between our experience of free will and the determinism of the universal

wave function. In quantum terms, these plays inscribe a quantum state of superposed worlds. The spectators' superior perspective allows them to see that there is no free will in such worlds. From the standpoint of the individual characters, however, the impossibility of self-location offers the illusion of free choice. Payne's *Constellations* is one such play.

Payne quickly rocketed into the annals of brainy British dramatists. *If There Is I Haven't Found It Yet* (2009) launched his career with a thoughtful analysis of apocalyptic obsessions, then *Wanderlust* (2010) turned a critical eye on the tumultuous intersection of social custom and desire. As Vicky Angelaki describes, Payne thematizes "relationships, one's place in the world, the private and social impact, or lack thereof, of our choices, as well as the ways in which individual lifestyles have direct bearing on others' quality of life" (*Social* 13). Because he presents "the spectrum of choices . . . as much infinite . . . [as] predetermined," his plays deftly balance a sense of resignation and resilience across from the sheer vastness of possibility (124). He takes an economical narrative (e.g., a relationship) and connects it to an uncaring, macroscopic system. This interplay between choice and fatalism has ramifications that echo beyond the individual to the society, the world, and the many worlds beyond. His breakthrough play, *Constellations* follows British dramatists such as Michael Frayn and Tom Stoppard by tackling quantum theory directly. Where Stoppard's *Hapgood* (1989) explores wave-particle duality, and Frayn's *Copenhagen* (1999) examines the uncertainty principle, Payne turns to the macrostructural element of wave function interpretation.

Constellations explores the branching possibilities that stem from a chance encounter. Roland and Marianne meet at a barbecue, organized by a mutual acquaintance, possibly once removed. After two lines, their relationship abruptly ends. Marianne introduces herself, but Roland rebukes her with a hostile "I'm in a relationship. So. Yeah." The scene cuts. In the next

line, Marianne introduces herself once more. Roland turns her down again, but more softly: "I've just come out of a really serious relationship. So. Yeah" (9).[13] The scene restarts again (and again). As different versions of the encounter proliferate, the play traces the many possible trajectories their relationship could take: they go on a single disastrous date; they have a serious relationship; they move in together; she is unfaithful; he is unfaithful; they break up; they stay together; they never meet again; they meet again, but the spark has faded; they fall back in love; they marry; and so on. Roland's career as a beekeeper anchors him to his tangible environment. Facing climate change and skyrocketing rents, he balances the relationship with environmental and economic realities. In contrast, Marianne's career as a "[t]heoretical early universe cosmolog[ist]" who focuses on "[q]uantum cosmology" encourages her to track dynamics in abstraction (21). Roland's eyes are on the actual, and Marianne gazes at the stars and myriad ways the early universe could have evolved.

At a glance, the play's scenes are Lewisian possible worlds. Each micronarrative is isolated and distinct, and we never explicitly return to a world we have seen before. Moreover, Payne painstakingly separates scenes into dynamically distinct bubbles. For example, the first two scenes repeat the same moment, but they are not divided between a "no" and "yes" branch to Marianne's question. Rather, the two scenes differ slightly on the histories that predate that barbecue. In scene 1, Roland is in a relationship, and in scene 2, his relationship has ended beforehand. The spectators are immediately asked to see each world as its own actuality with its own complete history, even if those histories share details. Unlike Mighton's explicitly Lewisian *Possible Worlds*, however, the worlds of *Constellations* seem to overlap before they split. The worlds on display were initially coherent, even if that moment lies before the action. Thus, Roland's (current or previous) relationship exists in every world. It must: that relationship

prompted his move to London (13-14). In other words, every Roland shares an initial node (his birth), and each life has branched since. As a result, *Constellations* evinces an inciting incident and a forward thrust despite its many-world structure and repetitive scenes. We watch the relationship progress along different branches. Scenes 1, 2, and 3 begin with Marianne's introduction, but scenes 4 and 5 begin later and later in that same conversation (9-15). In other words, Payne holds onto forward-moving dramatic momentum, which imbues the play with a more traditional dramatic character. George meets Joyce again and again, but Marianne and Roland's relationship skips forward with occasional backward trips.

The shared spacetime is more than a narrative convenience: as Marianne's career hints, Payne tackles the many-worlds interpretation explicitly. During their first date (in some worlds), Marianne describes her work to Roland: "[a] by-product of [quantum theory] . . . is the possibility that we're . . . [i]n the quantum multiverse [where] every choice, every decision you've ever and never made exists in an unimaginably vast ensemble of parallel universes" (22-23). From the initial conditions of that fateful barbecue, a wave function guides *Constellations* and presides over its decohering microworlds. Payne inserts new branching nodes later in the plot: their first date, an admission of infidelity, a ballroom class, and so on. Yet these worlds are still dynamically distinct, and so they do not influence one another. On the page, "*an indented rule indicates a change in universe"* (8). A distinct, horizontal line break cleaves worlds apart.

In the 2012 premiere at the Royal Court Theatre and the 2015 Broadway production at the Samuel J. Friedman Theatre, director Michael Longhurst represented the worlds in an abstract, quasi-mathematical manner. The Spartan set was dominated by several dozen white balloons, suspended from the lighting grid. When the play began, the balloons flickered on and off, an electric crackle of stark white. After a moment, an arrangement of balloons settled. When

the scene changed two lines later, the sounds of electricity again accompanied the flickering of balloons, which snapped into a new constellation. According to Angelaki, the notable productions of the play repeat this pattern: "sparsely decorated set[s], often featuring balloons alluding to the suspended nature of the characters' experience, but also to a multitude of possibilities, where existence is light, transient and contingent. . . . It is lighting and sound design that predominantly carry the weight of communicating changes and transitions" (*Social* 126). In New York, the balloons quite literally mapped constellations. They functioned like a truth table in modal logic, representing the possible properties for the set of Marianne-Roland worlds. A lit balloon signified a property's presence (true); a dark balloon indicated a property's absence (false). Each scene was thus a collection of relational properties, abstracted above in the design's binary language. This design partook in the representational artifice found in both Plato's dialogues and the Cartesian theatre. Moreover, the balloons offered a continuous reminder of the play's wave function: the guiding principles that generate each world, superior to the various microworlds of Roland and Marianne that appear throughout the performance. In short, Longhurst emphasized the tension between reality's vastness (the balloons) and the importance we invest in each moment (the live performance). Spectators, like the quantum physicist, glimpsed the truer reality in the logical arrangement of balloons, the succession of scenes, and the supervening structure of the play as a single function. But, as sensory beings, we are always pulled back into the immediate and actual.

As the play's universal wave function, the balloons were real, persistent, and ontologically superior. Yet the simple set and tight focus on two actors generated an intimacy that highlighted both the continuity of their space and their immediate actuality. Every world's distinctness ensures that they are mutually acausal but internally classical and dramatic. Scene

3's Marianne feels no animosity for Roland's rejection in scene 1 or 2. Those Rolands reject Marianne because he is in a relationship (scene 1) or hurt because of a recent break up (scene 2). Both follow classical causation, and we know the reason for the rejection. Yet, once Roland and Marianne become entangled, the Marianne-Roland branches of the wave function deterministically include every possible outcome for their coupling. When Marianne reveals her affair to Roland, she excuses herself on this universal determinism. She counters his request for an explanation with "[t]here's no linear explanation I'm afraid" (32). On the one hand, her comment gestures toward play's structure. Spectators cannot know the history leading to this event, because we spend but a momentary flash in each world. Her paramour's features even change between different versions of the encounter. A linear explanation is inaccessible. On the other hand, her comment stems from her work in quantum mechanics. She cannot offer a linear explanation because that explanation is a wave function that collects every possible outcome. If an affair is a possible outcome, then it will naturally occur in some branches. She cannot explain how they found themselves in a world in which she was unfaithful until she has self-located through her act of infidelity. By the laws of the universe, there are worlds in which she was unfaithful, he was, and both were. The specifics of her world elude her. Payne structures the play in agreement: we see these different outcomes without context.

Whenever the pair reaches an inflection point, spectators watch multiple possible trajectories. After Marianne's or Roland's affair, the pair serendipitously meets at ballroom class. The encounter proceeds in various ways: in some, they part ways immediately; in four, one asks the other for "one drink." In each, the proposer was also the dishonest partner, and again there is both a pattern and a sense of internal consistency. *If* Roland has had an affair and *if* that affair has ended, then he will try to reconnect with Marianne. From the superior vantage point of the

spectators, the deterministic outcome of their relationship is the complete set of every possible trajectory. But any given Roland and Marianne continue along one path, ignorant of the future. Worlds decohere and, as individuals, we are only conscious of our branch. However, each branch and the greater system are entirely deterministic: quantum chance arises when worlds decohere at inflection points, but any free choice is an illusion from ignorance. Or, as Marianne tells Roland, "[i]n none of our equations [in quantum mechanics] do we see any sign whatsoever of any evidence of free will" (24). Everything happens, and so choice is meaningless.

As with Plato's Socrates, the protagonists' deaths loom over the proceedings. Because there is a temporal thrust, every balloon will fade, and eventually, no branch of the universal wave function will include a Marianne and/or Roland. This theme interests Payne most, and mortality encroaches on their relationship early. Marianne is diagnosed with (often) terminal brain cancer. Hospitalized, she rejects the "garish fucking balloons" of well-wishers as a kitschy component of a ritualized death, and the constellation grows foreboding (63). The couple must come to terms with mortality across infinite possible worlds. Faced with a profligate universe, Roland challenges Marianne's worldview. He asks, "what's the point in me" (23)? If the universe is infinite, then we are restricted by the world into which we were thrown. Roland worries that, if one internalizes this cosmos, then cynicism is the only response. As he explains to a terminally ill Marianne, "I don't understand what happens when you know everything about everything . . . I don't understand how it helps. It's not gonna make this sort of thing any easier, is it?" Indeed, a disaffected cynicism festers in some Mariannes. Her affair stems more from nihilism than passion. But, in other worlds, she embraces her counterparts as a comfort. She tells Roland:

> I think it will [help console me] . . . Knowing that another me and another you could be on holiday. Or at home. Or in our seventies. Or parents. Or with my mum. Or at work. Or healthy. Brings me solace because . . . And I am sorry that we're here, but I promise you that another u—. (120)[14]

She cannot finish her speech before Payne abruptly cuts to another world. The "or" series may extend infinitely, never constrained by her completed utterance. Marianne understands that these counterfactuals are not available to this Roland and this Marianne; rather, she imagines her counterparts, who live happily with his counterparts. Yet, at the level of subjective experience, each world that includes Marianne's cancer also includes a Roland who suffers alone. Nothing they could have done would have changed their trajectory. Here, too, the constellation of multiverses expands in an unexpected direction: this exchange only occurs in the original British version. For the American audience, this Roland and Marianne never grace the stage, left to languish with the couples from unpublished drafts, revisions, and rehearsal room experiments.[15]

No Roland ever comprehends Marianne's worldview. As a layman, he interprets her explanations through the classical paradigm of free will and fate. As their relationships converge and diverge, the Rolands question how the many-worlds perspective interacts with personal accountability and fate. The tension is most apparent when Roland is across from an adulterous Marianne. After she explains that there is no reason for the affair, he retorts: "[i]f you'd said . . . it's because we don't talk about space enough, it might have made a bit more sense. I'd kick myself for not making more of an effort, but at least it'd make more sense" (32). He is concerned less with the act and more with the cause-and-effect reasons. Roland commits to his actuality and thus believes that she could have acted otherwise.

Similarly, he organizes his life around his choices: he struggles to pay rent in London because he decided to be a beekeeper, he decided he would not work for a big company, and so on. He understands his economic precarity as a result of his choices but takes pride in their ethical underpinnings. In short, his understanding of the world centres on his subjective self. But Marianne maintains that there is no "sign whatsoever" of free will. Rather, we are "just particles governed by a series of very particular laws." "Let's say that ours is the only universe that exists," she explains, "There's only one unique me and one unique you. If that were true, then there could only ever really be one choice. But if every possible future exists, then the decisions we do and don't make will determine which of the futures we actually end up experiencing" (23-24). The affair was the "one choice" that Marianne could make. However, a branching multiverse opens a space for luck, which correlates with Roland's understanding of free will. If we are lucky, we happen to find ourselves in a world wherein, after "rolling a dice six thousand times," we win the metaphysical lottery (23). Roland thinks the "decisions we do and do not make" are free will, but Marianne understands decision as quantum discontinuity. No matter how much knowledge one has, one cannot self-locate. As Saunders describes of the physics, this

> branching implies a form of "self-locating uncertainty"—uncertainty as to which branch is our own. . . . [Free choice] can at best be measured by statistics, and only then with high chance; they [those statistics] guide rational action in the same way that objective probabilities are supposed to guide rational action. ("Many Worlds" 23-24)

We must act as if we are causal agents and assume that the most probable outcome will occur. Marianne does just this. She maximizes her odds of finding herself in a world she desires: she is a well-published, successful scientist who works for a major university. But, with all her preparation and studiousness, precarity takes her, as it takes the riskier Roland.

Marianne's cancer becomes the unescapable boundary condition for all branches of the wave function. In the play's final moments, Marianne asserts her free will by opting for assisted suicide. The decision encapsulates the contradiction in her worldview: the wave function and her branch thereof are both deterministic, in that both will end in her death. Nonetheless, she "chooses" how to die. One could respond to the world of *Constellations* with nihilism. Instead, Payne's play ends by returning to the moment when the pair reunites at a ballroom class. From his naïve perspective, Roland asks her for a drink and tells her "if you change your mind and you wanna call it a day . . . you'll never have to see me again" (76). The promise is nonsense. Her counterparts are meeting infinite Rolands in every instant since the barbecue. But, when Roland fails to self-locate, he offers spectators hope: he can roll the dice and pray for luck. Payne seems to agree with Marianne that counterparts provide comfort, and the final scene escapes her cancer and returns to their infinite relationship. For us, that relationship never ends because we can always re-read the play and remount a production.

This proliferation of counterparts extends beyond the play. For the American publication, Payne cut significant portions of the script. The ending, which deals with Marianne's cancer, bears the brunt of the edits. The London version shows thirteen worlds in which Marianne is deteriorating; the American version shows five. Six of the cut scenes are single lines in succession: variations of Roland exclaiming "I don't want to talk like this" or Marianne pleading "[l]isten to me" (122-23). In London, these one-line scenes sent rapid-fire electric signals through the balloons, which recalled both Marianne's struggling neurons and the vastness of *possibilia*. The crackle grew threatening as, in every dwindling possibility, Marianne and Roland decohered. They decohere due to her death, but, moreover, her decision to opt for assisted suicide ensures that Roland can no longer understand her. The uncaring superstructure of

possibility, with its boundary condition of termination, looms over actuality. Where London's Roland's last line to a cancer-ridden Marianne is three frustrated variations on "I don't want to talk like this," America's Roland ends with a conversation about how he simply wants "more time" (74). In revision, Payne seems to have opted for the side of lived, actual experience. In either case, Payne ends the play on a paradox at the heart of human experience and the many-worlds interpretation. I intuit that things could have gone differently for me, but they could not have. I can only imagine other versions—on different branches of the wave function—for whom things went otherwise. In them, I am infinite; but in myself, I am locked to my isolated branch.

3.2. Jennifer Haley's *The Nether* and pilot wave theory

Advocates of the many-worlds interpretation celebrate its ontological simplicity, but many theorists reject it as absurd.[16] Opponents challenge the interpretation on both technical and intuitional grounds. What does "dynamic separation" in physical space *mean*? If, ultimately, the multiverse is a pure wave function, then what is matter, space, and time? And, perhaps the biggest technical hurdle, how does a branching universe interact with quantum probabilities? Thus, philosophers as divergent as Putnam and Nancy Cartwright reject the many-worlds formulation. Putnam summarizes the issue succinctly: "once you say that all possible outcomes are, ontologically speaking, equally actual . . . the notion of 'probability' loses all meaning" (629-30). Yet detractors such as Putnam are still drawn to the interpretation's ability to salvage determinism from the discontinuity often associated with quantum theory. If one hopes to eliminate collapse from a description of quantum mechanics, maintain strict physical determinism, and avoid a many-worlds framework, there remains an alternative: pilot wave theory, also known as de Broglie-Bohm theory or Bohmian Mechanics.

According to pilot wave theory, reality consists of two kinds of entities: particles and quantum states, which are described by wave functions. As a reminder, when a particle is in a quantum state, its matter mathematically "smears" across every possible trajectory it could take, until an event (a measurement) causes the state to "collapse" and the particle to localize. The many-worlds interpretation interprets the smeared matter as an indication of myriad other worlds, and collapse marks the moment when we decipher which world is ours. The other worlds fade from view, but they still actually exist. Pilot wave theory postulates instead that particles never transition into a quantum state at all: they are always actual, localized bits of matter. But the movement of these particles is choreographed by the wave function of the quantum state. Thus, particles do not adhere to the laws of movement described in classical physics but instead (metaphorically) wobble, following the troughs and crests of one branch of the wave function. As with the many-worlds interpretation, the wave function never collapses, and its infinite branches are equally real. However, "the only part of the wave function that matters as far as the motion of the particles [and by extension actuality] is concerned is the function in whose support the particles are actually located" (Bricmont 132). The quantum state ripples throughout all spacetime, but only one branch, our world, carries an actuality. The other branches are empty pathways. The wave function simply exposes our branch-ignorance. We cannot determine which branch before us is our occupied branch and which are those bare branches of *possibilia*.

Once more, we face an ontology with two modes of being: the quantum state's nonphysical, wave-like existence and the particles' concrete, material one. Furthermore, pilot wave theory describes two distinct realms. First, there is actuality, the single occupied branch of the wave function, which includes all the matter in the universe. Second, there are proliferating empty branches of the universe's quantum state, each of which offers a complete description of a

way the world could have been. Because pilot wave theories accept the reality of those empty branches, some critics of the interpretation (most vocal, David Deutsch) deride them as "parallel-universe theories in a state of chronic denial" (225; see also Valentini 477-80).[17] To be clear, the empty branches lack physicality, and the relationship between an all-guiding "pilot wave" and its causally inferior actuality evinces strong Platonic undertones. Like Forms, the quantum state of the universe causes the movements of the actual, and this causal relationship is unidirectional. As Bricmont, who advocates pilot wave theory, describes: the wave function of the quantum state "guides the motion of the particles, but is not affected by them. The quantum state is just *there.* . . . [And it] changes with time, even for an isolated system." He further opines that "one may have models of a quantum state for the universe that is static" in the form of universal law, elevating the quantum state to some eternity (180). In short, the quantum state belongs to a superior level of description, which guides the world and is accessible only to mathematics. Our lone concrete branch of the wave function is a trace of the overall wave function's total potential.

The pilot wave description is not explicitly possibilist, but they surely rhyme. The actual particles form the "fundamentally 'physical'" basis of actuality (180). The empty branches propagate, entangle, and evolve as if they had particles, but they do not. However, they are still real ways the world could have been. Had the particles been positioned otherwise, they would have moved along a different branch of the wave function, and thus a different state would have emerged. In the case that our particle heads west, it *could have gone* east, because the quantum state extends to the east and never collapses. In other words, the branches are worlds of mere *possibilia*, which exhibit an anemic mode of being. Our world is one possibility, plucked from the vast branching network of *possibilia*, but it is also the only actual world. If the many-worlds

stance offers a Platonic heaven stocked with infinite occupied caves, then, in pilot wave theory, all but one of those caves are empty. But the caves are still there.[18]

The structure of pilot wave theory is perfectly compatible with the theatre. Performance involves the physical world, staged *as if* it were another world through an apparatus. But the fictional world is merely a possibility, never occluded by the actual bodies and stage. A production has its own quantum state, entangling many pieces and imbricating their wave functions. The script, the directors, the actors, and the playwrights all pilot the material on stage, but ultimately the intersection of their intentions and actions becomes the sole position, realized before an audience. We can never know the exact initial conditions, but a night's performance develops from that place to an actualized staging. Other ways the performance could have gone linger like dead branches. In such a description of theatre, collapse is only apparent: the agents involved still have their motivations and intentions even after the show closes. Those same wave functions still pilot the play, night after night. Finally, the script itself presides over all else, a fact emphasized in Mighton's *Possible Worlds*. Penfield's electric pulses guide George's brain matter through reality's branches. Beyond Mighton, a spate of playwrights likewise questions theatre's ontological strata (e.g., script and performance, actor and character) to explore the intersection of a singular actuality, ghostly other worlds, and the forces that guide them.

Jennifer Haley's plays foreground theatre's ontological tiers to investigate the ethics of virtual realities. *Sustainable Living* (2011) draws parallels between geographical distance (as two different worlds) and the gulf between reality and reality television; *Breadcrumbs* (2010) treats memory as its own fantastical world, separate from the real; *Froggy* (2010) and *Neighborhood 3: Requisition of Doom* (2008) theorize the causal direction between digital worlds and actuality as the latter becomes increasingly laden with the former. Across this oeuvre, she questions the roles

of identity, agency, and continuity when new modes of being offer the individual incompatible pictures of herself. Each play stages a bifurcated world: a portion of the action occurs in the actuality of the characters, and the remainder takes place in the virtual space of a video game, television show, or memory. Unlike *Constellations,* Haley's plays lack a superstructure (i.e., the quantum multiverse) that contains parallel worlds. Instead, one world is nestled in another, often through play-within-a-play dynamics. By extension, she implicates the spectator's world as a yet more superior reality in this chain, which may too have its own superior. Her nested worlds may be hierarchical, but she investigates how human subjectivity misleads us, as characters accept their phenomenal experience and embrace an inferior reality as ontologically fundamental.

The Nether explores the ethical ramifications of such a world structure through nakedly Platonic interests. In the near future, business, education, and social life are conducted in "the Nether": a sophisticated virtual reality space, which is divided into "realms," each of which runs on a different physical server "in-world." Upon entering a realm, one creates a virtual avatar and must abide by its rules or risk expulsion. The play begins in a cold interrogation room. There, Detective Morris, an "in-world representative" of "an investigative unit of the Nether," interrogates Sims, the proprietor the Hideaway, a realm that encourages simulated pedophilia (12). The Hideaway adheres to a strict roleplaying code: participants must build their characters "from a set of prescribed 'looks,' and pass[] a draconian manners tutorial dissuading modern terminology." A successful applicant emerges into a "beautifully rendered 1880s Gothic Revival with a squeak in the top porch step" and must act as if it were of the period (12). Participants must also molest and violently murder the identical nine-year-old girls who populate it, or risk banishment. According to Papa, Sims's avatar, the Hideaway permits a "life outside of consequence" with consenting adults, after a totalitarian turn "in-world" (48). On the one hand,

Sims ensures that adults, his employees, pilot the children avatars. On the other hand, Sims's computer code is so proficient that his simulations are indiscernible from actual experience. Morris's investigation centres on Cedric Doyle, Iris's pilot. Doyle wants to cross over and become a shade, a person who lives exclusively in the Nether. If he becomes Iris, where does criminal responsibility for her rape and murder lie? Morris rehearses Platonic invectives against theatre. Does virtual activity encourage actual immorality? As the plot advances, Morris pries from Sims the location of his server, and the action oscillates between the interrogation room and the splendorous Hideaway.

The play resembles a Socratic dialogue. Three opposing sides debate the metaphysics of the virtual world and, subsequently, the ethics of engaging it. The debate focuses on the possibility of a virtual experience ascending to the actual (as Platonic mathematics, which the server code ultimately is). Morris opines that "God gave [us]" the actual world and our bodies. These gifts are divine because they contain the "materials of the earth" (62). Thus, she argues, "in-world" is a superior reality and the Nether is a shadow of shadows, peopled by literal shades. Sims disagrees. He argues that the Nether is not a shadow but a place that allows him to "be [his] fucking self" without harming others (19). For Sims, the Nether enables one to assimilate with his or her innermost identity. However, that essence is still connected to the real world, which remains ontologically superior. Rather than Plato's cave, however, the higher reality has become a poisonous land that "twist[s] people" and distorts their essential selves (62). Finally, Doyle argues that the Nether ascends the actual and assimilates with God, who he defines as "the way we are with each other," because it offers an experience of pure relationality without the interference of pesky identity (21). For Doyle, the particulars of actuality are corruptions: the Nether returns us to the pure relationality of unbridled *possibilia*.

Each debater accepts the Nether as the new "contextual framework for being," but they disagree about its causal relationship with actuality (17). According to Morris, the sensuousness of the Nether misdirects people away from valuable "in-world" pursuits. Thus, the Nether effects actuality. She worries, like Plato, that theatre misdirects one's reason. In contradistinction, Sims avers that each individual possesses a true nature, an essential identity. That true nature lies in a changeless eternity, which causes the actual, and the actual subsequently causes the virtual. But the Nether has no causal effects on the actual, and Sims cites studies that found no correlation between "in-Nether" and "in-world" behaviour. To cleanse participants of actuality's stain, Sims emulates the eternal and renders the Hideaway as a place where "[n]othing . . . can change. Which is a beautiful reflection of the way we are changeless" (21). Sims's argument resembles Plato's weaker stance in the *Ion,* where the muses guide artists to represent the eternal. Doyle's ontology, however, is more radical. He argues that the Nether's technology makes available to experience the purest form of reality—a relational, mathematical matrix that guides the universe. As computer code, the Nether strips beings of particularity and permits them to enter a different kind of changelessness, where they access the boundaries of all possible experiences. Thus, Doyle celebrates the "shades," who "cast off the limitations of physicality and become pure spirit" (37). For Doyle, the Nether's mathematical existence is not unlike the wave function to the physicist: it is a reasonable, accurate rendition of the superior reality, which captures a branching network of possibilities. Through a science fiction trick, technology allows one to enter the pure relations and access unactualized arrangements.

Throughout these debates, *The Nether* erects a border between its modes of being and questions how someone bound to these modes could distinguish between them. The virtual reality is piloted by the "in-world" reality and thus subservient to it. Nether realms depend on

physical servers, avatars depend on human pilots, and laws in the Nether depend upon the country where the server resides (16). This structure cosmetically recalls the pilot wave. Each realm is guided by a server, whose programming and legal jurisdiction set boundaries on the possible activity therein. But individual particles—participants—dwell in different branches of the virtual field of *possibilia*. Thus, Haley rehearses Platonic anxiety: what happens if the illusion becomes more vivid than the actual? As Morris explains, the Hideaway offers "sensations [we] can no longer experience in the real world," and Sims's code delivers these experiences with unparalleled sound, smell, and touch (30). Doyle's devotion to pure relation devalues sensation as "inconsequential," but Morris retorts that "[s]ensation is our gateway . . . [t]o understanding the rules of the world" (24). Likewise, the pilot wave is superior, but we only ever experience the inferior world of one matter-filled branch. Through sophisticated mathematics, the Nether makes sensible an ideal beauty that could be, but the actualized branch of *The Nether'*s reality lacks beauty. The "materials of the earth" have grown cold and ugly; as quantum-nauts, characters find refuge in the simulated dead branches.

Because it permits mathematical access to more vivid experience, the Nether coaxes participants' cognitive apparatuses to accept the virtual as superior. Haley leads spectators into the same confusion. The play evinces play-within-a-play dynamics, but the nested play is more vivid, more sensuous, and more theatrical. In its premiere at the Royal Court Theatre, Jeremy Herrin presented the two worlds in different styles. On the forestage sat a grey table and two chairs, which served as the interrogation room. Simultaneously realistic and dreadful, its proximity to the audience offered a heightened sense of immediacy. When Morris and Sims or Doyle debated ethics, they sat, static and stoic yet continuous with the spectators' space. The image encouraged spectators to view the interrogation as an extension of their actuality. Beyond

the forestage, however, a second stage hosted the Hideaway. Haley describes the virtual world as awash in a "ray of sunlight" (19), and, in that production, projections of leafed trees encapsulated a metallic cube that itself housed a warm and inviting Victorian room. As *The Guardian*'s Laura Barnett opines, the Hideaway offers "some of the best visuals I've ever seen on stage." The interrogation room was immediate, but the Hideaway was alluring. By positioning the Nether further from the audience, Herrin highlighted the ontological dependence of each deeper world on the former (the Nether, "in-world," the spectators' world). By elevating the Nether, the design also gestured to Doyle's more radical interpretation. Like mathematics, the computer code brings us closer to God.

Both in-world and the Hideaway are realistic dramatic worlds, beholden to the cause-and-effect sequences of realist drama. As Sarah Bay-Cheng notes in "Virtual Realisms: Dramatic Forays into the Future": "*The Nether* itself plays like something Ibsen might have devised had he written for the early twenty-first century . . . structured as a series of short sequential scenes, the play is both linear and explicitly causal" (690-91). Unlike the isolated bubbles of *Constellations* and *Possible Worlds*, *The Nether* maintains obvious causal interrelations between its worlds, and they constitute a single plot. However, in detangling the causal relationship between in-world and reality, Haley's sympathies seem to lie with Sims. He coded the Hideaway to abate his in-world pedophilic impulses: "no amount of cognitive behavioural therapy or relapse determent or even chemical castration will sway me from my urges . . . I am sick" (19). His eternal urges cause his activity. However, he decided to protect in-world children by redirecting his urges into the Nether. Morris's motivations are comparatively dubious. The play suggests that Morris is driven to steal Sims's unparalleled simulation. In fact, she never explicates whether she works in law enforcement (she never arrests him, after all) or corporate espionage. As in an Ibsen play,

Sims and Morris are both thrust forward by goals and ultimately antagonize one another. In short, the staged world of *The Nether* is classically deterministic, and distinct underlying wants motivate characters.

Despite these causal interrelations, Haley distinguishes between the virtual and actual modes of being. Sims and Papa share a single actor, but the other characters are performed by different actors across worlds. Morris's Hideaway counterpart is a man, Woodnut, and the middle-aged Doyle's is a nine-year-old girl, Iris. The dissimilarity between counterparts emphasizes the performative abstraction available in nested realities. Where *Constellations* and *Possible Worlds* track counterparts with a body, Haley is more interested in tracking "pure spirit": her characters' essences. Doyle embraces life as Iris because, through it, he experiences relations unavailable to his everyday body, relations which are only available to a girl, a child, a murder victim, and so on. These shifting relationships, shorn of the limits of physicality, permit him to approach the pure spirit of his guiding motivations. To stress the Doyle-Iris union, Haley demands that a child actress must play Iris. She notes:

> It is important to cast Iris with an actress who will appear on stage as a prepubescent girl. The child actor takes the audience *out* of the play[,] . . . which is desirable considering the content of her scenes. The audience is assured nothing awful will be enacted upon the child, whereas they have no such confidence with an adult posing as a child. A young actress also adds warmth, which is critical to the chemistry of the play. (66)

The play stages no scenes of molestation or violence because Doyle is not drawn to horrid spectacle. He seeks abstract relations, but a play cannot stage those. Haley posits that only a child actor can bring warmth and happiness to Iris's scenes, where an adult would prime the spectators to expect violence. The child also takes the audience out of the play, reminding the

audience that the embodied experience is itself a form of playacting. This uncomfortable disconnect—between the disembodied world of the Nether and *The Nether* and the manifestly embodied world on stage—generates unresolvable discomfort. There is no threat of real violence: these people are actors, who stand onstage before spectators. The girl who plays Iris plays her as entirely happy and innocent. This distancing effect throws into relief the similarities between the Doyle-Morris and Iris-Woodnut relationships. Morris remains enamoured of Doyle because of her time with Iris. Haley's world maintains strong essentialist undertones: Woodnut's interactions with Iris are a projection of Morris's and Doyle's true selves meeting.

The emphasis on an essential nature bleeds into questions of free choice. As Woodnut, Morris's desires and sense of fatalism are directly confronted. In the Hideaway, she experiences a loss of agency to the sensuous nature of the space and the role it requires. The first instance coincides with an utterly innocent scene. Woodnut (Morris) plays jacks with Iris, and he "*laughs, pleased with himself*" as he grows increasingly engrossed in the harmless fun. Eventually, he shakes himself of the illusion and mutters, "I have quite . . . forgotten myself" (29). He crosses the stage to the window to pontificate (an image straight from Ibsen) and "*the sunlight and shadow of leaves*" cast down upon his face (29). From Woodnut's perspective, he dwells in a real world with trees, warmth, and laughter. But his pilot (Morris) knows that this world is an inferior reality, guided by a server (her goal). Nonetheless, the illusion is so convincing that she succumbs to the space's claim on reality, as spectators are drawn into drama. Woodnut enters the rhythm of the place as a character; Morris says her lines and plays her role, even though she opposes the Hideaway morally, as an actor.

Eventually, Woodnut submits to the rules and violently murders Iris. Later, Morris defends herself to Sims:

SIMS: I don't force anyone to do anything . . .

MORRIS: It's here in the report. *What you made him do.*

SIMS: He got close to a little girl. He had sex with her . . .

MORRIS: He needed more information.

SIMS: He came back because he liked it. (44-45, emphasis added)

After the murder, Iris immediately reappears unharmed. Morris understands the Hideaway's combination of sensuality and lack of consequence as an infection, which obliged her to follow its dark laws. Haley, however, presents Morris as ignorant. In the end, she banishes Sims to an in-world existence. He warns her that "You don't know what you do, Detective, putting me out into the world," and her reply rings tone-deaf: "You are free to go, Mr. Sims. You are free" (63-64). Sims understands that, even in the actual world, he is guided by a superior force: his sick urges. Morris refuses to relinquish her faith in free choice as a fundamental feature of actuality. Her decision, Haley seems to suggest, imperils actual children and prompts Doyle's suicide.

Finally, the play's (divisive) epilogue highlights the metatheatrical face of virtual reality and cements Haley's ontological commitments. It explicitly affirms the hierarchical nature of *The Nether*'s worlds and thus rejects Morris's moral concerns. As the play's only nonsequential scene, a previous conversation between Iris and Papa replays with Doyle's and Sims's actors instead. The original scene was warm but unnerving. In the reprise, the scene's mood is unabashedly tender. The original scene cuts before Sims replies to Iris's "I love you," but the reprise includes Sims's response: "you cannot know how much I love you" (65). Doyle and Sims speak about love, trust, perfection, and eternity, and Haley implies that their "pure spirits" are indeed entangled on this unconventional branch of the wave function. Bay-Cheng complains

that, "[though] this may be reassuring to the morals of its audience, the epilogue works against the ontology for much of the rest of the play" (691).

A pilot wave reading of the play's causal structure concludes that the finale instead cements the play's ontology, albeit in a fashion that would still disappoint Bay-Cheng. Pure spirit, a wave of urges and desires, guides our movements whether our particles are material or magically in mere *possibilia*. Sims calls the pilot wave of human desire "the urge." He explains:

> Is it my problem the real world no longer measures up? . . . What are you afraid of? . . . The urge, Detective—the *urge*—as long as we are sentient, you will never stamp that out. . . . The point is—it doesn't matter whether you kill a boar or a demon. Whether you have sex with a child or an elf. It's nothing but images. And there's no consequence. (30-31)

Because the virtual is causally dependent on that same wave of pure spirit as the actual, it offers supernatural access to our nonphysical entanglements. In other words, the Nether makes tangible merely possible branches of the wave function as experiential mathematics. As formulas, even the worst desires find morally neutral expression. Haley entices spectators with the Hideaway's sensual theatrics. If we believe that our subjective sovereignty is unharmed by theatre, she suggests that we are obliged to agree with Sims despite his despicable character. Haley finishes the play without offering a concrete moral conclusion, but the apparent harm of Morris's actions—Doyle's suicide and Sims's banishment—intimates that, if we accept our fundamental lack of free will, we can neutralize the traumatic outcomes of our desires. Does Haley's theatre offer one such virtual space?

§

When George admits that his lives are "all different . . . If there's a unity that makes them all me, I don't know what it is," he enunciates theatre's dilemma for possibilists (66-67). Across roles, we often prize actors who disappear, whose celebrity vanishes beneath the heft of their disunited characters. Often, a commentator will praise actors as "chameleons" precisely because they proficiently disguise their actuality and stand in for some possible counterpart. But on stage, George *does* have an unavoidable unity: a spatiotemporal body, never occluded, no matter how extreme the stage magic. Indeed, worlds that try to establish a possibilist structure must rail against theatre's materiality: Plato fought tragedy with the disembodied dialogue, Descartes inspired theatremakers to twist the whole building of theatre into a refracting lens of vanishing points, and these quantum-aligned plays utilize short scenes, snappy transitions with electronic buzzes, myriad costumes, or different actors to stifle the spatiotemporal continuity that unites theatre viewership. In part, this problem is insurmountable: possibilism speaks about a world beyond our sensual experience, be it a realm of *possibilia* or other fully actual worlds. Likewise, both the many-worlds interpretation and pilot wave theory add a superstructure to our reality—the quantum state, described by a wave function—which is (by definition) beyond the scope of experience. To render such a thing cognizable requires artifice.

Mighton distinguishes between worlds by tracing George's quest via various Joyces, who act and are costumed differently. *Constellations* too embraces hard cuts between scenes, which tear the page with horizontal lines. On stage—in Longhurst's influential design, at least—the balloons, which illuminate the titular constellations, indicate the arrangement of a world with mathematical distance. *The Nether* utilizes two stages, dressed in different styles, and casts each character with multiple actors to emphasize the distinction between the two worlds. In each case, the worlds on stage *contain* possibilities that push the characters around. The characters

subsequently dwell in the world; they do not create it. The electrical impulses come first, a given George second; *Constellation*'s worlds fill the stage, but a certain Roland and Marianne step into their scenario; the code of the Nether links pilot to avatar. These characters are adrift and contained within an unfathomable cosmology. The system is vast, and so characters cannot locate their place within it: be that place George's perfect life with Joyce, Marianne's perfect life with Roland, or Sims's ability to slake his perversions without hurting anyone. Yet the universe is deterministic, and hopelessness seeps into the corners.

These plays enact different failures to self-locate among many worlds (be they vibrant or ghostly). First, the characters fail to determine which world is their actual world. George, Roland and Marianne, and the various shades of the Nether cannot distinguish between mere *possibilia* and their own *actualia*. Some are lost wanderers, adrift in this process (George, Roland, Morris), while others accept the self-location problem as a facet of reality (Marianne, Doyle). In any case, profligate worlds or their own cognitive apparatuses bar these characters from self-locating. Second, they are aware of the vastness of *possibilia*, but this awareness is only intellectual, and thus it offers no meaningful strategy for intervention. George may be mindful of his metaphysical plight, but he shifts myopically at Penfield's whim. Marianne understands the quantum science, but no understanding will prevent her untimely death; Sims recognizes the Nether's reliance on the in-world, and in-world's reliance on human desire, but that interdependence means intervention in-world destroys the Nether and leaves the guiding urge unaffected. As rational agents, each of these self-aware characters has only a single course of action despite the appearance of possibility. Finally, those characters who fail to recognize the vastness of *possibilia* cannot act rationally. The detectives fail to understand how Penfield (and Mighton) conduct their plots; Roland struggles to make sense of Marianne's plight; Morris's

unwillingness to accept the structure of her reality ends in suicide and the release of a pedophile. Of course, there is a contradiction here, because acting rationally does not matter in an entirely deterministic universe. Perhaps Mighton offers the cheekiest version of this lesson when the detectives solve George's murder by fluke.

Regardless, these plays offer something akin to quantum thought experiments. We see evidence that a bunch of things could happen, yet we only ever see the one thing at any given moment. Our notions of quantum states, other worlds, or piloted particles, however, plague us with knowledge that lies beyond our senses. Proof must be extrapolated from signs. But theatre is not purely rational. These worlds must struggle against the medium in which they dwell. These plays employ many theatrical tricks to convince spectators to see a many-levelled world on stage. But perhaps it is easier for theatremakers to embrace theatre's actuality and perform a quantum theatre of collapse.

Notes

[1] In "The Notebook and the Gun: Performative Witnessing in *Goodness*," Stephenson finds a similar technique at work in Michael Redhill's *Goodness* (2005). When the border between the fictional worlds on stage and the actual world are fractious, the audience enters the thrall of the playwright as much or more than the characters enter reality (see 118-20).

[2] Of course, Penfield's path is well trodden in theatre history. Alexander Leggatt's argues that Richard III's metatheatrical intrusions work in a similar manner in Shakespeare's play, deftly bridging the divide between performed world and spectator's reality (32-54). But Richard mediates between the world of the play and the audience's reality; Penfield mediates between the many worlds on stage and the audience reality.

[3] Few does not mean none. For example, in "Possible Worlds, Physics, and Metaphysics," Brian Skyrms directly relates this class of interpretations (most particularly, Many-Worlds) to possibilist metaphysics (most particularly, the extreme possibilism of David Lewis [329-31]).

[4] Lewis baptised his stance "modal realism," but he regrets the moniker. As he describes in *On the Plurality of Worlds:* "Had I foreseen present-day discussions of what 'realism' really is, I would certainly have called it something else" (viii). To limit confusion, I have opted for the more descriptive term *extreme possibilism* instead.

[5] Classical possibilism also talks about possible worlds, but their possible worlds are simply constellations, drawn between mere *possibilia*, which could obtain concreteness without contradiction (see Chapter 2's discussion).

[6] As Stephenson notes of Redhill's *Goodness,* stage directions can "present several options," but a performance selects one action, one action per night, or shows several in series. In any case, the effect is not the same. Here arises an importance difference between written and staged experiments in mere *possibilia* (118; see also Conclusion).

[7] Thus, in "On What There Is," Quine names the problem of modal ontology *Plato's beard*: "this tangled doctrine [that non-actual entities exist] might be nicknamed *Plato's beard*: historically, it has proved tough, frequently dulling the edge of Occam's razor" (21).

[8] Plato promoted the instructive power of thought experiments, but a Cartesian worldview treats the material world as God's gift, a source of endless awe that awaits our inquiry. And, even when Descartes himself advocates for the intersubjective mixing offered by an emotional theatre, his theory of emotions ties them to reason.

[9] Technically, the wave function presides over a configuration space, which describes the relationship between various observables of the system, and not physical space, which is (again, loosely) derivable from the information in the configuration space. Think about the fact that you can map anything on the *x*- and *y*-axes on a Cartesian plane (say, speed versus spin).

[10] Electromagnetic fields have many features a quantum state does not: for example, a source, and a complete configuration in three-dimensional space. But the analogy certainly helps (see Bricmont 133).

[11] Scientific realism embraces the same intuitions that motivate modal metaphysics, which aver that anything we can discuss must be, in one sense or another, real. One may think, by way of metaphor, that a modal realist is a scientific realist who accepts logical arguments as a form of measuring apparatus.

[12] Even interpreters who treat the wave function as a reality of mathematical objects (i.e., a Platonic heaven of sorts) or a guiding system that pilots particles around (i.e., a superior reality with a causal, mathematical link) understand the system as actual. But this is a problem of semantics surrounding the definition of *actual*. These other actualities are, in principle, inaccessible without mathematics yet real. For the purposes of a taxonomy of staged worlds, these descriptions are more reminiscent of possibilism.

[13] References to *Constellations* refer to the first American edition (2014) unless noted.

[14] These lines are only found in the Faber and Faber (British) edition of the script (2012). The line may have been cut due to the technical inaccuracy. Universal background time means that, in fact, there is no world in which the pair are in their seventies.

[15] Angelaki similarly concludes that "the depth of possibilities is never matched by a sense of intimacy in their relationship" because "[t]he superficiality imposed by the temporal constraints on each segment causes fractures to the overall feeling" (126-27).

[16] The many-worlds interpretation boasts more support from physicists than philosophers. In their poll of interpretations at a physics conference, Maximilian Schlosshauer et al. found that 18% of participants advocated the many-worlds interpretation, placing it third behind Copenhagen (42%) and information-based interpretations (24% [8]). Information-based quantum mechanics is a form of collapse theory (Chapter 4).

[17] As Valentini (who disagrees with the assertion) describes, many philosophers and physicists claim that "if one takes pilot-wave theory seriously as a possible theory of the world, and if one thinks about it properly and carefully, one ought to see that it really contains many worlds—with a superfluous configuration q [i.e., q='this branch has the particles'] appended to one of those worlds" (479).

[18] Plato's description of reality anticipates some features of the pilot wave picture. For example, in the *Sophist*, the visitor posits that, if one admits

> that among the things that are there is even a little bit of a thing without a body, that will suffice. What they need to tell us is what common feature is to be found equally among these things that lack body and those that have it, and allows them to say that both sets of things are. . . . [A] thing genuinely is if it has some capacity . . . either to act on another thing . . . or to be acted on, even to the slightest degree by the most trivial of things . . . what marks off the things that are as being . . . is nothing other than *capacity.* (247c10-e5)

Chapter 4: Actualist Staged Worlds and Collapse Interpretations

Roland Schimmelpfennig's *Idomeneus* offers a Nietzschean vision of the birth of tragedy. The list of dramatis personae contains only a chorus "of about ten to fourteen men and women . . . [though] it can be more or less."[1] When the play begins, they narrate the tragedy of Idomeneus's homecoming to Crete after his victory at Troy. A hurricane unexpectedly batters the king's fleet as it crosses the Aegean Sea. One by one, the waves swallow each warship until only Idomeneus's flagship remains. His men may have survived the decade-long war, but now "each one of one of them fights, kicks, / desperately / hopelessly / helplessly / for their lives, only for their lives, and yet they still die . . . drown, die – without discrimination, the young and old. It [the hurricane] takes each one."[2] However, the chorus tells us, Idomeneus refuses to die with his men. Instead, he begs the gods' clemency. Three choristers recount the divine response, which emanates from the storm: "What do you promise to do, / if you are spared, / if today you / survive, / then what will you do?"[3] For the first time in the play, a speaker uses a personal pronoun. Instantly, a lone chorister steps forward to answer that "you" as an individuated subject. The chorus brims with Dionysian potential: they shift between narration and imitation and speak as a sailor one moment and a storm the next. However, when an individual character emerges, he traps the play into the logic of drama.

The performer who now plays Idomeneus pleads for his life. If the gods spare him, he promises, he will sacrifice the first living thing he sees ashore. The hurricane acquiesces. Idomeneus survives. However, the divine pact binds him to the gods' tricks and drama's propensity to punish impulsive choices. Onshore, the first living thing he sees is his son, Idamantes. Because Idomeneus has spent ten years abroad, he does not recognize the child. As the horrified chorus details, Idomeneus wordlessly slaughters his victim (*Opfer*, meaning both

victim and sacrifice) and thus fulfils his promise. Idamantes's guards seize Idomeneus, hang him, and then skin him alive. These opening pages surely appease Aristotle's dramatic dictums. The play offers a textbook reversal. Idomeneus kills the youth to extend his own life, but instead, he guarantees his own execution and terminates his lineage. Furthermore, he experiences a concomitant recognition: when the guards seize him, he discovers that his victim was his son. But this Idomeneus does not wail or recant like Oedipus or Kreon. Rather, he begs once more. He begs neither the guards nor the gods but the chorus: "Why [*Wozu*] did I live and struggle if I have to die like this? I am not ready!"[4] He faces reversal and recognition but refuses to suffer the consequences of his choice. Instead of death, he wants another attempt at life. The action reaches a standstill, but a chorister eventually agrees that "that's not what happened." Soon, another member chimes in: "so, it did not happen that way." Encouraged by their metatheatrical intervention, Idomeneus declares that "[instead] it happened like this . . ."[5] The activity continues as if the last five minutes were never staged. This regression needs no stage magic because the chorus frames the preceding narration as a mistake. In the next line, Idomeneus recognizes his son after he washes ashore.

The sacrifice is postponed but not forgotten. Were Idomeneus to recognize his son, he would still need to sacrifice him as the first living thing he saw. Idomeneus confesses to his wife, Meda, that he owes the gods the boy's life. She convinces him to sacrifice Idamantes on a subsequent night, and these machinations end once more in Idomeneus's execution. Again, he refuses to suffer. Again, the chorus restarts the myth. Again, he relives. This pattern repeats, and *Idomeneus* develops into a performance about mythopoesis. In one variation, Meda convinces Idomeneus to spare the boy and incur the wrath of the gods; in another, Idamantes flees Crete with Elektra, and Idomeneus pursues the pair; in yet another, Leukos, Meda's lover, kills the

queen and usurps the throne. Each version culminates in Idomeneus's death, and each death stems from his pact. For their part, the chorus tries to instruct the king: we ought not to sacrifice another for ourselves. However, his greed, jealousy, and cowardice ensure that he will never regret his decision, suffer, or learn. As Schimmelpfennig himself explains in an interview with David Tushingham, the chorus becomes "bogged down in variations, but none of the variations offers a way out . . . the human sacrifices overshadow everything." But the chorus cannot talk forever. Like Idomeneus's army at sea, the performance must die, and the performers must rest.

In the final scene, Idomeneus yet clings to life. The tale returns to the beach, and a weary chorister suggests a "way out": Idomeneus first sees a dog instead of his son. However, others cannot abide by this finale because it rebukes the intention of the divine promise and the spirit of drama. Had it ended thusly, Idomeneus would have profited in ignorance. Another frustrated chorister narrates a scene where Idomeneus ignores the dog and guts, skins, and hangs himself instead. That impossible suicide is also "not what happened" because Idomeneus's selfish nature precludes self-sacrifice. The dog undermines dramatic law, and the suicide undermines his character. It becomes clear that Idomeneus does not desire a particular outcome. He will never be "ready" to die. In restarting the myth, the chorus gifts him that which he desires: furtive immortality, stretched across infinite stilted variations. He wants life's *potential*. A chorister becomes Idomeneus one final time and closes the play: "Life. / What a gift. / The waves. / / A promise is a promise. / / I am Idomeneus, / and I cling / / to life, / I cling / / to life." He repeats key phrases in a final act of prolongation, and the play reaches an impasse.[6]

In Soulpepper Theatre's 2017 production, the players found a "way out" by returning to the ecstasy of the dithyramb. After Stuart Hughes spoke Idomeneus's final words, the music swelled, and the cast erupted into a bacchanalian dance. They liberated the stage space from the

limited possibilities of drama and celebrated the raw potential of their bodies in that space. Then, the lights abruptly cut. The performance ended, and so died Idomeneus with *Idomeneus*.

This short reading of *Idomeneus* hints at the eerie convergence between contemporary theatre aesthetics and a strand of quantum theory. Through its morphing revisions, *Idomeneus* stages an actualist vision of reality. In the metaphysics of modality, actualism holds that the potential to-be-otherwise resides within actual objects. In other words, everything that is possible dwells within something actual, and actual things, therefore, *could have been* different. However, the context that surrounds an object limits its potential to a narrow set of possibilities: the possible worlds in which that alternative could have obtained concreteness. I argue that some contemporary plays stage actualist worlds, which concretize this potentiality within the bodies of performers and props. However, the conventions of plot and character (as well as physical laws) limit that potential. In *Idomeneus*, each chorister has, in fact, the potential to play Idomeneus: anyone could face the three performers acting as the hurricane, say Idomeneus's lines, and thus perform the role. Once a specific chorister becomes the king, however, his potential becomes limited to the possible lives which Idomeneus could live in a tragedy. That actor reclaims some potential when he resists this tragic fate, and the chorus retains its potential to shift the staged world. But the chorus cannot break the binds of drama or character. In the end, spectators merely glimpse potentiality in its fullness when the players embrace the explosive bacchanalia. At that moment, the fictional world seems to disappear, and the actors emerge, cleansed of character.

Plays like *Idomeneus* display an actualist performance ontology, which shares many ramifications with quantum theory. The worlds of these plays suffer from complications analogous to those in the *collapse interpretations of quantum mechanics* (*collapse theories*). Atomic experiments (and their interpretations) suggest that physical systems are ruled by chance

in one sense and linear in another. These two pictures of the same corporeal phenomena offer incompatible but valid descriptions of one underlying reality. According to collapse theories, an atomic entity's wave-like form collapses into a particle-like one under certain conditions. If this were the case, then an atomic entity's wave form would describe the evolution of its potential: the set of things it could be. Its particle form would correlate to the actualization of one such possibility. In other words, collapse theories forward an ontology where possibilities are real components of actuality, which disappear at critical intersections. *Idomeneus*'s performance ontology shares this structure. The play stages worlds that situate Idomeneus's potential-to-be-otherwise in the bodies and choices of actors and characters, but the play's patterns reveal the systemic limits of that potential. Idomeneus exerts his free will when he chooses to bargain with the hurricane and not die with his men, and the chorus exerts its own whenever it restarts the story. However, Idomeneus's character (the sort of person he is) and world (that of tragedy) limits him to a range of choices that end in suffering. Actualist worlds juggle these tensions (fate and free will, singular plot and multiple trajectories) without resolution.

The following chapter navigates this convergence between contemporary theatre and a branch of atomic physics. It begins with a history of actualist ontologies in theatre and physics. I treat two contemporaneous scientific paradigms and theatre practices: Aristotelian science and eighteenth-century experimental empiricism. In both cases, an actualist worldview influences theatre criticism and making. I then outline the ontological commitments underlying collapse theories. *Subjective collapse theory* suggests that subjective "measurements" are a primitive, irreducible fact of reality. Quantum strangeness would never collapse into an observable universe unless a subject interfaced with it. *Objective collapse theory* replaces measurement with randomness. Quantum strangeness collapses into tangible reality naturally, given enough time

and entanglements. I examine these paradigms across two very different pieces of theatre: Martin Crimp's *Play with Repeats* (1990) and Odin Teatret's performance *Kaosmos* (1993).

1. Actualism

Karen Bennett characterizes the actualist view "by means of the slogan 'Everything is actual.' [Actualists] say that there are not any things that exist that do not actually exist" (297). Actualism is the metaphysical stance that, if something exists, then it must be an actual entity. As a metaphysics of modality, actualism attempts to explain our implicit ontological commitments whenever we discuss possibility, potentiality, or counterfactuality. Unlike possibilism, which posits that some entities are *mere possibilia*, which *are* but *do not exist,* actualism preserves the intuition that the actual world is uniquely robust (see Chapter 3). However, actualists struggle to explain another widely held intuition: things could have gone otherwise. From the premises of actualism, it follows that everything which seems possible (could-be), counterfactually true (could-have-been), or contingently true (could-be-this-or-that) must either not exist at all or exist in the actual world. If these alternatives do not exist, then we have no metaphysical ground from which we can discuss alternatives. Subsequently, counterfactual speculation could not lead to knowledge.[7] If actualists wish to preserve the value of possibility (as quantum theory might demand), they must explain what possible things actually are. For example, consider the following counterfactual: there could have been unicorns. I intuit that this statement is true: evolutionary processes could have produced unicorns, had circumstances been different. Were I a possibilist, I could ground this intuition in my ontology: there is a *possible unicorn*, which is mere *possibilia* from my perspective but nonetheless *is*. As an actualist, however, I have two options: either my intuition is wrong, and unicorns could not have existed, or I must locate the

referent of the term *unicorn* somewhere in my world. If unicorns could have existed, and everything is actual, then it follows that some actual thing could have been a unicorn.[8] This quandary divides actualists.

Thus, actualists require a theory that explains the status of objects that do not exist concretely but seem truly possible. If no specific creature could have been a unicorn, the above counterfactual must be false. There could not have been unicorns. Philosophers offer multiple solutions to this problem, and their tactics share an essential feature: they explain how nonactual things such as unicorns could have existed by introducing an abstract kind in the roster of actual beings. For example, David Armstrong understands qualities like *being horselike* and *being horned* as actual entities (properties), which could be abstracted and rearranged to construct unicorns (possible entities).[9] Armstrong admits one kind of abstract entity, i.e., properties, but others are less parsimonious: for example, Aristotle posits nine distinct kinds of "non-substantial forms" in his ontology. Regardless, actualists who still defend modality often present a messy ontology: there are many kinds of things, all of which are actual.

If these possible entities (like unicorns) are explained via abstract entities (like properties), we must still clarify the circumstances that would have allowed the possible entity to exist. These alternative circumstances form the possible worlds of actualism. A possible world in this sense collects the non-contradictory relationships between objects that permit a possible entity to exist. Actualists construct possible worlds by rearranging the furniture of reality and producing alternative floorplans. We move the furniture around, deconstruct some pieces into their parts, and build new furniture from the material, but we must source everything from what already exists. However we ground their existence, nonactual things are possible only in floorplans (worlds) that accommodate them. This requirement inspires more questions, of course.

Were there unicorns, would there still be horses? Even if there could have been unicorns, they might not be possible in the worlds we can recognize. Perhaps every evolutionary story that permits unicorns bars humans. Whenever we explore possible worlds from an actualist perspective, we hold certain things constant and then adjust the world only as far as necessary to ground our speculations. Ultimately, we do not care if there could have been unicorns; we care if there could have been unicorns in a world that still included us.

Dramatic performance evinces an analogous interplay among the actual, the potential, and the possible. As Daniel Sack discusses in *After Live*, the bare stage possesses the potential to be many things. Once one sets anything onstage, however, the stage constricts to a narrower set of possibilities (1–20). Were an actor to step onstage, it would be no longer possible for that performance to go actorless. However, potential *actorlessness* (an actual abstract property) lingers as a broader possibility for space of that kind. Sack does not connect his description with the metaphysics of modality, but his account is solidly actualist. Furthermore, theatre deals with possible entities that have more life than linguistic markings (*possible unicorn*) or logical notes (◊U). The nonactual entities of staged worlds are fictional characters, locales, and objects. Tangible beings always contain the possible people, places, and things that the spectators watch: actors' bodies, sets, and stage properties. Actors act *as if* they had obtained qualities that they do not exemplify in daily life. They actualize those qualities and demonstrate that they are actual beings that *could have* those qualities. To this logic, Hughes never imitated a possible man named Idomeneus in Soulpepper Theatre's production of *Idomeneus*. Rather, he co-exemplified *Idomeneus-like attributes* and his own concrete body in actual space by acting *as if* he were Idomeneus. Each aspect of Idomeneus that he presented actually existed within him; otherwise, spectators could never perceive its staging. Furthermore, the staged world situates Hughes's

Idomeneus within a possible world of relations, produced by the actual components of theatre. In short, the material of the stage exposes its real potential to hold other possibilities. The apparatus of theatre seems perfect to explore actualist metaphysics.

Idomeneus helps clarify this intersection. The play's bald modality is unsurprising: Schimmelpfennig's plays routinely compress political, romantic, and mythic possibilities into the same space on stage. He toys with multiple possible versions of a single event in *Vorher/Nachher* (*Before/After* [2002]), *Ende und Anfang* (*Ending and Beginning* [2006]), *Hier und Jetzt* (*Here and Now* [2008]), and many others. His plays frequently "juxtapos[e] epic and dramatic representations of one and the same event, which denies us a coherent perception of one represented reality. . . . This theatrical strategy lets us reflect on what we hear, imagine what we are about to see, and review our own reaction to it" (Schreyer Duarte 103).

In *Idomeneus*, Schimmelpfennig imbricates many versions of a single story to examine mythopoesis as a process of selection. Each chorister offers a new version of Idomeneus's homecoming, but one theatrical event frames these versions as competing accounts. They hew one possible tale from the potential of Idomeneus's life, discard it, and then produce another. In doing so, they inscribe these possible lives into the stage space, and they whisk the action from a warship to a beach to a castle and back. They thus demonstrate the stage space's potential to be these places and the chorus members' potential to inhabit them. Furthermore, they entangle space's potential to *be ship-like* or *palace-like* with its potential to host many perspectives of the same moment in time. Because a different chorister prompts each revision, spectators confront the notion that each perspective constructs a different version of the same underlying reality. This kaleidoscopic effect motions toward the strange actuality from which every possible version of the story springs. At the play's 2014 London premiere at the Gate Theatre, director Ellen

McDougall emphasized this aspect of the performance in her design: the choristers were dressed as tourists, who earnestly competed to detail Idomeneus's grounding. As visitors, they are unfamiliar with the context of the homecoming. As observers, their diverse backgrounds (as tourists visiting from different locales) reinforces the unique situatedness of each vantage. As this design highlights, each spectator's perspective adds another possible version. Just as every revision begins with the hurricane and ends in Idomeneus's death, every spectator's recollection will begin with the swirl of activity and end with interpretation. As a result, the potential array of stories extends beyond the chorus to the spectator's cognitive faculties. As the chorus exposes their bodies' potential to inhabit possible versions of the same space, spectators are asked to question their own potential to dwell in different versions of the same event.

Because the play conflates perspective with the tension between actuality and possibility, *Idomeneus* explores how easily we adapt to new possibilities in a single actual world. The play's method of staging place exemplifies this theme nicely. At first, the chorus describes each environment thoroughly. When Idomeneus first washes ashore, several choristers struggle to convince the spectators that the stage space is empty: "a beach with nothing on [it] . . . Rocks, sand, stones, / Waves. Nothing else. A few trees . . . Not a lizard. Not a stray dog. Not a beetle. / Not even a single bird in the air. / Nothing, nobody there at all."[10] The negations ("not a" ["*keine*"]) may seem excessive. The stage is bare, after all. However, spectators will unconsciously inject features into any beach they imagine (e.g., cawing gulls or scuttling crabs). This aspect of cognition is unavoidable because we return to habitual images for cognitive primers (Chapter 2). Real beaches are not as empty as the play's mythical Cretan shore. Thus, the chorus toils to stage the beach as barren as the playing space and primes the audience to eliminate extraneous features from the audience's imagination. This request underscores how

swiftly we reduce a broad concept (the potential beach) into a single image (the possible beach we imagine) before we are aware. After the description, the choristers move *as if* they were on that rocky, empty beach—the burden of staging the world shifts onto the actors' bodies and the spectators' faculties.

Each time the chorus returns to the same environment, their description shortens. By the final monologue, the beach is curtly summoned with "that empty beach" and the associated movements ("Der leere Strand" [74]). In the penultimate scene, spectators anticipate the beach's desolation because of their prior experiences in the play. Then, a chorister adds a stray dog onto the beach. Because there was "not a stray dog" before, the spectators are primed to stumble over this hound. Before they can integrate the dog into their image and overhaul the world, the other choristers give voice to this discomfort. The spectators' cognitive faculties are again fully agitated. Then, Schimmelpfennig introduces Idomeneus's suicide in this window, which also breaches the laws of *Idomeneus*'s world. Radically revising the staged world, the play comments on Idomeneus's selfish character and demonstrates the spectator's' capacity to doubt their senses. When the chorus re-establishes the staged world for the last scene, the performance's actualist matrix expands to include the limits, too, of the spectator's cognitive faculties.

Finally, spectators witness how the conditions of tragedy restrict the stage's potential. First, the play curtails every chorus member's unique possibilities because the chorus never deindividuates. Historically, the Attic chorus was a group of male amateurs who surrendered their identity to masks. Instead, as Schimmelpfennig describes, *Idomeneus*'s "chorus no longer exists as a unit," but as a collection of distinct, unmasked individuals (Tushingham). Their individual qualities (i.e., gender, race, previous roles) never disappear from the spectators' cognitive frameworks. The play reinforces this fact by assigning lines to specific bodies. For

example, the first line in the play is spoken by "a man and a woman, both no longer young."[11] When a chorister becomes Idomeneus, his first line is attributed to that "man from the beginning" ("Der Mann vom Anfang"); later, that speaker is referred to as "The First Man" ("Der erste Mann"). Only a male-bodied performer, who is no longer young and spoke the play's first line, can obtain the quality *being Idomeneus*. Other actors retain the potential, but only he possesses the possibility.

Of course, character has inherent limits. Idomeneus, being the sort of person that he is, faces a particular set of possibilities. When he emerges, the first man answers the storm's "you [*du*]" with "I, I will" ("Ich, ich werde" [10]). *Werden* forms the future tense in German, but it also means "to become" when it lacks an infinitive. As Idomeneus promises that he *will* offer a sacrifice, the actor/chorister announces that he *becomes* a subject. He surrenders the subjunctive potential of the chorus and adopts the strict possibilities of character.[12] That actor never sheds the quality *could be Idomeneus*, even if he rejoins the chorus because the capacity to be Idomeneus attaches to his body and the spectators' memories. This process repeats as other characters (e.g., Idamantes or Meda) emerge. Despite the chorus's freedom, each member's actual body functions as a limit, of which character is the zenith. Nonetheless, the fourteen (or more) bodies on stage always indicate the breadth of possible stories that could dwell in that space, the perspectives that did not concretize.

Idomeneus is no uncomplicated celebration of storytelling. The story curtails each performer's potential, *Idomeneus*'s possible outcomes are trapped by the logic of drama, and Idomeneus is bound by his character. He may never recognize his fatal mistake, but spectators witness the limits of possibility, their capacity to impose limits in their cognition, and the enticing power of potentiality. As Idomeneus struggles to (re)live forever, the play suspends

restricted possibility and broad potentiality in an unresolved dialectic. In Soulpepper Theatre's production, they found a *katharsis* from this tension when they dismantled the representation through dance. As a spectator, I no longer expected Hughes to act *as if* he were Idomeneus. Instead, I only anticipated improvised movements in actual space. His body was free from drama's possibilities and able to explore his potential as himself.

In summary, actualism is the viewpoint that everything that exists is actual, and thus possibilities are anchored to actual entities. If an actualist thinker still accepts that things could have been otherwise, then she must find this possibility somewhere in the actual world. The various tactics to address this problem share similar issues. To save the intuition that the actual world is uniquely real, they ground the ontology of possible entities in the existence of some abstract entities in the actual world. Thus, we have one world, but it is messy. At a glance, theatre seems inherently actualist. Fictional characters are abstract entities: we reference them and reason about them, but they are not concrete. Instead, characters are bundles of qualities that inhere in actors. Whenever actors play characters, they find something of that character in their bodies. In performance, the players' bodies enter many relationships with space, stage properties, other actors, the text, the theatre, and conventions. Moreover, if a staged world seeks to resemble our cognitive and conventional expectations, a single body cannot co-exemplify some properties, such as *being the tragic protagonist* and *being happy*. As *Idomeneus* indicates, an actualist performance ontology is no stranger onstage. Two millennia ago, Attic tragedy already evinced an actualist understanding to stage figures and staged worlds.

2. Actualism and theatre history

Contemporary theatre is still influenced by, if not indebted to, Aristotle's description of tragedy. The Attic tragedies influenced Aristotle's theory of human nature, and his *Poetics* influenced dramaturgs and critics from Sir Philip Sidney to Cardinal Richelieu. In Aristotle's theory of drama, the protagonist's mistake introduces a possibility and its counterfactual. The spectator knows that, had the protagonist acted otherwise, the tragedy would not have occurred. However, he did act in that mistaken fashion, and so he reckons with the world of gods, conventions, and expectations. The action produces the necessary outcome of this entanglement: that sort of choice must lead to this sort of end, given the world. Aristotle's deep actualism necessitates an understanding of theatre where an abstract but actual thing—the essence of humankind—is made visible in a particular entity—the imitation. Furthermore, Aristotle understands essences as seedbeds of possibilities. In the seventeenth century, an experimental dramaturgy emerged as an alternative approach to stage actualism. In this later development, John Locke's repudiation of Aristotle's metaphysics played a significant ideological and ontological role. The next section examines this history and positions the actualist quantum performance ontology in the ongoing engagement with performance's inherent actualism.

2.1. Aristotelian actualism and tragedy

Aristotle hones his actualist intuitions throughout the logical *Categories,* the empirical *Physics*, and the speculative *Metaphysics.* The project begins as a solution to the Problem of Universals, inherited from Plato, which asks: why do different individuals partake in the same qualities? For example, you and I exemplify the quality *human*, which implies that *humankind* exists, this *humankind* defines the kind of thing we are, and we somehow share in it. Plato's

answer relied on a dyadic ontology: universal properties reflect ideal prototypes, which belong to a superior realm. In opposition, Aristotle conceives of universal properties as expressions of actuality's elaborate makeup. As G.W. Fitch describes, "Aristotle thought that existence of natural kinds, such as humans, depended on the existence of particular objects," and "Aristotelian actualism" is thus "a version of actualism that takes very seriously the idea that the only things that exist are basic actual objects and things composed of actual objects" (57). Aristotle's answer, matter-form dualism or *hylomorphism,* situates both actualized and potential properties within actual individuals. *Poetics*'s performance ontology stems from this hylomorphism.

All beings are composed of matter (*hyle*) and form (*morphē*). These constituents of actuality are inextricable: form cannot exist unless it is impressed in matter, and matter cannot exist without form's shape. You and I are both individuals, who express the human form as it inheres in our particular flesh and blood (our matter). Because all humans express these forms, the forms are real; however, the human form does not exist outside exemplars. This actualist picture has three primary elements, all of which inform *Poetics*: substantial forms, non-substantial forms (or accidents), and *potentia*. First, substantial forms define entities' kinds: their essences and their *telos*, or purposeful goal. You and I share the substantial form of humankind, whose essence is that of the *rational animal* and whose *telos* is *eudaimonia:* a flourishing that results from leading a virtuous life. Second, non-substantial forms (or accidents) are the features that individuate particulars who share the same substantial form. One's unique character arises from these qualities, appearances, ages, spatiotemporal locations, and so on. Third, matter is limited by its potential (*potentia*) to exemplify some forms and not others. For example, wood lacks the *potentia* to exemplify humankind. Beyond matter's *potentia* for specific substantial

forms, individuals possess the capacity (*potentia*) for some accidental qualities and not others. For example, flesh and blood have the (first) *potentia* to exemplify humankind. Once that *potentia* has been actualized (the first actualization), the resultant human retains the (second) *potentia* for certain qualities like baldness, tallness, angriness, and so on. If that person actualizes one of those capacities, e.g., baldness, then that second actualization is complete, and we have an actual, bald human.

In *Poetics,* Aristotle "follow[s] the order of nature" and defines tragedy as it relates to human flourishing and virtue (1447a). Because observation and inference found all human knowledge, we must observe other humans to decipher which actualized qualities encourage flourishing (see Chapter 1). "[F]rom childhood it is instinctive for human beings to imitate," Aristotle announces, and they "get their first lessons by imitation" (*Poetics* 1448b). We witness someone exhibit virtue, and we reason that she flourishes because of it. Because we share her kind, we also cognize that we could actualize that virtue (we share that *potentia*) and flourish too. Thus, we imitate her. Tragedy formalizes this inclination for imitation. However, the tragic poet demonstrates the pitfalls of unvirtuous mistakes. The essence of tragedy, according to Aristotle, is the "imitation of an action . . . [that] effect[s] through pity and fear the *katharsis* of such emotions" (1449b). In other words, the imitation actualizes a specific human capacity (e.g., hubris); the audience then imitates that capacity in response to the actor's presentation, at the peak of represented suffering; this collective imitation then spurs a *katharsis*, or clarification.

Put differently, tragic performance imitates and thus actualizes a universal human *potentia.* Aristotle champions the protagonist's character (a collection of capacities) as a "natural cause" of tragic suffering (1449). To this end, the tragic reversal demonstrates how some quality, when actualized, drives the individual from *eudaimonia*. However, the protagonist must be

admirable, though not preeminent in virtue. Because the protagonist's character both individuates him and causes his downfall, the spectators pity the protagonist. We feel pity when we witness "some evil . . . which befalls one who does not deserve it" (*Rhetoric* 1385a). However, the apparatus of Greek theatre is replete with deindividuating elements. Masks, choruses, songs, and the presentational style obfuscate the stage figures' individuality and throw their generic participation in humankind in relief. Spectators share the stage figure's kind and, subsequently, his capacities. Those capacities caused his suffering. It follows that the spectators feel fear, a "mental picture of some . . . painful evil in the future . . . harming *us*" (*Rhetoric* 1382a). In other words, pity inheres in us when we recognize the individual, and fear follows when we recognize that we share a universal kind.

Because the action evolves per necessity and probability, the protagonist's fate seems justified, if undeserved. Moreover, the spectators mimic the protagonist's suffering and thus actualize that character in themselves in the act of cognition. By actualizing an action's necessary and probable course, theatre demonstrates whether actions of that kind are conducive to human flourishing. In tragedy, they rarely are. This mechanism results from Aristotle's actualist ontology. Spectators and actors alike are actual particulars, each evincing a slew of uniquely actualized properties. However, spectators and actors are also the same kind of being, and therefore the spectators share the *potentia* (capacities) that the stage figures manifest. Performance actualizes accidental properties in safety, expose their failings, and exposes their existence in each human animal. The theatre of *Poetics* is an actualist workshop, which makes concrete the non-substantial form of suffering and encourages pity and fear to inhere within the audience.

2.2. Empirical actualism and enlightenment dramaturgy

Like Aristotle, Locke proposed an actualist ontology for his natural science. However, he jettisons forms, kinds, properties, and most other abstract identities as inventions that "belong not to the real existence of Things" (263). Aristotle decided that universal properties were actual capacities, common to objects that share a kind. Locke instead hoped to dissolve the whole notion of universals as incoherent, wherever they dwell. Rejecting Aristotle's hylomorphism, Locke's reality is characterized by an undifferentiated mess of matter and sensation. Universals (e.g., humankind, redness, baldness) are not metaphysical facts but psychological constructs. It follows that Locke's empiricism engenders a different kind of actualism. Moreover, it found unique dramaturgical expression in the eighteenth century. Where Attic tragedy actualizes the universal, the empirical dramaturgy emphasizes the conditions of the particular, allowing spectators to judge and categorize the play's action. The empirical theatre's preoccupations persist, albeit in an attenuated form, on the quantum stage.

Like most empiricists, Locke embraces a mechanistic reality. According to Locke, everything is comprised of corpuscles of matter, whose arrangement into different shapes accounts for all of the properties of objects. Aristotle held that entities arrive at our senses as forms. Because forms are real, we intuit an entity's essence when its form comes to our awareness. Thus, the masked stage figure arrives at the spectator as the universal form of man. But Locke dismisses forms as a silly notion that "very much perplexed the Knowledge of natural Things" (267). Instead, his world consists of matter in motion, which comes to our awareness as raw sensations. We parse these sensations via our faculty of reflection and subsequently categorize sensations into forms and kinds. In the seventeenth century, Locke's stance engendered radical notions. Aristotle could explain our similarity to one another: you and I share

a kind. However, Locke's features "not in substantial form nor in substance, but in structure [of matter], in the particular modification of the minute parts" (Ayers 250). Our similarities cannot be explained by appeal to an essential kind because there are no hard borders. Categories as basic as *human* or *mammal* lack metaphysical reality, and similarity and difference (between you and I, a dog, or a rock) exist on a continuum. Thus, Locke announces that the only "*Essences* of the Sorts or Species of Things . . . [that] come within the reach of our Knowledge . . . [are] those abstract complex *Ideas*, to which we have annexed distinct general Names" (267). Everything shares a singular essence—matter, which "constitutes everything in creation" and whose "universal nature" is to follow mathematical laws (Ayers 250). When we reflect on our sensations, which are generated by matter and its interaction with our material organs, we judge and theorize these arrangements of matter. But our categories are mere conventions.

Locke's mechanistic actualism retains a radical metaphysical *potentia*. His corpuscles are not specialized electrons, quarks, or leptons. Instead, he describes an undifferentiated prime matter, which is capable of becoming any corporeal entity if properly arranged. If everything is matter, then the matter corpuscles that comprise a particular dog *could have been* arranged as a human. All matter has the potential to be anything that is possible. Each observable object "has the boundaries and unity of a complex but discrete and coherent 'machine' . . . [of] dynamic interrelationship between the parts [of matter]" (Ayers 271). In other words, everyday objects are nothing but machines, which emerge from the complex rules that define the essence of matter. The interrelations between the interlocking parts of matter limit the involved corpuscles' *potentia* to a set of organic, relationally defined possibilities. Aristotle's matter is limited to a set of compatible forms; Locke's matter is defined by its infinite set of possible relations.

Finally, objects possess the capacity to provoke contradictory sensations in different subjects. Locke distinguishes between two types of qualities: primary ones, which are observer-independent (solidity, extension, motion, shape) and secondary ones, which result from the interaction between subject and object. In primary qualities, we observe nature's true face. The analysis of primary qualities "promises to explain all universal law and dark *potentiality* as mathematically derived from independently grasped attributes which are totally actual" (Ayers 254, emphasis added). However, the secondary qualities remind us that perspicuous objects (e.g., a pomegranate) can produce wildly individual effects in different subjects (e.g., taste beautiful to some, horrid to others). These secondary qualities do not resemble the objects that cause them—nothing about an object's solidity, extension, motion, or shape directly reveal its taste. It follows that we cannot find the truth of the matter (e.g., do pomegranates taste good or bad) in the objects themselves. Thus, it is necessary to teach the public to direct their judgement skillfully, so that they may arrive at the correct and moral understanding of secondary properties.

Dramaturgs revised the academic and practical treatment of theatre space in response to Locke's theories. In *The First Frame: Theatre Space in Enlightenment France,* Pannill Camp succinctly describes the theatre aesthetic that echoes Locke's project as a movement toward a theatre of experimental observation and judgement. As he summarizes:

> By the middle of the [seventeenth] century . . . [Denis Diderot] called for *an immanent relationship between real and staged states of affairs*. In his dramatic theory, Diderot stopped short of rejecting the academic distinction between reality and theatrical representation, reformulating the boundary as the inevitable result of the impermanence of human existence. This reformulation helped make the case for lifelike theatre that all

> but merged entirely with the world known to spectators as real . . . the reformed theatre should present itself to the spectator like a candid view of nature. (17; emphasis added)

These empirical spectators are spectator-scientists, who judge a dramatic presentation that offers "a putatively candid view of simulated natural forces under artificial pressure" (122). Where scientists extrapolate from experiment to nature, spectators extrapolate from staged activity to representation of particulars. Scientists infer laws, and spectators judge social truths. Stage conventions adapted to stress characters whose class, living conditions, and daily experiences were more like the spectators', helping spectators evaluate the staged activity and apply their evaluations to life. Camp suggests that dramaturgs rejected Aristotle's aesthetics and privileged "discrete object[s]" instead of actions. Stage objects are first perceived as actual objects, then "their status as imitation is understood by a mature, experienced mind" through reflection (83).

Where Aristotle's paradigm actualizes a capacity of humankind, the empirical tactics generate two overlapping *as if* perspectives. First, actors act *as if* the action were real. Second, spectators view the activity *as if* it were natural forces in containment. Rather than make cognizant a metaphysical truth, these twin frames imbue the performance with interpretability. After all, one cannot exercise judgment unless there is something to judge. If the spectators judge the stage image rightly, they have understood an actual possibility for the staged figures. The *as if* experiment has delivered a social truth. The empirical frame treats the *as if* of theatre as an experimental apparatus, which reveals true capacities for the particulars on stage.

Of course, *Idomeneus* recreates neither of these performance actualisms. Either feat is impossible. Schimmelpfennig's play emerges from our current relationship to possibility. It makes tangible potentiality itself by imbricating logical, natural, and aesthetic possibilities without preference. Idomeneus's choices fling him into looping, intersecting, and diverging

paths. This proliferation makes tangible a strange reality that unites our own many possible lives. And the chorus reflects the wave-like nature of potential: every possible *Idomeneus* crests from the chorus, whose bodies set the boundary conditions for his emergence. If the empirical theatre refocused actualist aesthetics from the universal form to the particular matter, then quantum theatre shifts it from matter to raw *potentia*.

3. Collapse interpretations and contemporary theatre

Since quantum theory's birth, some scientists and philosophers have advocated an actualist modality for quantum entities. In *Physics and Philosophy,* Werner Heisenberg analogizes quantum entities directly to Aristotle's *potentia*:

> the probability wave . . . meant a tendency for something. It was a quantitative version of the old concept of *potentia* in Aristotelian philosophy. It introduced something standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality. (14–15)

The vast potential of the atomic entity is reduced to a set of positions by the initial conditions of the experiment, the quantum state of the measurement apparatus, and (ultimately) the quantum state of the universe. Mathematically, this *potentia* evolves as a linear wave function, whose amplitude distributes the probability of different outcomes. As the wave function evolves through time, it collects a proliferating set of possible outcomes—known as a *superposition* of states. Whenever we measure a quantum system, however, it instantly snaps into one position—known as an eigenstate. On the one hand, the snap seems acausal (why does it choose one possibility over others?); on the other, it follows the probabilities implied by the crests and troughs of the wave's equation and only occurs when we take a measurement.

In my third chapter, this situation was compared to a man in a superposition of possibly heading west and possibly heading east at a crossroads. At the next forking path, his quantum state evolves into possibly heading west-north, west-south, east-north, east-south, and so on. Whenever two entities in superpositions interact, they become entangled into a new quantum state, described by a new wave function, which collects all possible interactions across all possible positions for both entities. In experience, however, we never see wave functions, superpositions, or entangled entities. In other words, atomic entities appear to be in a superposition when left alone, but they collapse into a single state whenever we interact with them. Thus, any realist interpretation of quantum theory must explain what that linear wave, which draws the boundary conditions of an entity's *potentia,* is. In Locke's worldview, the prime matter could be anything, and an object's properties emerge from its physical arrangement. In atomic physics, isolated atoms in a superposition inhabit (near) infinite positions and relations *simultaneously*. Potentiality does not lie dormant in a quantum entity's matter or structure. Instead, the entity is continuous with its *potentia*. Quantum theory describes a reality that is strange and inaccessible, and quantum theatre actualizes this peculiar world by celebrating the potential for actors' bodies in space.

A spate of philosophers argues that the wave function exists in our continuous physical reality, but it disappears before we can see it. In other words, the *potentia* of a quantum entity collapses into an eigenstate under certain conditions.[13] This stance is known as *collapse theory*, and it preserves many facets of Aristotle's and Locke's worldviews, where potential resides in matter. When contemporary theatre converges on this picture, it stages the sort of world found in *Idomeneus*, oscillating between an actualized wave of choristers and collapse of concrete drama. Collapse theories seek to alter the foundational Copenhagen interpretation as subtly as possible

while increasing its explanatory power. Where the prior interpretation describes how we relate to our experiments (via complementarity [Chapter 1]), collapse theories elucidate the unobserved reality beneath those experiments. This explanatory framework relies on a simple but off-kilter notion: in some circumstances, the classical world yanks quantum objects across a real classical/quantum divide and transforms them into classical objects. Thus, entities evolve into a quantum state only if isolated from the classical world, which is comprised of eigenstates. Collapse theories diverge in their description of the collapse process, but they begin with John von Neumann's mathematical axioms in *Mathematische Grundlagen der Quantenmechanik* (*The Mathematical Foundations of Quantum Mechanics* [1932]). In particular, von Neumann inaugurates *subjective collapse theory*.

3.1. Martin Crimp's *Play with Repeats* and subjective collapse theory

According to von Neumann, collapse occurs whenever a measurement from the classical world requires information from a quantum entity. "Measurement" features in von Neumann's axioms as an occult power, as irreducible as gravity. Superficially, *measurement* occurs when a *subject* interacts with a quantum state *object*: hence, subjective collapse. We cannot import the robust sense of subject and object from psychoanalysis into von Neumann's system. His subject is purely grammatical: a *doer* of the verb *to measure* to the *receiver* that is the quantum state object. *Measurement* emerges somewhere in the cause-and-effect chain between the quantum state, the measuring apparatus, and our subjective perception of an eigenstate. He explains that

> this boundary [between subject, object, and measurement] can be pushed arbitrarily deeply into the interior of the body of the actual observer . . . but this does not change the fact that in each method of description the boundary must be put somewhere . . .

> experience only makes statements of this type: an observer has made a certain (subjective) observation; and never any like this: a physical quantity has a certain [objective] value. . . . Now quantum mechanics describes the events which occur in the observed portions of the world, so long as they do not interact with the observing portion . . . but as soon as such an interaction occurs, i.e., a measurement, it [collapses]. (420)

Von Neumann leaves his terminology vague, so long as his math works. But subsequent thinkers were inspired by his prose, which references the observer's subjective experience. Most influentially, Eugene Wigner's "Remarks on the Mind-Body Question" proposes that measurement crosses the mind-body divide and solves the Cartesian question. Consciousness collapses "spooky" quantum reality into the eigenstates with which we are familiar. In turn, Wigner inspired substantial new-wave quantum mysticism and art.[14] In these subsequent cases, the subject more closely resembles that of psychoanalysis: an agent who others an object via an act of measurement. Subjective collapse theory posits that, without a measuring subject, the universe is nought but an unobtained quantum soup. Subjective experience enters the ontology as an irreducibly basic entity, without which physical systems would never achieve classical form. Some contemporary theatremakers explore the ramifications of this worldview: they offer looping revisions, measure and then re-measure a possibility, and expose the parallels between potentiality and actuality, degrees of freedom and linearity, and free will and fate. In quantum terms, some plays capture a moment between waveform and collapse, where spectators see a wave evolve and then collapse into a singular fact. Moreover, that collapse occurs because of a character's agential measurement.

Crimp's work, which is notoriously non-naturalistic, non-narrative, and obscure, often interrogates the ontology of performance. As Vicky Angelaki describes, he "has helped redefine

dramatic writing in our time, as it has consistently defied categorizations according to extant traditions" (*Plays* 1). Her study of Crimp's oeuvre situates him in the history of anglophone political theatre, following Brecht's influence. Like the latter, Crimp estranges his spectator from the stage to highlight the "sociopolitical aspect of the artistic event"; however, Crimp's defamiliarization techniques further expose the "molecular structure of theatre" and thus generate "novel possibilities" impossible in daily life. In turn, his plays offer strange "perceptual engagement[s]" with unfamiliar possibilities in continuous space (Angelaki, *Plays* 12–13; see also States 101–06). When Crimp examines the tensions among fate, free will, and the limits of our social environment, his plays evince a performance ontology that converges with subjective collapse theories.

Play with Repeats nakedly examines the boundaries of potentiality available in the apparatus of society. *Play* follows Tony as he tries to recover "the possibility of another life" lost to a wrong choice (20). It opens in a rundown bar, where Tony asks a barfly, Kate, and her boyfriend, Nick, the inciting question: "What is there that you regret?" (1). The odd grammatical construction presages the play's structure. Regret "is there": an actual entity comprised of lost potential that sets Tony's boundaries. The lovebirds dismiss Tony, but he persists, characterizing regret as a spectre of lost possible lives:

> We're human beings. And perhaps I'm repeating myself, but for human beings everything should be possible. The language we speak tells us that. It tells us that the potential—by which I mean not only what we could be, but what we might've been—the potential is infinite. And so what is *meant* to happen—which is surely the realisation of that potential—are you with me?—what's meant to happen, hasn't happened. (8–9)

Succinctly, Tony describes an actualist ontology. First, he equates human nature to *potentia*. In Tony's worldview, human life is a wave function that starts in a superposition of could-bes and whittles down to a particular position through time. Tony also recognizes degrees of freedom within his reality: he chose how to act in the past, and those choices collapsed his potential into his current life eigenstate. Those lost possibilities haunt him as a regret because other possible lives could have been better. Furthermore, he projects this awareness forward, and he is paralyzed by the fact that he might not obtain the best of all possible futures. As he moons over his fate, his beliefs echo the sort of quantum mysticism that often develops precarious contradictions. For example, he maintains both that potential is infinite and that our destiny is the realization of that infinite potential (22). But potential is an unobtained superposition, like the bare stage. Any realization of that potential is a single outcome within its boundaries. Tony's mistake echoes Idomeneus's: he yearns to realize the potential of life itself but fails to understand that any realization will necessarily involve a loss of other possibilities. Kate winces at the mysticism, but she shares Tony's ennui: she too regrets her past, which is plagued by a failed acting career and infertility (the result of a prior abortion). Eventually, Nick grows frustrated with Tony's harassment and threatens to stab him. Tony narrowly escapes, but the shadow of death already looms over his quest. *Play* thus stages a world that is structured around a wave function of regret.

The remainder of the play explores the ramifications of reversing such a collapse and recovering one's potential. Tony seeks Lamine, a blind "African Marabout[,] . . . telepathist, [and] clairvoyant" who "doesn't inhabit the world in a material sense" (10-11). His blindness permits him to see the unmeasured world where "everything is possible," and he utilizes "action at a distance" to pluck one possibility out of the immense *potentia* (11–12). Crimp neatly

correlates sight, measurement, and potential. We learn that Tony's existential crisis grows from a single day, when he failed to "assert [him]self as a man" and thus lost his "destiny": a promotion and his wife-to-be, Heather (20). Lamine's ritual, which involves bisecting the stage with a string, works its magic. Tony returns to the fateful day but retains his memories. *Play* thus stages a world where one can undo collapse and return to *potentia*'s probability space. Tony soon proves that the subject's measurement collapses the wave function of *potentia* in this world. First, he demands that Franky, his boss, offer him the promotion, and she does so. Second, his façade of manliness keeps his conversation with Heather afloat. At a glance, Crimp's world validates Tony: had he taken a different measurement, he could have caused his potential to collapse onto a different outcome.

Though the scientist sets an experiment's boundaries, the outcome is still fundamentally probabilistic. Tony learns the limits of the measurer's influence. First, his celebration for the promotion subsides, as Franky explains that the supervisor must help the illiterate, depressed, and neurotic employees. Working-class woes constrain him, and Tony rejects the job, "not [because of the] fear . . . not the responsibility . . . I can't explain . . . It's not me" (38). Despite realigning his measurement, the boundary conditions of the system leave Tony unable to both receive the promotion and be suited to it. Moreover, Heather is no long-time fiancée but a middle-aged student whom he meets for the first time at an unlit bus-stop. This situation would never collapse into a betrothal. As their scene progresses, it becomes clear that Tony failed to assert himself "as a man" when he let her escape the awkward encounter. As she prepares to embark, he gets drunk, pins her, and tries to rape her. She narrowly escapes. Despite reclaiming his *potentia* and taking a new measurement, the greater system of Tony's life collapses onto the same eigenstate. Act 1, scene 1 repeats as act 2, scene 2 with minor variations. Again, he regrets

his choices and seeks Lamine. Crimp seems to remind his audience that we continually strive to re-measure our past, as we wonder how things could have gone otherwise. However, when the experiment is over, we always return.

Play exposes the relationship between human potential and the possibilities that are afforded by our character and socioeconomic relations. Tony looks at the past and sees the upward mobility, marriage, and housing that was afforded to his parents. Such things therefore exist within human potential for people of his kind, but he fails to see how his milieu renders these things improbable. If Tony is a tragic figure, social institutions replace the gods as the weavers of fate. For example, Tony and Heather share an economic background: she attends an adult learning centre because she could not afford education in youth; he barely maintains a cramped bachelor apartment. Neither can obtain a life beyond their obligations and are thus trapped into systems of behaviour. However, they never discuss these shared woes. Instead, they bond over discriminatory attitudes. Heather confides that she thinks her teacher, Lawrence Bott, has an "an ethnic problem" with women's sexual liberation, and Tony complains that Marc, who receives the supervisor position in his stead, is an affirmative action hire (46). The pair's bus-stop conversation culminates in collective Holocaust denial:

> HEATHER: (*Confidential).* You see—personally—I don't believe that number of people died. In the gas chambers. I don't believe it's *humanly possible* for that number of people to die.
>
> TONY: I don't believe it either. I never have.
>
> HEATHER: It can't be. (47)

Heather denies that human potential contains the possibility of the horrors of the Holocaust. Like Tony, she clings to *potentia* instead of dealing with the horrifying outcomes that resulted from historical acts of measurement. Tony pines for his parents' successes, and Heather agrees:

> I think we all as human beings have a duty to direct people's attention away from all that ugliness. . . . [That is why] I really like visiting stately homes. . . . The big ones naturally. . . . The most beautiful thing is to sit in one of those rooms and imagine it's mine. . . . [Then] I can breathe. I say to myself: yes, this is me. (47–48)

Because stately homes were obtainable in the past, she knows they exist in human *potentia*. Mirroring Tony, she projects the possibility of an aristocratic life into her future. Heather's regret offers another version of the play's presiding temporal dualism: her ideal future is a return to the past. The active rewriting of history, one filled with stately homes and no Holocaust, similarly enacts an attempt to actualize some unactualized possibility. To linger in this fantasy, she "direct[s] her attention away from" the social cost of fine living. The system that offered this lifestyle to few was detrimental to many, which would include Heather and Tony. Likewise, Tony's (culturally derived) conceptions of masculinity, sexuality, and biology restrict his sense of "acting like a man." Crimp construes the pair as deplorable but unfortunate people restricted by an uncaring system. That system encourages them to misdirect their anger and traps them in a wave nostalgic regret, where a flourishing life does not exist in their *potentia*.

Like Idomeneus, Tony languishes in an endless cycle. The versions of Tony's encounters deviate from one another, but the degrees of freedom are negligible. Before the play begins, Tony has worked on an assembly line, lived in a tiny bachelor flat, and patronized the same pub nightly for twelve years. The repeated scene (act 1, scene1 and act 2, scene 2) amplifies his aimless repetition to the play's ontology. In the second version, Tony loses Lamine's business

card before he can contact the marabout. As Tony searches for the lost card, an irritated Nick stabs Tony to death and flees. During the scuffle, Kate finds a peculiar document: the job advertisement, which is now so ancient that "it's falling apart" (72). With the simple stage property, Crimp exposes the depths of Tony's desperation: spectators have only seen two cycles, but Tony has dwelled in his *potentia* for uncountable repetitions. Spectators are only privy to the two repeats before death. Further evidence suggests that Tony has relived these days and harassed Heather many times. For example, when the pair speak in act 1, scene 4, she opines that Lawrence is "actually quite attractive." Later, she comments that Tony is "very like Lawrence" (42-43). In act 2, scene 1, Tony finds Lawrence in a launderette—in each loop, he has sought Lawrence to ape his qualities and attract Heather. Tony's search for a specific eigenstate (the marriage and job) traps him in endless doomed variations, as he strives for a life that lies beyond his possibility space.

Over time, Tony's state evolves into an indeterminate haze.[15] After a measurement collapses the wave function, the quantum entity immediately evolves in a new wave function, given its new conditions. That prior collapse informs the new possibility space. The world's consistency arises from the history of specific collapses because each erases the previous wave function. Through the strange trick of Lamine's mysticism, Tony loses the anchor of a consistent history of particular collapses and finds himself afloat in *potentia*'s vagueness. The advertisement disintegrates as the Tony system evolves, and his sense of self also smears irrecoverably. Before act 1, scene 1, he has already dissolved into an amalgam of impersonations, imitated mannerisms, and stolen anecdotes. Most obviously, his lines in the twice-performed scene are a mess of stolen lines from Lamine, Heather, Franky, and Lawrence. Spectators become aware of this fact in the second version, and the play's structure encourages

spectators to reflect on act 1, scene 1, as a link in a long chain. We cannot determine who Tony is beneath the tangled mess of citations.

Tony loses his ability to self-locate and often forgets his motivation in scenes, which Crimp marks with the stage direction "*vague recollection*" (41, 54). With no forward thrust, Tony defines himself through his entanglements. Heather receives the worst of it. He craves her subjective measurement: he needs her to collapse him into an eigenstate where they share a classic sort of life. But from her perspective, they only have this one, five-minute conversation—a single, brief experiment. She escapes Tony's assault because she aborts the measurement process:

> HEATHER: *(eyes shut).* I haven't seen you. I swear I can't describe you. Don't hurt me.
>
> TONY: What d'you mean? We've been talking. We've been dancing. What d'you mean you can't describe me?
>
> *HEATHER cannot speak.*
>
> TONY: Open your eyes! OPEN YOUR EYES! (*He . . . forces her eyes open.*) Look. It's me. Don't you remember me? This is me. Anthony. I want to marry you. (51)

Her temporary blindness, a refusal to measure, imprisons Tony in his quantum fugue. Tony cannot evolve a new wave function from a collapse-less history. Unmeasured, a quantum state continues to evolve linearly and deterministically. Similarly, Tony is entombed in the circumstances that prompted his original flight into potentiality.

Furthermore, *Play*'s naked performativity extends Tony's ontological quagmire to the nature of performance. The play's list of dramatis personae hints at its ontological preoccupations. Tony is listed alone, but Nick/Terry, Kate/Franky, Lamine/Lawrence/Marc, and Heather/Barbara are each compressed into a single character line (i). As the action unfolds, this

doubling comments on the nature of performance. In particular, Kate and Franky unite the play's actualist worldview with the actualism of the performance environment. Act 2, scene 2 begins earlier in the evening than in act 1, scene 1. In the newly revealed dialogue, Tony tells Kate "I've always thought: I know her from somewhere, we've met. We've spoken before. But now I see that what it is you're very like somebody. . . . You're genuinely like Franky where I work" (60). On stage, Kate and Franky share a body. Later, when Tony flirts with Kate, he mimics the tactics that Terry (Nick's actor) employed in act 1, scene 3 to flirt with Franky (Kate's actor). Through the haze of potential, Tony conflates Terry and Franky's relationship with Nick and Kate's. The spectators are encouraged to follow suit: the relationships are different possibilities for the same bodies, in both the play's social system and in performance.

Spectators also witness how a body can flourish (as Franky does) or become trapped (as Kate does), despite the same unfriendly environment (Tony's and Nick/Terry's actors). The women are distinguished by their measurement tactics. Franky flourishes because, as her name implies, she "asserts herself as a man." She performs in daily life without realizing it and brings the apparatus of performed masculinity into her measurements. Kate, an actress, reacts to the performativity of everyday light with existential angst. In playing an unconventional role, Franky succeeds in a hostile environment; in refusing to act, Kate rejects reality altogether and spends her nights drunk. But neither tactic allows the actor to escape the system and its pressures. This metatheatricality extends beyond their double casting. In the repeated scene, she responds to Tony's questions by quoting Jaques in *As You Like It* and Macbeth:

> KATE. All the world's a stage . . . We're actors. The world's a stage . . . We strut. We fret.
>
> NICK. She's right.

> TONY. No, I'm sorry, but she isn't right . . . I mean this isn't an act. This is me. I'm here. I'm making decisions. I could've stayed over there where I normally sit but no I've come over here of my own free will . . . An actor is repeating a part, but this is different, this is entirely different . . . / , / This is significant. This is me.
>
> KATE. It's a tale told by an idiot . . . Signifying nothing. (2–3; 64–65)

As metatheatre, an actress felicitously declares her actual status: she is an actress like Kate and the entire *as if* world is staged. Like Tony, she communicates in a pastiche of citations, unable to locate herself. The player, it seems, is lost amongst the many possible variations of life she leads on stage.

But Tony refuses to entertain the metaphor. Instead, he asserts that he is no actor and his "free will" defines him. Tony's beliefs once more evince contradictions. Actors are the element of performance where free will enters. Tony is the deterministic character, whose existence is scripted; his actor makes choices within that system. On stage, Tony's actor refuses to admit that he is an actor, and thus he succumbs to the boundaries of the script. The actor could have refused to cross the stage or say the line. Ultimately, the script and the performance are entangled, and Tony fails to understand the relationship between a scripted system and the individual's measurements. Furthermore, *Play* repeats nightly during its run. Like Tony, the players strive after a better version of the performance as they play out its variations. Each night, they make different choices and react to one another's, exercising their free will within *Play*'s limits. The potential of that performance collapses in the evening's final output. Then, the production continues to evolve. Its *potentia* expands once more, a new wave function for the next night, when it will collapse once more.

The performance must end, and Crimp inserts a terminus. Where *Idomeneus* concludes in a stalemate, *Play* demonstrates the necessity of Tony's death by including a final scene without him or his actor. For a moment, spectators witness a classical dramatic world. At the factory, spectators learn that Tony's co-workers overcome systematic injustices that dwarf Tony's metaphysical angst. Terry is illiterate and uneducated; Barbara self-harms and has an untreated anxiety disorder; Marc struggles to balance the employees' needs. One cannot help but see the restrictions on each of their potential. Tony's limited possibilities are ultimately entangled with the malaise of week-by-week ennui settling over the play's working-class Britons. Nonetheless, the assembly line continues. Terry/Nick, Franky/Kate, and Heather/Barbara must escape these limits or succumb to its repetitions. As with *Idomeneus,* the players cleanse themselves of these relations through the Dionysiac potential of music: "*a loud driving rhythm . . . prevents conversation*. . . . *They surrender to the relentless optimism of the music*" (76). This is not *Idomeneus*'s free bacchanalia. The driving rhythm and the involuntary nature of surrender suggest that dropping the performance mode is not escape enough. The music stems from the script, the limiter of the stage's potential. Tony refused to accept the metatheatrical similarities between life and stage, but his absence permits the other players to grasp for their bodily potential, which lays beyond the systems of society and drama before the curtains close. But when they do so, they discover reality's driving beat, whose relentlessness implicates our world in the same aimless cycles. This sound stymies any real corrective. Like Heather and Tony, these workers cannot converse with one another.

3.2. Odin Teatret's *Kaosmos* and objective collapse theory

Crimp emphasizes his characters' and actors' subjective measurements (restrained by systemic relations), but many thinkers reject the idea that measurement belongs in a fundamental ontology. The argument runs as follows: the collapse theory above implies that the physical universe requires something like us to exist. Without a subject and its consciousness (Wigner) or some undefined subject entity (von Neumann), the universe would merely be a quantum state of intangible superpositions (Bricmont 213). It follows that the dynamics of classical physics (gravity, for example) would not emerge without us. These implications roil contemporary biases against subjective and deistic descriptions of nature.[16] For many, nature should not require "subjects" in principle; it should exist even if it were nothing but dust. *Objective collapse theories* offer an alternative description of the quantum situation that treats classical nature as something that exists even when unmeasured.

These theories embrace the stochasticity of quantum mathematics and treat collapse as a random process. As Hilary Putnam describes:

> [t]he collapse could be spontaneous. For example, it could be an ultimate statistical law of nature that a particle has a certain fixed probability of "jumping into a position eigenstate." . . . Alternatively, the spontaneous collapse could be provoked by a "trigger." ("Philosopher" 626–27)[17]

In subjective collapse theories, the subject *causes* the object to collapse via the act of measurement. In objective collapse theory, scientists may *trigger* a collapse, but they do not *cause* it. Instead, collapse is an acausal, statistical phenomenon, a constant of nature. Every entity in a quantum state could collapse into an eigenstate at any moment. Thus, spontaneous collapse occurs infrequently. In fact, the odds of collapse are so low that we should not expect

ever to witness it in a laboratory (Bricmont 213). However, the objects of everyday life are composed of billions upon billions of atoms. This sheer volume all but ensures that at least one atom will collapse at any moment. As soon as one atom in a system collapses, the rest follow suit (per entanglement). Of course, measurement still triggers a collapse, but only because it entangles the object with the vast system of scientist, apparatus, furniture, and so on. With so many entangled atoms, collapse becomes statistically guaranteed. The terms *subject*, *object*, and *measurement* disappear from the fundamental ontology. Crucially, scientists regain their objective position in the study of nature. A lifeless universe would collapse continuously by sheer chance, so why would the collapses we trigger deserve scrutiny?

In Neumann and Wigner's accounts, the subject's choice to measure offers a semblance of agency. In objective collapse theory, particular outcomes result from a stochastic universe, which the subject happens to inhabit. Quantum collapses redistribute matter, generate flashes of stability, and then recede into a new *potentia* (Bricmont 214-15). Because quantum systems are entangled, the collapses ripple through the imbricated wave functions of reality and shunt the universe into one of its possible alignments. Each snap is followed by the return of super-positional haze, which never lasts long before reality snaps into focus once more. The subject does not matter, but the same system of universal laws reigns over both subject and object. This description may seem untheatrical because theatre assumes the measuring act of spectatorship. But objective collapse theory still requires measurement for humans to sense the quantum realm—the function of measurement merely changes. Moreover, spontaneity and stochasticity are as integral to live performance as they are to objective collapse theory. Odin Teatret's *Kaosmos* reflects this sort of ontology. It was developed through improvisations, entangled with an unexpected text, and evolved into three additional performances.

Danish theatre group Odin Teatret functions as director Eugenio Barba's dramaturgical toybox. Where Crimp's post-Brechtian political dramaturgy demonstrates the importance of subjective collapse, Barba's work with Odin Teatret builds on Brecht's techniques and toys with spontaneity.[18] From this foundation, Odin Teatret offers a "molecular study through theatre of how the wider natural, social and scientific realities function" across from objective reality (Sykes 175). They utilize montage, gesture routines, and extended 'not-buts' (a staple Brechtian technique, in which the actor begins one action and then continues to do that action's opposite [Chapter 1]) to excavate a shared space between spectator and performer. Rather than gesture toward social choices, however, Odin Teatret constructs simultaneous spaces, gestures that are devoid of specific content, and unrelated alternatives to emphasize how a shared reality offers a "seed-bed" of possible trajectories (23). Through these extreme alienation techniques, the resultant performance resists measurement. When any given audience member arrives at a sense of meaning during the performance, that spark of recognition feels stochastic: it depends on the linguistic, historical, and artistic reference points which that spectator happens to have. Thus, the performances linger in a state of strange *potentia*.

Including *Kaosmos*, all of Odin Teatret's performances were developed in the same fashion until the mid-1990s. In *Towards a Third Theatre,* Ian Watson describes the process:

> Prior to rehearsals, Barba compiles material on the themes he wants to use as the basis . . . [as] his own private resource. . . . As rehearsals begin[,] . . . [he] suggests particular aspects of a theme which he asks his actors to use as the basis of a purely physical improvisation. . . . These initial improvisations are invariably solo affairs. . . . Once an actor begins an individual improvisation . . . [Barba] remains an active observer . . . [and] the actor must remain open to all possibilities in this initial phase of the work. S/he must

> not edit his/her reactions or pre-plan his/her responses to the theme before s/he begins. (77–79)

First, Barba prompts his actors to explore a thematic notion through improvised movement. Actors develop a series of motions (gestic sequences) exploring that theme, and Barba observes them without interference to derive the shape of the production. Performers are not permitted to share their thoughts as they improvise, nor do they react to one another's work *as if* it had sense. They comment only on the shape of the sequences, the boundary conditions for sense-making. In effect, Barba stays collapse by permitting each isolated performance to evolve into a superposition of possible meanings, intentions, and references. Eventually, collective improvisations bundle the isolated routines into simultaneous montages, and these montages then enter into simultaneous spatial montages with one another. Thus, each isolated sequence becomes entangled in the quantum state of the performance. Only now does Barba impose text. In Barba's terminology, the "pre-expressive" gestic sequences enter a dichotomous relationship with the "expressive level" of sense, which evolves into a miasma of possible interpretations. Each performance strives to retain this liminal space (Sykes 13–30). In short, Odin Teatret's productions develop in a fashion analogous to a spontaneous collapse: actors come together, their sequences entangle, and then the spectators glimpse the transitory state between measured initiating theme and the curtain call, which spontaneously collapses into meaning.

Kaosmos offers a clear example of how improvisation evolves into quantum performance. As Leo Sykes describes, the theme developed from a description of subatomic physics that privileged the interaction between parts over the parts themselves (likely from Fritjof Capra's *Tao of Physics*). From this collapse-based description of quantum mechanics, Barba concluded that "the actors' material is a piece of potential . . . [that] can be used in the

creation of different scenes" (39). The resulting "organized chaos" demonstrates Barba's central directorial principle, namely that "the director is . . . the person who knows the subatomic reality of theatre" (qtd. in Sykes 126). As a quantum performance, *Kaosmos* contains more narrative content than most Odin Teatret shows. But the polyglot script prevents spectators from measuring the entire system at once, thus delaying collapse. The original audience was Danish, but every actor in *Kaosmos* speaks in their mother tongue: English, Danish, Spanish, Norwegian, or Italian. The action takes place in a strange space where a contemporary urbanite and some folkloric villagers prostrate themselves before a large, white door. The door guards both "the land where no one dies" (to the urbanite) and "the law" of the universe (to the villagers [Sykes 186–88]).[19] A malevolent force named the Doorkeeper protects it, while his scythe-wielding twin sister reaps human lives, and the whimsical Doña Musica tells stories.

The performance develops into three diverging and converging threads. In one, the urbanite Man-Who-Doesn't-Want-to-Die (Man-Who) questions the Doorkeeper about metaphysics as he tracks performance time on his wristwatch, struggles with a consumptive cough, and tries to steal into the afterlife without the pain of death. In another, the Man from the Country (Country Man) patiently awaits admittance to "the law" while he reads stories from books affixed to the door. In the third, the Mother travels across a lake to rescue her child from Death. The primary languages distinguish the three threads: Country Man speaks Danish with the Doorkeeper, the isolated Man-Who speaks Norwegian, and the Mother cries for her lost child in Italian. Musica narrates in English throughout, Death stalks characters in the form of the Doorkeeper's Spanish-speaking Sister, and Danish peasants intrude on each thread. Actors slip between roles in different sub-tales, and the stage images blend into novel arrangements and iconic poses, such as the stations of the cross and the pietà. The boundaries between these

threads remain fuzzy, and spectators witness the bewildering *potentia* that resides in bodies, objects, and stage space.

The activity on stage shifts between different contexts without blackouts or explicit scene changes. First, the preshow establishes the primacy of the space-between-worlds, which functions like the narrative space inhabited by *Idomeneus*'s chorus. The performance begins when the spectators enter the venue:

> *As the spectators enter from the North The Doorkeeper sits at the South. He waits for them to be seated, looking at them with a gaze that is at once threatening and seductive . . . He sits next to a tall, rectangular shaped object, which has an oriental carpet hanging over it. It is, in fact, a door. The violin and accordion are playing gently.* (182)

Once the spectators are seated, "*[t]he Doorkeeper sounds the chord on his shovel which has a piano string attached to its length*" and the preshow music halts mid-bar, the unresolved melody left to hang (182). That tone summons full stage lights and the staged world violently erupts. Because the performance begins abruptly, spectators cannot acclimate. They are not primed to enter into the conventions of theatricality, and the staging of the world is unanticipated. Its continuity with their own space remains undeniably present—a fact emphasized by the seating, which situates the audience on opposing flanks. The Doorkeeper stands on stage before the play begins, and thus he dwells in the same world as the audience. Nonetheless, the sharp distinction in lighting distinguishes the stage space as unique, if not spatially isolated. Scenes 1-3 establish the Doorkeeper's control over the staged world. He strums his shovel a second time, which conjures a blackout followed by two pools of light. One focuses on him; Musica appears in the other and raises her hands in supplication. The Doorkeeper continues strumming, and each strum shifts her into a different pose. In short order, the Doorkeeper thus activates the performance

space, distinguishes it from the actual world of spectators, and demonstrates his control over this experiment. This liminality implicates the spectators in the same strange system, and they watch the world onstage alongside the Doorkeeper. The staged world of *Kaosmos* emphasizes the spatial *potentia* of the theatrical ritual and its dependence on the copresence of spectators.

After this ritual, the Doorkeeper strums six times and summons six more performers. First, Man-Who rushes onstage alone. He appears sickly, and "[p]erhaps *he is a drowned man,* perhaps *he has just been violently baptized*" (186, emphasis added). Like the spectators, he too enters from the north door. He comes from the spectator's world, but he enters the space after the performance has begun. He shares in the Doorkeeper's sense of liminality, but context marks him as an interloper. Throughout the play, he too watches the stories unfold; everything seems staged for him (as a lesson, perhaps?). However, he cannot play the role of the spectators' stand-in in this strange world because he speaks Norwegian, not Danish. He speaks the play's first line in a language that is incomprehensible to the audience: "I'm looking for the land where no one dies" (186). He receives no answer. The remaining actors (garbed in folkloric Danish clothes) enter from the south, including Country Man, who approaches the Doorkeeper and begs "admittance to the law." At first, Musica narrates and speaks for Country Man, despite the actor's bodily copresence. In English, she explains that the Doorkeeper denies his request, though "it is possible" that he will gain admittance later (188). These three brief scenes establish the performance's complex relationality. The Doorkeeper oversees the performance space while marking it as continuous with the spectators'; he creates Musica, then summons the interloper Man-Who and various Danish villagers; Musica narrates the story of the Danish villagers. Man-Who is not a mystic power over this space but a spectator whom, due to language barriers, the other spectators cannot comprehend. These crisscrossing signals evolve into a system with

linguistic boundaries and narrative developments, which are hopelessly entangled. Technically, spectators choose which piece of the puzzle to watch, but physical proximity and linguistic compatibility draw them into relations with particular aspects of the performance. Thus, the audience can never resolve the play into a single system, a situation amplified by the fluidity of the boundary between worlds. The performance resists measurement.

Scene 4, "The presentation," opens the multitude of possible worlds within this system of potential. After the six players enter the space, the Doorkeeper introduces each by his or her real name, character, and a brief description. Then, this actor performs a sample of the gestic sequence that later represents his or her world. For example, the Doorkeeper announces, "Roberta [Carreri] plays The Mother who is looking for her child, stolen away by death" (191). Carreri then spins, furiously stamps, and pleads for her child's safety in Italian. When this sequence is later repeated, the activity around her shifts into the world of the Mother. In *Idomeneus*, the chorus walked *as if* they were beachbound to inscribe the beach onstage. *Kaosmos*'s gestic sequences similarly stage a new world, but they lack an environmental connotation. Instead, they shift the abstract relations between actual bodies onstage. These relations never evolve into outright intelligibility, and the stage directions reinforce this necessary vagueness: "*he is like a protecting spirit, or an unseen bogey-man,*" "*perhaps it is a dowry . . . or perhaps it is payment,*" "*perhaps he is just a man suffering cardiac arrest . . . Perhaps this is Christ*," and so on (203, 208, 216-18). *Kaosmos*'s characters indicate space's potential to hold their story, but the absence of a fictional environment retains the sense of *potentia*. In short, rather than collapse into fiction, we see the space where endless fictions could, and indeed do, live. Carreri's sequence entangles nearby performers in the Mother system, and those performers adopt roles to fit the Mother's quest. When Carreri acts as if she were a Danish

villager or another supernumerary, however, she speaks Danish and abandons the Mother's gestic routine. Every routine involved was developed in isolation by the solo performer, then put into a montage. The Doorkeeper names the performer first, and so he entangles the dramatic possibilities of these stories with the performers' actual bodies. Those actual bodies produce meaning in continuous space but do so through stochastic chance: the elements of the montage lack meaning until they enter a relationship that triggers it.

After scene 4, the play develops its three narrative threads, which unfold in a simultaneous montage in the stage space. For example, in scene 23 ("Short threads from different stories remain separate"), Man-Who pontificates on death, the Mother cries for her child while paddling across a lake, and Country Man rings an ersatz doorbell to entreat his entry. Because of their simultaneity, these isolated sequences still inform one another as entangled parts of *Kaosmos*'s system. Country Man sings a children's song, which acts as a soundtrack for the Mother's journey across a lake; the Mother trades her eyes for passage as Man-Who compares blindness to death (227-28). Spectators may focus on one narrative thread, but their measurements lack the causal efficacy of von Neumann's subject. They do not *cause* the play to collapse into meaning. Instead, an individual spectator becomes entangled with the part of the system that she happens to recognize. This unpredictable compatibility reflects the spontaneous nature of objective collapse theories. Entanglement between spectator and performance encourages the *potentia* to collapse into a "galaxy of flashes," a brief moment of recognition (Bricmont 215). This stochasticity is pushed further by the spectator's seating position, which languages she speaks, which references she recognizes, and so on. The audience is always heterogeneous, of course, but here the members' heterogeneity defers the resolution into a singular fictional narrative. Even after she becomes entangled with a scene, however, the rest of

the montage stubbornly persists. The other possibilities haunt the edges of perception like the ghosts of what could have been, had she sat on the other side or had she spoken Italian. *Kaosmos* emphasizes how much chance plays into our understanding and our meaning-making, and never lets us forget that alternate interpretations were possible.

As the performance nears its end, Man-Who grows increasingly alienated from the playing space as the interplay of possible fictions develops into explicit metatheatre. In scene 24, Man-Who finally draws the Doorkeeper's notice, who ritualizes the former's death. First, he places Man-Who in the doorframe, which lies flat as a coffin; then, Musica hands Man-Who a sheaf of corn and summons the Sister; she approaches, scythe unsheathed. However, he refuses to participate in even the liminal space between spectators and villagers, where the godly beings dwell. Instead, he questions the Doorkeeper's power over the space by reasserting actuality: he "*crushes one of the heads of corn against his chest. He then chews the corn and spits it out*" before asking "I just crushed the corn. Was that a real action, or was it theatrical fiction?" The Doorkeeper ignores the "*awkward question*" and abandons him (228-30). The awkwardness does not stem from the threat against fiction; the question is awkward because theatre is always both. A staged world is real activity and represented action. Theatre requires an *as if* posture toward real entities, and the traditional theatre ignores this awkward question. It is rude to expose that which is conventionally hidden. Theatre always indicates the potential in actual things to be otherwise. Man-Who spends the rest of the play "*wander[ing] around chewing and spitting out corn*" while tracking the performance time on his wristwatch (240). As Sykes describes, his unanswered crisis leaves the spectators not with an awareness of theatrical artifice but instead "with the discomfort of being unable to disentangle the real from the fictive" (30; see also States 30-31). This entanglement is purposefully quantum theoretical. He is a real man, aware of his

status as an actor, doing real things; but he plays a role that refuses to play roles. At this moment, Man-Who can only be defined by his relations to the other bodies on stage, devoid of particular semantic content (still, no one else speaks Norwegian) but capable of happenstance flashes of intelligibility.

Once he has crossed this threshold into metatheatre, the play careens toward his death with heightened alacrity. First, the other two stories resolve. The Mother decides that death fits her child better than life, and Country Man collapses before the law. Man-Who then announces:

> MAN-WHO: Time's up now . . . But tell me, who is the protagonist of this performance? *[in Norwegian]*
>
> THE DOORKEEPER: The one who dies at the end. *[in Danish]*
>
> MAN-WHO: Is this theatre? *[in Norwegian]*
>
> THE DOORKEEPER: Yes, this is theatre—a thread made of mischief and guile. The character dies and the actor returns to life. *[in Danish]* (243)

He dies, and the threshold between performance and performer expires. Musica "*undresses The-Man-Who and redresses him with a white skirt and a white bandage round his chest. He dances in a state of tortured ecstasy . . . as he is metamorphosed into a strange looking angel*" (246). Previously, he was dressed in everyday street clothes. Now, he dons a costume and a character for the first time. Where *Idomeneus* and *Play* allow their protagonists to escape the limits of dramatic fiction and regain their *potentia*, Man-Who embarks on the opposite journey. He becomes a fictional entity and relinquishes uncertainty for the strictures of performance. The villagers and the Sister then "*also undress, revealing modern day clothing beneath their old-fashioned costumes. When they drop their costumes they also drop their characters*" (246). Man-Who becomes a character, and the characters become spectators to his transformation. The other

actors regain their *potentia* with this ritualistic undressing and then "sing . . . [and] stamp rhythmically around the stage" in a Dionysian celebration (248). Man-Who's journey into the land where no one dies is the path toward immortality through fictionalization.

The representation of death heralds the death of representation. But still, the performance refuses to collapse into an eigenstate because the performers never truly drop character. The script explains that "*Roberta (who had been playing The Mother), now in a red suede mini-skirt, black stockings and carrying a whip comes and kisses The-Man-Who voraciously, she then leaves him again*" (248). She performs scripted actions and dons a costume, and her interactions with Man-Who (not his performer!) leave her entangled with the staged world. After the celebration, Musica leads Country Man through the door and into the afterlife, as if his tale were never completed. In the final moments, a new character (and actor) enters—The Disinherited Son of the Devil. He plays a jaunty violin tune, which prompts Musica and Country Man to chase one another around childishly. That trio then exits, left somewhere between playacting and merely playing. The Dionysiac song swells once more, and everyone loudly marches out of the playing space. Roberta exits last, and the performance just ends. These lingering fragments of representation and presence leave the levels of reality—staged world as a possibility, actual world, the *potentia* of performance—unresolved. *Kaosmos* refuses to collapse. Instead, it smears its inextricable ontologies levels and then fades, bit by bit, from the playing space.

Kaosmos rebukes our attempt to measure it. Any interpretation lies at the intersection between chance and the impossible task of following myriad threads in montage. *Kaosmos* momentarily collapses whenever it happens to strike a chord with a particular spectator. However, the disconnect between action and narrative retains the sense of stochasticity. Furthermore, the creation process produced an inventory of gestic sequences that act as a set of

possible actions for the performance. Like an actualist metaphysician, Barba arranged those sequences into one possible floorplan. However, those gesture sequences could be arranged otherwise. Sure enough, *Kaosmos*'s material found life in three additional and independent performances: *Inside the Skeleton of the Whale, Doña Musica's Butterflies*, and *Ode to Progress*. Such an afterlife is unique in Odin Teatret's oeuvre. In fact, *Kaosmos* altered Barba's approach to play development: in his words, *Kaosmos* possessed "a mysterious effectiveness and a capacity to produce meaning," which inspired the group to explore "simultaneity and contiguity to its extreme" by rearranging the material (qtd. in Ledger 94). These performances always cast at least one player as "a kind of observer," whose position recalls the scientist's (Ledger 94). As Sykes explains, "[l]ike the box Niels Bohr designed in order to catch the indeterminate interplay between waves and particles. . . . In theatre, like in the surrealistic physics of the twentieth century, everything may assume opposite meanings" (326).

§

When Idomeneus declares, "I become," he announces the dilemma for the protagonist of an actualist world. He exists in a continuous cycle of frustrated becomings, and these becomings open him to the massive realm of *potentia*. At the same time, he cannot confidently say "I am": given these endless variations and subjective perspectives, he loses his sense of self to all the things he could be. His refusal to play the tragic game allows him to stage his free will, but the system sends him back toward death. Likewise, *Play*'s Tony loses himself to the variations as he dissolves into a mess of citations. In the two variations that play out each night, his sense of self is so diminished that he begs his victims for ontological validation. Tony's variations are not

structured around the rules of a genre but his choices. Thus, he equates himself with his freedom to choose. This attempt at self-definition fails, and he fails to locate himself within his looping field of possibilities. In a dramaturgical mercy, Crimp executes Tony. *Kaosmos* sacrifices its protagonist to rescue him from a cycle of refusal. In his ritualistic murder, he gains immortality as a fictional entity (but one who will always repeat the same way, as people read the script or watch the recording). Like Idomeneus, Man-Who tries to cheat death. But Man-Who's linguistic isolation leaves him as unmoored as Tony, unable to figure out his position in an alien context. He retreats into the actual, eating corn and checking his wristwatch. His death pulls him into the fiction, which both immortalizes him and catapults *Kaosmos* to its ontologically tricky conclusion. In these plays, the result is stunningly similar: to break the cycle of variations, repetitions, or *potentia* myopia, the actors drop their characters and return to the dithyramb.

These plays enact three failures to self-locate. First, the characters fail to accept a position eigenstate from among the many possible lives they could lead; aware of superpositionality, protagonists seem unable to find joy or satisfaction in any outcome. The illusory experience of *potentia*—through imbricated subjectivities, mysticism, or theatrical ritual—renders impossible the experience of a single concretized reality. Second, they lose their senses of self to their possibilities. Among the possible lives, their connections to the beliefs, forces, or actions that constitute them erodes. As they lose selfhood, they cling to life for its raw potential and not a particular, actionable outcome. In short, they surrender the value of an obtainable goal for a paralyzing miasma of potentialities. Third, they are disabled by option paralysis. These protagonists linger at a threshold, before a becoming that never becomes. Physical thresholds such as doorways, terminal thresholds such as death, and generative thresholds such as birth and marriage haunt these plays. Crossing a threshold (like taking a measurement) means actively

eliminating some possibilities. Children, pregnancy, and infertility haunt these characters as lost possibilities: Idomeneus's infanticide, Tony's loneliness, Kate's infertility, the Mother's lost child, and Man-Who's inability to embrace the bride. Superpositionality offers freedom of choice, but the limits of society, biology, possibility, chance, and time arrest their evolution and render some potential outcomes impossible. Of course, live theatre always maintains a sense of this potential because the theatrical illusion never erases (and can never erase) the physical bodies beneath the performance. These actors could play someone else. Performance differs night to night, taking the same system in a quantum state and collapsing it into an eigenstate through the measurement of performance.

At the end of the Mother's story, *Kaosmos* offers a convincing explanation for the draw of these actualist experiments. After crossing a lake that one can only navigate if blind, she finds Death's garden. She pleads for her son's life, and Death shows her two possibilities:

> THE MAN FROM THE COUNTRY: [*reading as DEATH*] "I shall name two flowers: Poppy, Forget-Me-Not, and you shall see their whole future, their whole human existence." And The Mother looked down into the well and it was a joy to see how one flower became a blessing to the world, to see how much pleasure and happiness it spreads around and she also saw the life of the other flower, full of sorrow, want and wretchedness. . . . "Which of them is the flower of misery and which the flower of happiness?" she asked. "I cannot tell you that," replied Death, "but this you shall hear; one of these flowers was your own child." (236)

Unable to bear the thought that her child might have blossomed into the flower of misery, she leaves him to die. Even if she must kill him, she clings to her child's potential to have been the flower of happiness. Later, when the Mother disrobes and becomes Roberta, she embraces Man-

Who in erotic ecstasy. The Mother disappears, and Man-Who dies without a Bride, but the potential of a future child remains. In the actualist approach to *potentia*, we cling to that potential life even if we must navigate its endless possibilities blind. In atomic experiments, we can never see a superposition, but we can sense its aftereffects. Our knowledge of wave functions, however, plagues us with an actual entity we can never verify. Any measurement will collapse an entity's potential into a single position. But the potential, even before the collapse, is still actual. When a theatremaker stages an actualist world, that incorporeal potential is made tangible for the observing spectators through the *as if* of the theatrical illusion.

Notes

[1] "Eine Gruppe von etwa zehn bis vierzehn Männern und Frauen. Es können auch mehr oder weniger sein" (Schimmelpfennig 3).

[2] "DREI ANDERE FRAUEN: . . . Alle von denen kämpfen, strampeln, / verzweifelt / / hoffunfslos / hilflos / ums Leben, / nur ums Leben, / und sterben doch,
FÜNF VERSCHIEDENE: ertrinken, krepieren - / wahllos / jung und alt. Es trifft jeden" (6-7).

[3] "SIEBEN: Taub vor Angst / glaubt Idomeneus . . . / / im Tosen des Orkans / / eine Stimme zu horen, / eine Frage:
DREI: Was / was versprichst du zu tun, / wenn du am Leben bleibst? / Wenn du das hier / überlebst, / was tust du dann?" (Schimmelpfennig 10).

[4] "Wozu habe ich gelebt, gekämpft, / wenn ich so sterben muß./ Ich bin noch nicht so weit!" (22). German has several question words that translate to the English *why*. The sense of *Wozu* is *for what purpose* and must be answered with a *goal*. It is, in short, a teleological question compared to the more common *Warum*.

[5] "DER ZWEITE MANN: So war es nicht:
DIE FRAU: so ist es nicht gewesen.
DER ERSTE MAN: Es ist so gewesen" (22).

[6] "So war es nicht: / so ist es nicht gewesen. / Es ist so gewesen: / / Die Wellen rollen langsam an den Strand: / / Versprochen ist versprochen. / Versprochen ist versprochen. / / Der leere Strand. / Der Mann. / / / Der leere Strand. / Der Mann. / / Das Leben. / Was für ein Geschenk. / Die Wellen. / / Versprochen ist versprochen. / / Ich bin Idomeneus, und ich hänge / / am Leben, / ich hänge / / am Leben" (73–74).

[7] Put differently, every true statement must relate to actually existing entities, laws, or relations; otherwise, the statement is false by failure of reference. In turn, this requirement stems from the lineage of logical positivism, which expects any robust philosophical system to have a method of verifying the truth of statements. Simply put, logical positivists argued that every meaningful statement must be about empirical observables or relate to distinct entities. Ludwig Wittgenstein's *Tractatus Logcio-Philosophicus* and Alfred North Whitehead and Bertrand Russell's epic *Principia Mathematica* offer the clearest examples of this project.

[8] This requirement descends from the Barcan formula, $\Diamond\exists xFx \rightarrow \exists x\Diamond Fx$, which one can read roughly as "If F could possibly exist, then there exists an x that is possibly F."

[9] Others, such as Bernard Linksy and Edward Zalta, argue that possible entities that never obtained concreteness exist as a trace in the logical structure of reality (trace actualism); others still, like Bennett, advocate strict actualism that treats propositions, statements, or similar units as actual abstract entities. This dissertation does not delve deeply into the intricacies of different version of actualism. I seek only to delineate the ontological presuppositions of contemporary theatre performance, not the "correct" answer to reality's basic materials. In other words, I am

interested in *Idomeneus*'s ontological commitments, not in the conformity between those commitments and fundamental reality. For a better overview of these stances, see Armstrong 3–13; Linsky and Zalta 445–50; Bennett 315–20.

[10] "am Strand . . . nichts . . . Felsen, Sand, Steine, / / Wellen. Sonst nichts. Ein paar Bäume . . . Keine Eidechse. Kein streuenender Hund, kein Käfer. / Nicht einmal ein Vogel in der Luft. / Gar nichts, niemand da" (Schimmelpfennig 18).

[11] "EIN MANN UND EINE FRAU, BEIDE NICHT MEHR JUNG" (4).

[12] In the German script, the sequence leading to Idomeneus's emergence supports this reading. The questions that summon Idomeneus's becoming—"what will you do?"—request an active subject: the hurricane utters the nominative form of "you" (*du*) four times but never the accusative or dative forms (*dich* or *dir*). Likewise, when the chorus erases an event and rewinds the tale, the exchange "[t]hat's not what happened: / so, it did not happen that way" ("[s]o war es nicht: / so ist es nicht gewesen" [22]) involves a negation of the verb *werden.* It might be more directly translated as "[s]o it was not:" / "so had it not become."

[13] When I say position eigenstate (which I often shorten to eigenstate), I refer to a position that is as accurate as can exist within the limits of the uncertainty principle. One ought to add "within the limits of uncertainty principle" each time, but that would add significant bloat and no real clarification.

[14] Most famously, physicist Fritjof Capra's *The Tao of Physics* positions "eastern" mysticism as quantum theory's precursor. Quantum mysticism has its allure, but it tends to trivialize the accomplishments and particularities of both mystical traditions and atomic science.

[15] Crimp takes pains to establish that the blind Lamine is the only person who can continuously dwell outside measurement and actualization. Although this performance is not in any way blind, Sack dedicates a chapter in *After Live* to examining how blindness allows objects to retain some of their potential as art pieces instead of narrowing their expression into a singular possibility (116–24). The similarities are notable (and repeated with the blind Mother in *Kaosmos*).

[16] For an example of the sort of thing such thinkers are trying to avoid, see Alfred North Whitehead's process metaphysics in *Process and Reality*: an ontology designed to weather any change to the scientific paradigm. Whitehead finds it necessary to posit an original subject, which he calls *god*, at the beginning of the universe. The original subject's only role *in* the universe is to establish the opening relationships between objects and, by extension, the first collapse that permits all subsequent collapses.

[17] This approach is technically known as *Quantum Mechanics with Spontaneous Localizations* (*QMSL*). Its most popular formalization is *Ghirardi–Rimini–Weber theory* (GRW). Most of my discussion of *objective collapse theory* follows the GRW approach (see Ghirardi).

[18] For example, in interviews, Barba extols Brecht's unique ability to "measure[] himself against that which is essential": Brecht developed original pieces but always measured those works against scientific achievements, great works, and an objective reality (qtd. in Sykes 2; see also Chapter 1).

[19] All quotations from *Kaosmos*'s script are taken from Leo Sykes's dissertation, which includes the entire script. She was an assistant director for the performance, and her dissertation includes an English translation. *Kaosmos* offers us a rare opportunity to see a single language script with a documented rehearsal process of an Odin Teatret performance.

Conclusion: . . . When Acting as a Wave

After the preeminent physicist's sudden death in 1955, Bertolt Brecht set to work on his *Leben des Einstein* (*Life of Einstein*) piece once more. The project had already become something of a white whale for the playwright. In life, the pair were friendly. Their long-running correspondence began in 1939, and they shared fervent socialist politics. However, the scientist had also retained a conservative view of reality. He had denounced quantum theory on metaphysical grounds before leaving the field, as he demanded strict causality as an immutable axiom. Parts of *Einstein* portray the scientist's work with sympathy. He mistakenly rejects the quantum theory, but, in Brecht's play, his zeal for causality stems from his understanding that "revolutions [both political and scientific] need a good cause."[1] Brecht uses the term *Kausalität* to mean both scientific causality and political cause, applauding Einstein's intuition through his odd terminological choice. But Brecht sours on Einstein's role in the proliferation of nuclear arms. With sarcasm that echoes *Leben des Galilei*, *Einstein* wryly states that "myths of Hiroshima reach Princeton" and "the populace fearfully looks to the great Einstein, champion of peace."[2] Brecht cannot resolve Einstein's complementary faces. He was a socialist and the revolutionary voice behind relativity; he implored the Americans to invest in atomic weapons and rejected the new science of quantum theory.

Earlier in the draft, Brecht describes a scene where "Einstein watches as his best students turn away from questions of why and toward questions of how (quantum theory)."[3] Einstein focused on the *why* of an ordered universe, his famous dictum that God does not play dice. However, his intellectual opponents offered an epistemology of *how*, later dubbed *practical realism* by Werner Heisenberg. Niels Bohr, Heisenberg, and the other new quantum theorists proposed an elegant innovation over the classical approach. When confronted with

incomprehensible experimental results, they refocused the scientific paradigm on the observable *hows* instead of the nebulous *whys*. In turn, they developed a new mechanics of measurements. Brecht's aesthetic of conscious theatricality likewise privileges the observable. Their observables were the black spots on photoelectric plates or the water droplets in cloud chambers; his were actors, sets, and stagehands, human bodies and things in space. Brecht's experiments on stage approximate with eerie precision the practical realism and complementary viewpoints that undergird the Copenhagen interpretation of quantum mechanics. Brecht even elucidated his theory of character as an atomic man in 1926, the same year that Heisenberg published the paper that engendered the quantum shift. In sum, however much Brecht's politics aligned with Einstein's, his metaphysics and epistemology reflected his peers in the Copenhagen generation.

Yet Brecht never named Heisenberg's work as an influence, and Heisenberg's anti-communist politics and role as a German physicist in World War II alienated the pair politically.[4] In writing *Einstein*, Brecht had stumbled into the same puzzle that would consume Michael Frayn's *Copenhagen* (1998): the story of atomic science had neither classical nor Brechtian heroes. "Atomic physics will one day be converted into literature," Brecht's collaborator Manfred Wekwerth writes, "but Brecht's attempts to write an Einstein play prove just how difficult that is."[5] *Einstein*'s final draft is three fragmentary pages. Brecht instead spent his last productive days tweaking *Galilei*, which spied atomic physics through the hazy cloud chamber of metaphor.

Brecht and the Copenhagen interpretation offer a strained initial point of convergence, but this dissertation traces parallel tales of subsequent divergence. Since the mid-century, other interpretations of quantum mechanics have proliferated. Where the Copenhagen interpretation centred on the *how*, most subsequent interpretations of quantum mechanics return to Einstein's

why. As explored in Chapters 3 and 4, David Bohm proposed a causal interpretation at Einstein's urging in 1952. An unseen wave choreographs his reality, a hidden *why* beneath the strange experimental and mathematical results. In 1961, Eugene Wigner plotted a radically different course. In his depiction of reality, the physical world relies on consciousness. It would not exist as we know it without conscious beings supplying a *why* through an act of observation. In 1968, Bryce DeWitt offered yet another solution. The experiments and mathematics are precisely correct, he opined, so long as we accept a multiverse of worlds, whose totality is causal, deterministic, and complete. Rather than accept reality as fundamentally unknowable, these physicists sought to reposition physics on a compelling *why* that ameliorated the oddities of previous discoveries. To do so, one needed a position beyond human experience—either at the scale of a superior entity or in material reality's underlying fabric.

As Hilary Putnam outlines in "A Philosopher Looks at Quantum Mechanics (Again)," the interpretations of quantum mechanics continue a history of forking paths. One may propose the existence of some persistent entity (i.e., the wave function), which reduces quantum strangeness to a byproduct of our ignorance. This strategy culminates in the collapse-free theories. Alternatively, one may regard reality as deeply stochastic, randomly jumping into focus, smearing into a wave-like haze, and then collapsing into focus again. This approach posits collapse theories. Persistence, the primary feature of collapse-free theories, saves determinism by sealing the universe's fate in an inaccessible, higher order. An utterly deterministic universe is, in principle, scrutable to scientific objectivity. But this tactic trades the uniqueness of our world for an infinite sea of others (either occupied, per many-worlds theory, or empty, per pilot wave theory). Inconstancy, the core feature of collapse interpretations, trades strict determinism for a more local reality. This stance saves our world's prized position as the sole robust world and,

moreover, restricts science to the domain of sensible things. But it describes an irrevocably alien reality, characterized by quantum leaps, discontinuity, and chance. In a collapse-free picture, our universe might be one small cog in a clockwork multiverse, but we will never see the rest of the machine. In the collapse picture, our universe is the sole robust one, but the reality is fuzzy and practically unknowable. Today, both routes still win adherent physicists and philosophers.

As physicists work through the Copenhagen interpretation, theatremakers tackle Brecht's artistic legacy. Artists and physicists have arrived at resonant twin solutions. On stage, the sparring paradigms re-examine theatre's most ancient themes. The debate between free will and fate finds a tense middle ground. Characters either experience free will in a fatalistic reality or experience fatalistic constraints in a free reality. The collapse-free theories—whether pilot wave or many-worlds—match those plays that present a fatalistic reality. Playwrights like Jennifer Haley, Yasmina Reza, and Nick Payne subject characters to the machinations of an enigmatic, infinite, fatalistic system. The play, its writer, and the theatre itself choreograph the characters' fates, and the actors dutifully follow. Their ontological ignorance as inferior beings (i.e., characters in a play, not humans in the auditorium) guarantees their inability to interfere with the higher-order reality. These playwrights present reality as deterministic at a macroscale. Individual lives are tethered to single threads of the immense many-worlds fabric. So positioned, we cannot self-locate. So ignorant, we feel *as if* we have free will. From its superior vantage point, which the theatre always provides, the audience witnesses a simulation of the macroscale. There, the dictates of fate reveal themselves in uncaring splendour.

The collapse interpretations, which embrace discontinuity and randomness, resonate with the plays that promote free will but find it constrained by circumstance. Theatremakers like Caryl Churchill, Martin Crimp, and theatre group Odin Teatret discover spontaneity and

potentiality within their characters'/actors' bodies. One body, they posit, possesses discontinuous possibilities that leap into being. However, characters are trapped by relational worlds, where people, places, the government, and social institutions are oppressively entwined, and likewise the actors, the theatre, and the audience. In a double-slit experiment, an electron has the *potential* to pass through the left slit or the right slit. However, if one closes the right slit, then the *possibility* of moving through that slit vanishes. In other words, the world's current matrix of relations irrevocably restricts the potential of all inhabitants. History, social systems, and cultural myths limit our possibilities, which are sometimes meagre (or even singular). So tangled, these characters cannot locate their essential selves—that boundless potential. So ignorant, they define themselves through their relations. Theoretically free, they are practically ensnared by circumstance.

Throughout this dissertation, I analyze the interpretations of quantum theory and the performance ontologies as counterfactuals. Quantum theory involves several levels of counterfactuality: different interpretations are counterfactual descriptions of reality (*if* there is a persistent wave, *then* . . .); each interpretation explains what the other ways an experiment could have gone *are* (*had* I set up the experiment differently . . . *if* the electron appeared here . . .); and thought experiments offer counterfactual fictions (e.g., *if* the photon appears here, *then* the cat dies . . .). The quantum theatre evinces a similar nested structure of counterfactuality: a performance stages a counterfactual reality, itself comprised of many worlds or possibilities, which are in turn fictionalized into narratives. In both cases, I adopt the philosophical notion of possible worlds, a tool for counterfactual acknowledgement, and the two common ontological interpretations thereof. With *actualism,* our single world contains all possibilities latent within it, though this requires us to accept the existence of irregular entities. According to *possibilism,*

there are many (or two) worlds, equally real, but separate modes of being. The parallels to the interpretations of quantum mechanics are immediately evident. In theatre, the competing ontologies align with the historical divide between actual presence and fictional representation.

I have avoided judging the interpretations of quantum mechanics themselves. Of course, I find some interpretations more plausible than others, but I am in no place to critique the work of physicists and philosophers at the cutting edge of science. The performance ontologies, however, deserve some additional evaluation. The many-worlds element of possibilism entices some playwrights. After all, theatre broadly shares contours with these interpretations. Plays are staged night after night as separate worlds, one evening's staged world has no access to the others, multiple productions of the same play exist with wildly different worlds, the script and its drafts add yet more worlds, and so on. In the many-world and pilot wave theories of physics, these other worlds evolve in parallel to one another. Due to the practical limits of actual space, the plays that evince this sort of *possibilist* ontology instead stage their worlds in sequence or series. Often, theatremakers underplay this dissonance through clever plotting. For example, Nick Payne's *Constellations* constructs an unbroken dramatic trajectory despite rapidly transitioning between worlds. Scenes are set worlds apart, but they evolve through the same temporal plot centred on one relationship's counterparts. Payne emphasizes the thrust of his characters' lives across worlds and occludes the lack of simultaneity. Other playwrights turn to science fiction devices, which set the protagonist adrift between the multiverse's supposedly dislocated realities. For example, in *Possible Worlds*, a supervillain's devious apparatus lifts the protagonist's consciousness to the level of a director's or playwright's. From there, the protagonist spies his multiverse from the critical distance often afforded to a spectator.

Here lies a tension between modal ontology and theatre. A spectator accrues knowledge about a whole multiverse through the actual time of performance. In plays like *Possible Worlds,* the protagonists achieve an otherwise impossible transworld identity and thus build knowledge alongside the audience. However, this tactic situates characters in the liminal space of metatheatre and excuses them from the dramatic logic of the many-worlds on stage. In turn, these tactics risk revealing the inherent actuality of the theatregoing experience. On the one hand, every production generates many separate worlds across its daily performances. On the other hand, average theatregoers attend one single performance. Theoretically, I understand that *Richard III* played the night before I attended, and it will play the night after. However, I witnessed one performed actuality. The other worlds are, from my perspective, objects of thought. Simply put, the process of theatregoing foregrounds the theatre's transient immediacy and occludes its many-world features. In a possibilist universe, other possible worlds are objects of contemplation and not experience. Likewise, other productions and performance are objects in memory. But plays that stage a multitude of possibilist worlds during one performance face the limits of sequentiality and ephemerality. In any given moment, the spectator's perspective is superior to that of the characters; but the lack of simultaneity between worlds leaves the macrostructure outside human experience. The possibilist elements of these plays require the spectator to continually compare the single actuality before them with the other actualities throughout the night. Of course, physicists face an analogous issue. A specific experiment can only be performed once, and other outcomes must be inferred from similar experiments performed in sequence. In other words, our experiments are sequential, and we extrapolate from their similarities (in initial conditions) and differences (in outcomes) to a theory of simultaneity. In short, theatremaker's struggle with possibilism matches those of science.

But possibilism attracts philosophers precisely because it grounds modality while safeguarding an absolutely deterministic actuality. We postulate the existence of other worlds to discuss counterfactuals without suggesting that our world *could have gone otherwise*. When I speculate "had I eaten breakfast this morning, I would be less grumpy," I consider a world simultaneous to my own, where my counterpart ate breakfast this morning. At this very moment, I conclude, he would be less grumpy. My reasoning about that world is only valid, however, if we assume that my counterpart's world adheres to a fundamental causality. In other words, the strict demands of a possibilist picture require each world to evince a causal structure, or the small worlds will not appear conceptually accessible. But causality, by definition, unfolds in time and cannot be demonstrated otherwise. In order to present the small worlds as causal-in-themselves, theatremakers must present them one-by-one, so that spectators can recognize their cause-and-effect structure. But this restriction conflicts with the simultaneous evolution required by the many-worlds and pilot wave ontologies. Were Payne to set *Constellations*'s worlds on stage at once, its narrativity (and fatalistic themes) would disintegrate. The spectator's decision to focus here or there would foreground the transient actuality of the event and the freedom of choice. A possibilist staged world retains its embeddedness in the actual even as it refers to faraway lands.

In contradistinction, actualism's bizarre discontinuities fit the vagaries of the performance context at its most extreme. These plays are happy with simultaneous experiences because there is one world, shared by spectator and character alike, shot through with relations. However, performances of this kind tend to sacrifice causality. Odin Teatret's *Kaosmos* intrigues its audience, but the experience of spectatorship is an impressionistic fugue. Like the collapse theories, actualist plays privilege immediacy and locality over narrativity. However, they must confront the fact that our cognitive apparatuses narrativize the world. Our brains are continually

collating sensory data into a cause-and-effect structure to support our movement through space (Chapter 2). If a play's world is elusive, the processes of cognition are taxed and aggravated. Caryl Churchill's *Traps* (1978) thwarts most attempts to stage it because of this very issue. By trying to foreground the potentia that dwells within each body, *Traps* abandons our causal anticipations even as it presents realistic situations in a continuous space. The resulting play communicates the experience of indeterminacy but bucks sensibility. Possibilist staged worlds are readily dramatic and easily digested as representations. Actualist worlds are intractably experimental. Actualist realities are undoubtedly performative, but their boldness often alienates. It is no surprise that many-worlds possibilism finds more purchase in commercial theatre than actualism's extreme relationality.

Of course, almost every play evinces aspects of both paradigms. Every possibilist staged world seems to emerge from the bodies of performers and actual objects at the level of moment-by-moment experience. And every actualist staged world seems to represent some isolated elsewhere, even if that elsewhere appears momentary and fractured. Take the particularly germane case of María Irene Fornés's *Fefu and Her Friends* (1977). Its first and third acts are realistic dramatic situations. The second act, however, is environmental, playing throughout the theatre space. The eight characters veer off into four pairings, and each spectator moves to and watches one of these threads. In effect, she tackles the possibilist problem by mixing simultaneity and sequence. At the same time, the other three scenes (each with its own micro-audience) play in other areas of the space. Fornés captures actual simultaneity in this acutely theatrical moment, and her worlds are spatially distinct. However, after the end of the concurrent scene, they repeat four times, so that spectators may watch each. The issue of sequentiality creeps back into the event as spectators circle the venue. Furthermore, characters move between

areas of the auditorium during that simultaneous scene (i.e., they move between the worlds). And so, the actuality of theatregoing asserts itself. The narrative structure, the repeatable nature of performance, and the existence of a script betray its guiding determinism. The embodied moment-to-moment experience of watching and being watched is undeniably actualist.

Throughout this dissertation, I demonstrate that possibilism and actualism offer robust analytical tools to theatre scholars. They help parse the ontological commitments of individual plays, genres, and live performances. Most plays construct their worlds around one set of commitments over the other. In other words, plays stage worlds whose performance ontology mostly commit to one paradigm. The same is true, of course, in science. Physicists must always balance the ideality of mathematics and actual observations. In this dissertation, the framework of modal ontology bridges staged worlds, our perception of the theatrical event, and the paradigmatic theories of science. In the second chapter, I present a cognitive theory of theatre as an experienced counterfactual (which I call a staged world). In that account, all perception has an underlying counterfactual structure, cognitively embodied in actual neurons, unconsciously parsed as possible ways the environment could be, and presented to conscious awareness as the actual world. In other words, the structure of perceptual experience supports both counterfactual paradigms (as an actual object or speculated possibility). This counterfactual approach to theatre reveals profound similarities between theatre and science as processes, forever bound up in actual findings and counterfactual explanations. This analysis extends far beyond the quantum theatre examined in this dissertation—any performance can be elucidated through this method.

Since the origins of quantum mechanics, theatre and physics have shared an intense period of epistemological upheaval, complex experiments with unexpectable results, and metaphysical angst. Through Brecht and the century that followed, the theatre played a part in

the articulation of this new reality. Even now, when quantum mechanics is nearly a century old, the history of interpretation and revision offers valuable lessons. Recently, a spate of commentators analyzed developments in politics through the history of quantum mechanics. In his article for *Quartz,* for example, Parag Khanna writes "[w]ant to understand how Trump happened? Study quantum physics." He champions quantum-theoretical interpretation as a model for disentangling fundamentally irresolvable geopolitical problems. Others, however, have tethered quantum mechanics to postmodernism and blamed the pair for the slide toward post-truth relativism. When *Oxford Dictionaries* chose "post-truth" as the word of the year in 2016, we could not help but ask: in contemporary discourse, brimming with "alternative facts," what does it mean to say something is true (Flinders)? Clickbait fake news, blatantly partisan reportage, amorphous inaugural attendance, the careless handling of facts by politicians and pundits, social media and its increasing role in social and political life: these factors threw a stark light on our cultural relationship with the truth, facts, and reality.

Bohr, Einstein, Heisenberg, Schrödinger, and Brecht faced the same question at the birth of quantum theory. They did not respond to an eroding epistemic faith with anything-goes relativism, however. Instead, quantum theory teaches us that, despite a fundamentally unknowable reality, we can yet devise frameworks that distinguish between the viewpoints that are anchored in a shared reality and those that merely disregard facticity. Complementarity*,* the Copenhagen notion that contrasting explanations of phenomena offer valid-yet-incompatible pictures, pushes us to admit to our positionality when fixing our objects of analysis. We participate in one reality, but we must remain acutely aware that our framing apparatuses obfuscate most of it. In the practical realism of quantum mechanics, an underlying reality establishes the boundary conditions of all possible experiences. With those borders firmly

established, we can both respect subjective orientation and retain a shared world where meaningful action of all sorts remains.

To this day, commentators and philosophers alike point to the theatre as a metaphor for dishonesty. Daily, pundits decry "political theatre"; in *On Truth*, Simon Blackburn compares "play-acting" to "bullshit," an utterance "where there is no assertion made [about truth or falsity] but only the appearance of one" (58). Blackburn's throwaway example demonstrates the ingrained nature of this antitheatrical bias. Working precisely in the very medium that has long roiled detractors, these quantum plays loudly disagree with Blackburn. Instead, they echo the interpretive movements of atomic physics. Moreover, they do so with political and scientific efficacy in mind. Theatrical performance can coach spectators toward a conception of reality, make tangible the ramifications of our metaphysics, and explore human potentiality and its systemic limits. By reframing anxieties that have plagued theatre since Attic Greece—that generative tension between our experience of free will and the logic of determinism—quantum theatre suggests a way forward. Reality is bizarre but interpretable, flexible but not all-permissive. Infinite possibility does not mean that everything is possible. Instead, our shared potential is always a negotiation between complementary pictures, relational restrictions, and irrecoverable circumstances. Some limits on our potential must be questioned because they eliminate laudable possibilities and entrench cycles of suffering. Other restrictions may be embedded into the fabric of reality, a guiding equation at the edge of our perception. Theatre, physics, and philosophy have articulated and mapped these boundaries in a mutually beneficial exchange throughout the twentieth century.

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[1] "Ihre Theorie ist ein Aufstand und für Aufstände benötigt man eine gute Kausalität" (*Werke* 10: 984).

[2] "Kunde von Hiroshima erreicht Princeton. Die Bevölkerung sieht mit Furcht auf den großen Einstein, den Vorkämpfer des Friedens" (10: 984).

[3] "Einstein sieht seine besten Schüler sich von der Frage des Warum zur frage des Wie wenden (Quantentheorie)" (10: 984).

[4] I have opted to largely avoid Heisenberg's role in World War II. In precis: he was in charge of one (of two) nuclear programs for the Nazis. According to British intelligence, his branch never pursued atomic weapons despite pressure to do so. When pressed by the Nazis, Heisenberg had claimed that a weapon was unfeasible. Yet his computations played a central role in the Manhattan project. His motives attract heated debate. It is unknown whether he sabotaged Nazi efforts to weaponize the atom (as he sometimes claimed), if he failed to understand the mechanics of an atomic bomb (as his detractors rebut), or, perhaps the most likely, if he was single-mindedly focused on a reactor and never gave the bomb much thought. In any case, Heisenberg was a fervent nationalist yet not a member of the Nazi party. Johannes Stark, a physicist and member of the Nazi inner circle, publicly proclaimed Heisenberg a White Jew and a pacifist. But Heisenberg's wealth of familial connections (most notably, between his mother's family and Heinrich Himmler) spared him the worst of Nazi investigations. For opposing views on this debate, see David Cassidy's *Uncertainty: The Life of Werner Heisenberg*, Thomas Powers's *Heisenberg's War: The Secret History of the German Bomb*, and Michael Frayn's play *Copenhagen*.

[5] "Sicher wird man einmal auch solche Fälle in Dichtung umsetzen, aber wie schwer das ist, beweisen Brechts Versuche, ein Einstein-Stück zu schreiben" (266).

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