THE COST OF QUANTIZING: EXPLORING THE STAKES AND SCOPE OF QUANTUM INTERNATIONAL RELATIONS

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Abstract

Quantum approaches to International Relations theory have proliferated rapidly in recent years, challenging the field to come to terms with the influence of physics at its philosophical foundations. These new theoretical perspectives draw on quantum physics, quantum social theory, and prior quantum interventions in other disciplines of social science. But unlike prior debates around the desirability of "adding" science to the study of world politics (Morgenthau 1946; Kindleberger 1958; Bull 1966), the call of quantum IR theory is one for transformation (Barad 2007; Fierke 2022; Murphy 2021c; O'Brien 2021; Zanotti 2018). In this dissertation, I explore the *stakes* and *scope* of this quantum transformation to better understand the process of quantizing inquiry into International Relations. The first chapter sets out the metatheoretical stakes of quantizing IR by engaging with critical responses to prior works of quantum. Situating quantum approaches in the broader intellectual history of the field, I argue that understanding the "cost" of quantizing IR cannot take the form of a cost/benefit logic, instead recognizing the opportunity cost of remaining Newtonian. The second chapter turns to the development of quantum mechanics within physics to demonstrate the relatability of key concepts for social inquiry, despite the vernacular divide. The third chapter turns to methodology, discussing the philosophical sources supporting 'quantizing through translation,' drawing on both the quantum social theory of Karen Barad and broader influences including Walter Benjamin, actor-network theory, and Donna Haraway. The next trio of chapters serve to demonstrate the breadth of quantum's utility across the discipline through a set of conceptual case studies related to major subfields of IR. The fourth chapter speaks to debates in peace and security studies, and provides a quantized account of violence through a diffractive reading of Johan Galtung's "Violence, Peace, and Peace Research." The fifth chapter turns to foreign policy and strategic studies, arguing that the non-traditional diplomatic strategy of "track two diplomacy" abides a quantum game-theoretic logic, and that this can only be fully appreciated by interrogating its quantum-like assumptions. Chapter six then addresses international political economy through an attempt to redefine "the market" in quantum terms. Recognizing the stakes and scope of quantum IR explored through the dissertation, the conclusion reaffirms the case for quantum to be understood as transformation rather than addition, and sets out future directions for research in quantum IR.

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Introduction

> *"Matter and meaning cannot be dissociated, not by chemical processing, or centrifuge, or nuclear blast. Mattering is simultaneously a matter of substance and significance, most evidently perhaps when it is the nature of matter that is in question, when the smallest parts of matter are found to be capable of exploding deeply entrenched ideas and large cities." (Barad 2007, 3)*

The Stakes and Scope of Quantum International Relations

This dissertation explores quantum International Relations, in an effort to question the unquestionable and imagine the unimaginable. But at the same time—and in a completely opposite way—this dissertation is also a rediscovery of the familiar, the quotidian, the established. For all its conceptual novelty, one of the core lessons of quantum International Relations is how profoundly structured by physics our collective imaginaries have always and already been. Quantum IR is a project of (re)discovery.

I think that this double-claim of quantum IR is too often overlooked, and if we do not recognize that we are all subjected to the boundaries of our imaginaries, then we are doomed to miscalculate the value of the quantum leap in IR theory. That is why this dissertation begins with a clarification of the "cost" of quantum, where I suggest not only that the cost-analysis applied to quantum must follow a transformative logic rather than an additive one—an analysis of opportunity cost rather than cost/benefit—but also that there are sufficient precedents for recognizing imaginaries' impacts in IR theory that physics-phobia alone cannot justify the miscalculation of quantum's value any more than physics-fetishism can exaggerate it. Chapter 1 takes stock of the assessment of quantum IR from its thoughtful skeptics, separating what falls into the margin of error between cost-logics and what questions remain open for quantum IR to address. Chapter 2 then turns to the development of quantum mechanics, reviewing the concepts and developments in quantum physics necessary to engage in the debates around quantum IR. While quantum may appear at first to be a foreign language, the content of the concepts is sufficiently familiar that following along with quantum IR should be no more difficult than adapting to the

language of any other scholarly tradition. Chapter 3 discusses the method of quantizing by translation, expanding on the original discussion that I presented in *Quantum Social Theory for Critical International Relations Theorists* (Murphy 2021) by further reviewing the philosophical-methodological influences of Walter Benjamin, actor-network theory, and Karen Barad and Donna Haraway.

Quantum IR is not limited to a certain subfield or theoretical perspective in International Relations, and after the first trio of chapters outline the framework of quantum IR (metatheoretically, physically, and methodologically), the next three demonstrate the breadth of quantum's applicability by engaging conceptual case studies across the discipline. By "conceptual case study," I refer to the methodological treatment of concepts as cases. Case studies are well-established in debates around research design in International Relations, especially in projects of conceptual innovation (Bennett & Elman 2007, 178). Drawing on the familiar use of what Levy (2008) calls "illustrative case studies" that function as plausibility probes for a theoretical argument, but informed more directly by principles of research design developed in critical security studies (Salter 2013, 16-17), my guiding methodological assumption is that if empirical cases generate conceptual insights at a first level of abstraction, then it should plainly follow that conceptual case studies—that is, concepts treated as case studies—can similarly generate conceptual insights at a higher level of abstraction. While I have previously argued (Murphy 2020) that concepts can serve as case studies to describe individual philosophical projects,[1] this dissertation moves from the exploration of philosophers to the exploration of the imaginary. To this end, the three conceptual case studies provide not only particular insights into the applicability of a quantum imaginary in the specific subfield of each chapter, but—taken as a whole—also ground a philosophical claim that the imaginary is relevant at a foundational level to social inquiry taking place in the field of International Relations. Chapter 4 provides a quantized account of structural violence, responding to

[1] In the book chapter referenced, I argue that the influence of Simone Weil on the thought of Giorgio Agamben can be established through a conceptual case study analysis of Weil's concept of "decreation" and Agamben's concept of "destitutent potential," specifically as Agamben diverges from the political project of Walter Benjamin.

security and peace studies. Chapter 5 addresses foreign policy and strategic studies literatures by arguing that track-two diplomacy abides a quantum-like strategy of social entanglement. Chapter 6 approaches the difficulty of defining the market in international political economy by articulating a quantum model of economic structures. The final chapter then provides concluding remarks and outlines the implications of the dissertation research project.

Quantization, Imaginaries, Critique

By way of introduction, I wish to clarify the status of quantum in my approach to International Relations theory. As James Der Derian and Alexander Wendt (2020) note in their special issue of *Security Dialogue*, there is no single quantum theory of IR, but instead quantum approaches in the plural. Similarly, both quantum social theory and quantum social science include a variety of approaches (e.g., Barad 2007; Haven & Khrennikov 2013; Orrell 2018), which inform this project but form which I remain distinct. For this reason, an essential step in setting the stage is to clarify how I approach quantum thinking—not as actuality or analogy, but imaginary. By more clearly explaining how actuality-driven and analogy-driven approaches operate, I will clarify the fuzzy boundaries that separate the imaginary-driven approach from its alternatives. While I recognize the importance of clarity, I must also note that describing this trio of quantizing drives, I do not want to suggest that there are only three paths. The boundaries between these paths are fuzzy—a point perhaps made most clearly by Danah Zohar's (1990) frequent drifting across the actuality/analogy "boundary"—and each drive opens up space for diverse interpretations, methodologies, and conceptual investigations. Like stage directions describing the set as a curtain rises, my preliminary remarks will sketch the contours of a complex conceptual stage upon which the drama of quantum IR unfolds.

Quantum approaches to social science grounded in a claim of actuality justify the move to quantum theory on the assumption that social reality is—in a fundamental way—quantum. That is to say, *contra* assertions that quantum is a property bounded to the microscopic that necessarily decoheres at

the larger world of human interaction, there is an as-yet-unrealized (at least experimentally) quantum coherence at the human scale. This is obviously a bold claim, and the strongest proponents of actualist approaches to quantum social science do not shy away. Scholars of International Relations will be familiar with Wendt's quantum mind approach, which stakes an avowedly actualist claim in the early pages of *Quantum Mind and Social Science:*

> I argue that human beings and therefore social life exhibit quantum coherence – in effect, that we are walking wave functions. I intend the argument not as an analogy or metaphor, but as a realist claim about what people really are… While one could read this book entirely in that way, as an interesting analogy, my personal belief is that human beings *really are* quantum systems. (Wendt 2015, 3).

If, in the long run, quantum coherence is discovered at the macroscopic scale of human life, then the quantum actualists will be vindicated. Actualists claim that quantum ideas are relevant to social science because the substance of sociality itself *really is* quantum. While this approach is vulnerable to a particular kind of scientific dismissal from those who eschew theorization that explores beyond the experimentally known and knowable, it also makes great strides in unifying social and physical, natural and cultural, scientific and humanistic.

A second cluster of approaches presents quantum's relevance as a matter of insightful metaphor or analogy. Agnostic if not opposed to the actualist claim, the analogist proposes that social phenomena exhibit patterns that are like the patterns analyzed through quantum mechanics. Like the classical[2] econophysicists, quantum-like modellers in finance and economics explore how physical equations can help to explain, explore, and predict economic phenomena.[3] In *Ubiquitous Quantum Structure*, Andrei Khrennikov clarifies the analogist inspiration for his inquiry in the very first sentences of the work:

> The *Quantum-like paradigm* (QL) is based on understanding that the mathematical apparatus of quantum mechanics (and especially quantum probability) is not rigidly coupled with *quantum physics*, but can have a wider class of applications. (Khrennikov 2010, 1).

[2] Throughout the dissertation, I will use "Newtonian" and "classical" as per the conventions of the field under analysis.

[3] See Haven and Khrennikov (2013) for the relationship between econophysics and the quantum-like paradigm.

Leaving little room for misinterpretation, Khrennikov is clear in his demarcation of "quantum" phenomena that have *quantumness* from "quantum-like" phenomena that have *quantum-likeness.* Conscious of the significance of this difference, his analogist claim preserves a clear distinction between physics and non-physics by respecting the terminological specificity of Q and QL:

> As a comment on the use of the notion quantum-like (QL) behavior, I think that it would be useful to preserve the term "quantum" for quantum physics while, in other models which are still based on quantum or, more generally, non-Kolmogorovian, probabilistic description, we should use the term "quantum-like". (Khrennikov 2010, 7).

While the mathematical models driving analysis in much of the quantum-like field of economics (as well as mathematical psychology) establish one kind of analogical linkage, conceptual studies may similarly leverage quantum ideas as metaphor. The maintenance quantum/quantum-like divide involves a kind of trade-off, imposing a limit on the metaphysical radicality of this vein of analysis while also assuaging concerns of speculative overreach plaguing actualist accounts.

The third cluster of approaches—including my particular intervention—considers the quantum move as one taking place at the level of the imaginary. The "quantum leap," so to speak, is one from a social science grounded in a Newtonian imaginary to one grounded in a quantum imaginary. In *Ontological Entanglements, Agency, and Ethics in International Relations*, Laura Zanotti describes the ontological imaginary in the following way:

> While not constituting a homogenous theoretical framework, ontological starting points constitute a shared common sense – a system of references that legitimizes theoretical and political position. (Zanotti 2018, 1).

The imaginary legitimates theoretical and political ideas within that system as a broad set of references that serve as a starting point. In Murphy (2021c), I describe the imaginary in terms of possibility, defining it as "the set of assumptions that sketches the contours of the possible within which a theory can operate" and arguing that "an imaginary is a boundary of the infinite" (Murphy 2021c, 8). Different imaginaries will impose different boundaries on the infinite permutations of thought and action possible within them.

While this may be straightforward in mathematical terms—the infinite number of fractions between 1 and 10 must be a larger infinity than the infinite number of fractions between 1 and 2—a shift in the imaginary represents a complex challenge for philosophical investigation. When we approach quantization from the approach of quantum-as-imaginary, we investigate the very foundation philosophical assumptions that make thought and action possible.

This specific move from a Newtonian imaginary to a quantum imaginary is significant for social scientists and theorists because of the profound impact of the Newtonian imaginary in setting the terms of the "shared common sense" (Zanotti 2018, 1) among social scientists. In *Meeting the Universe Halfway*, Karen Barad calls for a new quantum social theory that begins with a rejection of these Newtonian ideas: "What is needed is a reassessment of physical and metaphysical notions that explicitly or implicitly rely on old ideas about the physical world—that is, we need a reassessment of these notions in terms of the best physics theories we currently have" (Barad 2007, 24). In a similar manner, Wendt's (2015) *Quantum Mind and Social Science* begins with a reflection on the profound contradiction between the social sciences' reliance on Newtonian physical thought and the impossibility of consciousness within Newtonian metaphysics.[4] As these and other accounts of quantum social theory have highlighted, there has been a widespread impact of the Newtonian imaginary on social science. And yet, direct challenges to Newtonian physics occur rarely at the level of a physical imaginary, and more commonly treat the distinct phenomena of physics envy or criticize attempts to make predictive arguments that rely on oversimplifications.

Within this cluster of imaginary-driven quantization, there are many different ways to undertake the process of quantization. For example, a new system of though could be constructed from the theoretical ground up, beginning with the principles of quantum mechanics (e.g., Barad 2007; Zanotti 2018). As I have argued previously, one of the key goals of my particular intervention into quantum IR is

[4] While Barad and Wendt focus primarily on the theoretical side, see also Allan (2019) for an exploration of Newton's impact on the practice of world politics.

to demonstrate the productive potentiality of quantum/IR dialogue. If I were engaging in foundation-level theory-building, my homological method might identify the IR homologies to the units, forces, fields, and dynamics of quantum mechanics. Because my project instead seeks to join the many conversations already underway in International Relations, my theory-building is more mid-level, identifying homologies in the world through their quantum-likeness but then translating from a Newtonian imaginary to a quantum imaginary. As will become clearer through the methodological discussion in Chapter 3 and the conceptual case studies that follow, this approach emphasizes how quantum thinking can support a shift in the boundaries of the possible within social inquiry.

More specifically, my engagement with quantum IR has largely taken place in dialogue with critical theories of International Relations. I believe that quantum ideas can contribute to the ongoing debates and discussions of critical IR in a variety of ways, and quantum IR stands to benefit from an infusion of criticality.[5] In the context of critical IR, I have recently differentiated between my project of "quantizing critique," efforts that propose "quantizing *as* critique" and "quantized critique" (Murphy 2022). *Quantizing as critique* understands the quantum move itself to be a critical one, mobilizing quantum ideas to destabilize long-held assumptions in IR theory and proposing alternative models in a manner very similar to that of early critical scholarship (e.g., Cox 1981). We find Wendt's (n.d.) discussion of quantum as a critical approach in the Frankfurt sense illustrative here, insofar as his project truly does seek to dispel a false Newtonian consciousness (around the Newtonian nature of consciousness!). I describe *quantized critique* as projects seeking to build new critical projects from the ground up, beginning with quantum social-theoretic principles to forward explicitly critical projects. This second kind of critical scholarship takes quantum as a new heuristic for understanding how critical theoretical (and perhaps political) aims can be achieved through a distinctly quantum path (e.g., Zanotti 2018; 2021). Alternatively, the

[5] For example, critical debates around ethics, raised here in chapter 4, as well as in the work of Laura Zanotti (2018), as well as critical methods, raised here in the conclusion in dialogue with Critical Security Studies.

relationship between quantum and critique that I explore in this dissertation and in Murphy (2021c) is *quantizing critique*. This strategy takes critical IR as its starting point before quantizing that mode of inquiry, and may have a strong strategic justification for further development—it stands to reason that demonstrating the utility of quantum for existing work in critical IR would do a great service in bridging the gap between critical and quantum IR. Just as there are many multiple modes of quantization, there are similarly numerous paths from quantum to critique. I remain convinced that the shared ground between criticality and quantum thinking—combined with the rich intellectual diversity of both sides—sets the stage for a provocative and productive dialogue. It is my hope that this dissertation marks an agential cut into this phenomenon of quantum/critical IR, employing an imaginary-driven methodology of quantizing (critique) through translation to demonstrate the stakes and scope of quantum International Relations.

Chapter 1
The "Cost" of Quantizing International Relations

> *"Since the start-up costs for thinking in quantum terms are high, my goal in this 'preface' is motivational: to explain why it is necessary to turn to such an exotic theory to solve basic problems of social ontology. In particular, I show that the agent–structure problem stems from the fact that the ways in which social scientists have dealt with an essential feature of the human experience – namely experience itself – originate in classical assumptions about the mind–body problem." (Wendt 2015, 7)*

Introduction

In the preface to *Quantum Mind and Social Science*, Alexander Wendt stakes a bold claim, that the core problems that social scientists are unable to solve—the 'hard problem' of consciousness and the agent/structure problem chief among them—are due to the fact that contemporary social science abides Newtonian physics. On a whirlwind tour of physics, biology, neuroscience, mathematical psychology, financial modeling, game theory, and many other fields, Wendt introduces a quantum ontology that unifies the physical and social worlds and provides a hypothesis that is "too elegant not to be true" (2015, 293). The entry costs for social scientists willing to join (or at least follow along) on the quantum journey, Wendt acknowledges, are high, as there are many concepts to learn that pose fundamental challenges to the way that we are taught to think about the world. But the benefits are similarly high.

While prior interventions in the quantum debate have articulated potential benefits of taking a 'quantum leap,' I am interested in this chapter less in articulating a final answer than in making sure that we are asking the right question. After all, many readers seem to interpret the decision to take or not take the quantum leap as a matter of weighing costs and benefits, and careful conclusions can indeed be reached in either direction. But this misses the core difference of quantum approaches as a fundamentally different logic of metatheory—this is a transformative imaginary,[6] not an additive wager. In short, I argue

[6] See Zanotti (2018) and Murphy (2021) for more on the quantum imaginary.

that the "cost" of quantizing International Relations has been subject to the wrong kind of cost analysis. Our comparison is not whether the added value of quantum ideas offer novel analytical leverage that is in some manner greater than the effort expended in learning quantum ideas. Rather, the cost of quantizing ought to be weighed against *the opportunity cost of remaining Newtonian*. The question of quantum's cost can only ever be asked in the context of Newtonian physics' cost.

Indeed, the history of International Relations is replete with similar situations, where disciplinary failure occurs not in the inability to answer a question posed, but the inability to answer a posed question. We can find examples of failure to pose taking place across the subfields of International Relations. In critiquing conventional and constructivist approaches to security studies alike, feminist scholars have argued that existing approaches failed in understanding the breadth of violence because key questions were unfathomable within the existing discourse. Carol Cohn's (1987a) investigation of technostrategic language in nuclear defense circles revealed that the human cost of nuclear war was lost on its key strategists because the language itself drew attention away from humanity. Lene Hansen's (2000) analysis of gendered violence patterns highlights how existing constructivist in securitization theory failed to notice how gendered power differentials mediate access to speech. Antiracist scholarship in International Relations theory has similarly drawn attention precisely how deleterious the effects of silence on a subject can be. Just a few pages after Hansen's rebuke of securitization theory, Robert Vitalis (2000) took aim at the "norm against noticing" in IR theory. In this article, Vitalis argues that the systematic exclusion of race and racism from the dominant discourses of great power politics serve to uphold white supremacy, while also obfuscating empirically the racial logics informing international interventions, imperialism, and so on. Errol Henderson (2013) argues that the failure to interrogate the racist lineages of ideas of anarchy—both in the history of International Relations and a field and the antecedent theoretical canon—upholds a binary distinction between white politics and tropical anarchy. And within international political economy, an analytical eclecticist critique leveled by Peter Katzenstein and Stephen Nelson has argued that the

failure of dominant schools of economic rationalism to predict and understand the global financial crisis of 2008-2009 was not one of misreading the evidence assembled, but of misjudging what evidence was relevant in the first place (Katzenstein & Nelson 2013; Nelson & Katzenstein 2014). These three examples are by no means exhaustive, even within their own traditions. But what these different critical perspectives (feminist, antiracist, analytical eclecticist) responding to different fields (security studies, IR theory, international political economy) demonstrate is that there is a clear precedent within International Relations for novel research programs to offer transformative rather than additive contributions. Indeed, looking back through the disciplinary history of International Relations, we frequently find examples of existing theoretical approaches seeking to evaluate new ideas not on their own terms, but on the established terms. What I would like to suggest in this chapter is that the quantum move is similarly transformative in a technical sense—and therefore, to analyze the quantum move, one must consider opportunity cost rather than cost/benefit.

The remainder of the chapter proceeds in three sections. The first surveys three significant critiques of quantum interventions in International Relations theory—by Patrick Thaddeus Jackson (2016a), Bentley Allan (2018), and Laura Sjoberg (2020)—and discusses how the logic of cost/benefit rather than opportunity cost informs the approach to quantum work. The second section addresses the question of transformation and addition, arguing that the quantum imaginary's complementarity with existing social theory is a transformative strength rather than a reduced benefit. The concluding section then stakes the argument for opportunity cost analysis and returns to the critiques listed above to discuss the questions that remain for the continued development of quantum International Relations.

Cost/Benefit Critiques of Quantum

While interventions into the debates of quantum IR have elicited significant and thoughtful responses—including some clearly in favour of the project (e.g., Harrington 2021; Prieto 2021) and others resoundingly

opposed (e.g., Donald 2018; Waldner 2017)[7]—some of the most thought-provoking responses to the growth of quantum IR have come from a readership that is at once both curious and skeptical. I will discuss three thoughtful reviews falling into this final camp. In order of publication date, they are: Patrick Thaddeus Jackson's "Fundamental Grounding," Bentley Allan's "Social Action in Quantum Social Science," and Laura Sjoberg's "Quantum Ambivalence." Each subsection will first briefly summarize the author's critical response before then demonstrating why each is grounded in a cost/benefit analysis that assumes an additive contribution.

As a prefatory note to this exercise, it is perhaps worth recalling that while each of these essays makes claims about quantum IR as a research project, the specific focal point in each case was a single work—in the case of Sjoberg, the direct object of critique is Zanotti's (2018) *Ontological Entanglements*, while Jackson and Allan respond to Wendt's (2015) *Quantum Mind and Social Science*. Out of fairness to those authors, then, my analysis will focus on the *logics* embedded in their comments about quantum IR, rather than the validity of *specific claims* made about quantum social theories *writ large.* For example, while Jackson (2016a, 1153) and Allan's (2018, 92) critiques of epistemological representationalism may hold for Wendt's specific engagement with quantum consciousness, they surely must not be commenting on Barad's approach to quantum social theory—which directly rejects the correspondence theory of truth (2007, 44-5). Similarly, Sjoberg's (2021, 133) critique of quantum IR being untethered to feminist normative commitments surely cannot be intended as a judgement of Barad's (2007) systematic exploration of the feminist and queer implications of quantum mechanics. Rather than the *content* of each essay, my primary concern here is lies in the *logic* of assessment. If we are to understand issues with how thoughtful interlocutors have mismeasured the significance of quantizing IR, then attention to

[7] While criticisms from the physics community about Wendt's claim of a quantum reality would be a significant concern for an actualist paradigm in quantum IR, that critique runs out of steam in quantum approaches driven by analogy or imaginary. To this end, a response to the macroscopic decoherence critique from physicists against actualist quantum social theory is beyond the scope of this dissertation.

fundamental questions of logic offers more than specific premises. While a refutation of content points may gain theoretical ground step by step, a higher-order analysis moves by leaps and bounds. The quantum question is a capital-letter Big Question for IR theory, and we must make sure that we have a clear view of the Big Picture.

Patrick Thaddeus Jackson: "Fundamental Grounding"

In "Fundamental Grounding," Patrick Thaddeus Jackson responds to the high stakes framing of *Quantum Mind and Social Science*, speaking directly to Wendt's ambitious vision "less to set a specific research or scholarly agenda" than "to get something onto all of our agendas" (2016a, 1153). Rather than debate the model of Quantum (Wo)Man that Wendt proposes or the scientific apparatus that upholds a quantum model of mindedness, Jackson focuses instead on the social-theoretic implications of social life. While he seems intellectually curious and careful in his examination, Jackson ultimately concludes that the failure of Newton to provide a reasonable answer to the hard problem of consciousness is ultimately unnecessary for social scientists: "unless we are trying to complete the unity of science project, we can safely *ignore* the physics of consciousness" (2016a, 1157). Rejecting Wendt's call to unify physical and social ontology, Jackson asks "why not…be content with starting 'from a social-science point of view' that highlights the intentional character of social action, and leave aside both physical and divine matters?" (2016a, 1157). Social science can understand the world in relational terms, and intentional objects like war, trade, and torture can be discussed without first establishing a theory of consciousness (Jackson 2016a, 1155, 1157). Jackson does not dismiss the project, but carefully presents a case against what he views as the subordination of social science to physics.

From the first page of the essay, we find two pieces of evidence that suggest that Jackson frames *Quantum Mind and Social Science* as an additive contribution. First, Jackson summarizes Wendt's contribution by saying that: "Wendt's wager, so to speak, is that these issues of fundamental ontology have important implications for how we practice social science, and so we *should* be thinking more about

them than we do" (Jackson 2016a, 1153). That is to say, Jackson presents Wendt's contribution as an effort to address an absence of fundamental ontology in metatheoretical debates around social science. We would then understand Wendt's move as adding a quantum perspective on fundamental ontology to the debates around philosophy of social science. The same additive framing is present when Jackson narrows into the actual quantum mind hypothesis that Wendt presents: "What Wendt wants to get on the agenda now is the problem of consciousness" (Jackson 2016a, 1153). In this second statement, the additive framing is even clearer—Jackson sees Wendt as putting consciousness on the agenda (by adding a quantum fundamental ontology). We find further evidence of an additive framing towards the end of the piece, when Jackson poses the question cited above: why not be content with social science without physics? While not directly describing Wendt's efforts as additive, Jackson's question assumes the possibility of both a social science without physics *and* a social science with a concern for physics added. In the conclusion, then, we find further evidence that the assessment of quantum is for what it adds to a social science assumed not to need it—meaning that merits are judged in terms of added benefits.

While the additive logic must to some extent be deduced from the phrasing of certain key phrases, the assessment of benefit is clear through the middle section of "Fundamental Grounding," where Jackson seeks out what is new in the world of Wendt's quantum man. After introducing the picture of quantum vitalism for the reader, Jackson turns his attention to a direct critique of the familiarity of some of the insights. Because this passage clearly establishes the benefit-assessment side of Jackson's cost/benefit analysis, I quote here at length:

> Individuals as fundamentally relational, social structures as potentialities rather than parametric constraints, social action as (re)creative of the social world…This all sounds very familiar. Indeed, it sounds very similar to the basic scientific ontology, or model of the social world, brought into international studies in the 1980s by feminists, poststructuralists, and constructivists—including Wendt himself…Most of the conception of social life on offer here would not be out of place in any contemporary relational or practice-theoretical piece of social science. Similarly, Wendt's discussion of linguistic communication as involving the use of words in a shared context to shape future action in a way that is not well captured by the linear notion of causality (pp.234-36) sounds a great deal like the analysis of performative and constitutive language by

> constructivists like Nicholas Onuf and Friedrich Kratochwil, who were in part inspired by John Searle and J.L. Austin. (Jackson 2016a, 1155).

This appears as the crux of Jackson's critique of the quantum project—if we can reach quantum theory's conclusions without taking the quantum path, and if remaining on a non-quantum path lets us carry on theorizing without having to add physics, when what value does the quantum leap really add? If the experimental argument does not pan out, is the quantum vision of the social world "just a heuristic"? Indeed, it is in this light that Jackson's skepticism of the quantum project emerges—because he understands Wendt to be adding quantum to social science, he assesses its benefit in terms of what is added in comparison to what existed before. If we can reach some quantum conclusions through performativity, others through linguistic constructivism, others from a poststructuralist perspective, others through a feminist analysis, and so on, then the work of adding quantum to existing debates in IR theory appears to have a limited payoff. While Jackson does ultimately call for debate rather than drawing a conclusion at the close of his review, the cost/benefit logic animating the essay infuses a large dose of skepticism towards the utility of quantum theory for International Relations.

Bentley Allan: "Social Action in Quantum Social Science"

While Jackson takes aim at Wendt's quantum leap, Allan is more directly focused on *Quantum Mind*'s foundation of scientific realism and the place of social action. To this end, "Social Action in Quantum Social Science" is not a critique of the import of quantum ideas into social theory *writ large*—indeed, Allan is explicitly open to quantum ideas informing a post-classical path for social theory (2018, 87)—he shares substantial reservations about the specifics of Wendt's approach to develop a new wholly-quantum social science. Allan's essay begins by following Wendt's discussion of quantum decision theory to develop a quantum account of social reality grounded in scientific realism before then turning to Wendt's use of quantum game theory to move from agent to structure. Throughout, Allan is consistently sympathetic to the project of a post-classical social science; however, he expresses concern that "a quantum physical constraint…could limit the possibilities of post-classical social theory by leading its theorists to force their

ideas into quantum forms" (2018, 89). While supportive of the theoretical exercise—calling Wendt's decision theory "braver and more consistent than the quantum decision theorists who decline to put their ontological money where their models are" (2018, 91)—he rejects what he identifies as a correspondence theory of truth operative in Wendt's quantum/scientific realism. To the extent that Allan appears enthused by quantum's contribution to a post-classical social theory, he appears skeptical about the substance of a contribution made by a framework that "replicate[s] things that social theorists might already know" (2018, 95), citing Whitehead, Dewey, Deleuze and Guattari, Connolly, Swidler, Sewell, Adler and Pouliot, Goddard, Sending, Nietzsche, Bergson, Tarde, Massumi, Latour, "and others" throughout the piece as antecedents to various quantum insights and theoretical moves. If other approaches seek to develop social theories that move past Newton, then social theory need not return to physics in order to reject Newtonian foundations. And there may be both lower entry costs and fewer limitations to theoretical innovation if we avoid quantum mechanics: "we can adopt a contextual view of human agency," Allan tells us, "without having to constantly work our account of the social into the terms and mathematics of physics" (2018, 98). Ultimately, Allan argues that while there are benefits to be reaped from an engagement with quantum insights, these are undone by the potential limitations of re-embedding physics in social theory and the existence of non-quantum post-classical theories of the social world.

The additive language is not as clear in Allan as we saw in Jackson, but we still find traces of the additive *logic* present in the assessment of *Quantum Mind*. First, when Allan presents his central claim that quantum ideas have much to offer post-classical social theory as lessons rather than an overarching framework, we ought to recognize the additive logic implied. For example, in the statement "while insights from quantum social science should be an essential component of any post-classical social theory, the task of theorizing social agency should not take place exclusively under the constraints of quantum physics" (Allan 2018, 87), there is an implied logic of addition in the sentence, that quantum ideas can be

added in to the broader conceptual collectivity of "post-classical social theory." However, when incorporated in part rather than in whole, Allan counsels to stop his addition shy of importing limitations or barriers. Where we do see explicitly additive language is in Allan's two assessments of the "value-added" of quantum theories (2018, 89, 95). In the first statement, quantum is weighed against other contextual accounts of agency, and Allan leaves the question of quantum's value-added open; in the second, Allan speaks for Wendt, suggesting that we might see the value-added by quantum as less about innovation and more about conformity with the causal closure of physics. While I think that this latter point slightly misinterprets Wendt's claim that we are already generally abiding a causal closure (but should be conscious about which one we choose), the logic of Allan's phrasing remains additive—whether contextual agency or causal closure conformity, quantum *adds*, and we are to determine if it adds *enough*.

The additive logic and the benefit assessments are intricately linked in Allan's critical essay. The costs established are not only those of entrance admitted by Wendt, but also the limiting costs of coherence with mathematical formalism. In effect, Allan offers a *via media* in his critique of Wendt, concluding that a wholesale adoption of quantum incurs too many costs for too few benefits, but that the incorporation of quantum ideas into a broader post-classical social theory can maintain the additive benefits while limiting the costs. Thoroughly imbued with a cost/benefit analytical logic, Allan leaves the reader with much to consider about the place of quantum, suggesting a humbler contribution to the field.

Laura Sjoberg: "Quantum Ambivalence"

In her response to Laura Zanotti's *Ontological Entanglements*, Laura Sjoberg expresses a sympathetic but critical perspective towards the use of quantum social theory to inform critical IR theory. This is not a dismissive perspective—indeed, Sjoberg states that she is an attentive, avid, and (uncomfortably) agreeing reader of quantum IR (2021, 126)—but instead focuses her intervention on the profound feeling of ambivalence that she experiences in reading quantum IR. "Quantum Ambivalence" begins with a narrative account of reading *Ontological Entanglements*, noting the feelings of agreement and

ambivalence as they arise, before directly addressing that ambivalence. The second half of the essay addresses the two key producers of unease bound up in quantum IR—the relationship between quantum IR and feminist theory, and the ethics of according a privileged position to physics—before ultimately concluding that her ambivalence remains. As the title suggests, ambivalence is the core focus of Sjoberg's essay, and her summary of this feeling offers a window into the essay's core argument:

> My ambivalence is twofold. I find *Ontological Entanglements* (and much of the quantum IR research programme to which it contributes) replicates many of the ontological commitments that make me a feminist *without* feminisms' explicit political commitments, and that I remain uncomfortable about the importation of physics into IR, even when it is this newer, more flexible, kinder quantum approach. (Sjoberg 2021, 131)

Sjoberg argues that quantum IR—even Zanotti's kinder quantum IR—runs into two problems that cannot fully be overcome. While, as I will discuss below, both concerns merit further consideration in the coming years for scholars of quantum IR (particularly those speaking to critical audiences), the specific *presentation* of these sources of ambivalence both apply the additive logic of a cost/benefit analytic.

Sjoberg reviews a series of significant contributions made by feminist theorists to dispel conventional accounts of structure, agency, causality, relationality, performativity, and many other social forces and factors. While this summary is—explicitly—*not* an attempt to directly devalue *Ontological Entanglements*, it does set up an additive critique. Namely, Sjoberg repeats that she "find[s] the relationship between *Ontological Entanglements* and feminist theorising uneasy" (2021, 133). Despite similar conclusions being reached, the paths are different and—for Sjoberg—too distant from one another. "While Zanotti cites and relies heavily on feminist theorist Karen Barad, and mentions at a couple of key points the masculinism of one or the other substantialist approach," Sjoberg posits, "the commonalities that the approach in *Ontological Entanglements* has with feminist theorising are not discussed explicitly" (2021, 133). This part of Sjoberg's reflection on the quantum/feminism relationship speaks directly to the question of benefit, insofar as the lack of context vis-à-vis feminist theorising makes it difficult to assess the processual contribution of quantum theory to feminist theory.

If we accept Sjoberg's assessment that the conclusions are similar, then the benefit would be found in the journey. Here, Sjoberg indicates that these are not explicitly articulated in quantum social theory, and, indeed, that there is a further cost assessed beyond the entry-cost acknowledged by Wendt and Jackson. Namely, there is a normative cost incurred because feminist politics do not emerge directly from quantum assumptions:

> Many of the political commitments explicit in contingent, contextual feminist theorising are implicit *if they exist at all* in quantum ethics…I am left to believe, then, that quantum ontologies do not *necessarily* share feminisms' normative commitments, even if Zanotti does, and therefore *Ontological Entanglements* does. (Sjoberg 2021, 133)

The core message to be gleaned for our analysis of Sjoberg's critical methodology is that an ambivalence towards quantum IR can be justified from a feminist perspective first by the limited benefits to be accrued as a result of a quantum leap and second from the cost of normative commitments. Beyond a question of benefit, Sjoberg presents issues in terms of cost as well. Finally, Sjoberg subordinates transformative theory vis-à-vis additive moves directly in this discussion, as she states that "I cannot tell whether to be happy that I agree or frustrated that this feels like something I have heard before, couched in different terms" (Sjoberg 2021, 129). If quantum is an additive move, this is a problem—if it is a transformative move, then this is a starting-point.

The second area of critique might best be labelled as an epistemological concern, as it deals with the ethical implications of adding the terminology of quantum physics into International Relations. Indeed, while this section of the essay presents serious concerns around physics envy, scientific fetishism, and the disciplining practice of marginalizing supposedly "non-scientific" forms of knowledge by the social-scientific gatekeepers of knowledge in the IR community, the core argument against the adoption of a quantum framework for IR theory again follows a cost/benefit logic. The additive assessment of benefit is clear in Sjoberg's description of the quantum move as "an unnecessary political minefield," specifically insofar as the description of *unnecessary* presumes that IR can choose to proceed with or

without a physical imaginary: “It is unnecessary because, as outlined above, direct critiques of mind-body dualism, the simplicity (or even existence) of cause, and foundationalist approaches to ethics both manifest their problems and provide alternatives without resorting to a quantum metaphysics” (Sjoberg 2021, 135). As with politics, so with epistemology—Sjoberg sees quantum’s added benefit as limited, because critical descriptions and alternatives can be developed without moving to quantum. Similarly in line with the political critique, Sjoberg’s cost-side analysis of the epistemological stakes of quantum move us beyond an entry-cost evaluation. Namely, Sjoberg argues that references to quantum and Newtonian physics “share, especially in their deployment in international theory, a *gravitas* that comes with the classification of (‘hard’) science”— problematic and costly baggage for quantum IR because “this *gravitas* has often been used either intentionally or inadvertently to exclude some knowledges and privilege others” (Sjoberg 2021, 135). If quantum IR were to succeed, Sjoberg worries, then the end result may again be that “*scientific* practice will be privileged over *non-scientific* practice because the transition from abstraction to practice does not disturb the privileged position of science in/as/of knowledge” (Sjoberg 2021, 135-6). In short, Sjoberg argues that we must consider the potential cost of a new scientific perspective resulting in the reification of disciplining practices against interpretivist approaches to international theory. On the epistemological front, choosing to add quantum physics to discussions of International Relations risks incurring a cost of marginalization, with limited additive benefit in terms of new insights of the problems with Newtonian fetishism or alternatives thereto.

While Sjoberg raises two significant and thought-provoking questions around the politics and ethics of a quantum move, both of these are articulated in terms of a cost/benefit analysis, assuming quantum to be an additive move—and indeed arguing that it is an unnecessary addition. Like Allan and Jackson, Sjoberg’s cost/benefit analysis of quantum IR finds that its additive potential is limited. But is this really the most appropriate logic for analyzing the value of a quantum leap?

Transformation, not Addition

My point in reviewing the critiques of Jackson, Allan, and Sjoberg is not to reject them out of hand, but to highlight how each critique employs a cost/benefit analysis that treats the quantum move as an additive one. I would like to suggest that describing quantum theory in these terms misses the transformative stakes of quantum IR. By looking to quantum leaps in proximate fields of study, we find clear examples of how quantum theory is transformative—even when looking at its most apparently additive moments. Furthermore, the claim of opportunity cost logic should be even more familiar to IR theorists, as the discipline is replete with opportunity-cost moves. The second half of this section reviews precisely these disciplinary precedents.

Quantum contributions from game theory to queer theory and decolonial theory to financial modelling demonstrate that quantum ideas can add value to fields. For example, game theory benefits from the superpositionality of plays within an entangled game system, queer theory makes use of the both/and duality as a strategy for queering binaries, decolonial theory recognizes the quantum-like entangled ontology embedded in Indigenous cosmologies, and financial modelling benefits from the predictive capacity of quantum equations. But even in these situations where the benefits appear to be additive, the underlying logic of the quantum move is transformational. In game theory, it is not the addition of a quantum equation to the model of game theory but the fundamental transformation in the *logic* of games, from turn-by-turn frameworks of conventional games to a quantum superposition of plays within an entangled game system (Arfi 2005). In Barad's (2014) application of quantum mechanics to queer theory the core benefit is not found in adding dualities on top of binaries but fundamentally shifting from a world of binaries to one of dualities. Other scholars (Bowman 2021; Peat 2002; Salter 2022) have brought quantum mechanics and Indigenous cosmologies into conversation, demonstrating not a benefit of adding quantum to Indigenous ideas, but of fundamentally regrounding the terms of the conversation from a Newtonian framework that marginalizes Indigenous perspectives to a quantum one that

complements the ontological relationality of Indigenous cosmology. Within the domain of financial modelling and economics, quantum's contribution is not to add a new mechanism for determining price but a radical reintegration of uncertainty into the core models of finance and economics (Haven & Khrennikov 2013; Orrell 2020). The lesson to learn from the experience of these proximate fields is that even when quantum ideas are introduced in ways that seem additive, the benefits to the field are not found in the mere practice of "add quantum and stir" but in the reshaping of core ontological assumptions from Newtonian to quantum physics. Even within physics, the decision of much of the scientific community to focus on experimental development instead of recognizing the metaphysical and ontological significance of their discoveries can produce the illusion of quantum as an additive move in physics.[8]

Recognizing the transformation/addition difference also clarifies how quantum contributes to existing ideas that challenge dominant conceptions. Barad's approach to queer theory, for example, does not pretend that pre-quantum queer theory upheld binaries. Rather, the existing efforts of theorists to queer binaries are strengthened by the complementary framework of quantum physics. While we might say that the additive value of quantum concepts is found in aligning relational ideas with the relationality of the quantum world, the transformative value of quantum is far greater.[9] Instead of Newtonian queer theory beginning with a fight against its own causal and ontological closure, a quantum queer theory operated within a philosophically complementary framework. Therefore, while the existence of a theory or an assemblage of theories reaching a conclusion similar to a new quantum theory may imply a limited

[8] The quantum revolution, however, is far more radical than that, and recent work by Carlo Rovelli (e.g., 2017; 2019; 2021) marks a significant return of a physicist to deep philosophical reflection.

[9] To this end, we could imagine that if quantizing a particular theory was able to "solve" a difficult problem, a cost/benefit analysis could tell us that adding quantum was worthwhile. Both transformational and additive logics, opportunity cost and cost/benefit analyses *could* be employed for the theoretical or metatheoretical adjudication of the value. My argument is that they *shouldn't*, and more specifically that resigning ourselves to an additive logic entails an *a priori* decision to underappreciate the value of the quantum leap.

additive value, the transformative value is—if anything—*increased*, as greater and freer dialogue can take place.

If we understand quantum as an imaginary (Zanotti 2019; Murphy 2021c), then it should come as no surprise to IR theorists that quantum's change is transformational. Indeed, in Carol Cohn's discussion of technostrategic language referenced above, she explores the powerful role of language in setting the bounds of what is imaginable and what is unimaginable:

> Learning the language is a transformative, rather than an additive, process. When you choose to learn it, you enter a new mode of thinking—a mode of thinking not only about nuclear weapons but also, de facto, about military and political power and about the relationship between human ends and technological means.
> Thus, those of us who find U.S. nuclear policy desperately misguided appear to face a serious quandary. If we refuse to learn the language, we are virtually guaranteed that our voices will remain outside the "politically relevant" spectrum of opinion. Yet, if we do learn and speak it, we not only severely limit what we can say but we also invite the transformation, the militarization, of our own thinking. (Cohn 1987a, 716).

Let us recognize here that the imaginative sword cuts in both directions—by remaining in a Newtonian imaginary, we are limited in certain ways; by entering into a quantum imaginary, we are limited in others. The choice to remain Newtonian comes with the opportunity costs of certain ideas being unimaginable, specifically around complexity, uncertainty, entanglement, and relationality; the choice to take a quantum leap means that we bear the opportunity cost of missing out on Newtonian claims to objectivity, linear and local causation, separable entities, and lawlike regularities. In a complex, uncertain, entangled, and relational social world, one set of opportunity costs seems almost infinitely higher than the other. It is that opportunity cost of remaining Newtonian that is far too often forgotten when analyzing the quantum leap.

There is a second reason to consider the quantum move as a transformative rather than an additive one, and again it draws out a familiar theme in the metatheoretical debates around International Relations. In this case, the relevant refrain recognizes that pre-existing ideas influence our view of reality. This ought not be a controversial statement, as agreement arises from far corners of the field's intellectual

debates. While an exhaustive summary would fill many volumes, a series of examples can help scratch the surface of the unprecedented scope of consensus. Arnold Wolfers argues that theories of morality, philosophy, and international politics are an inescapable starting point for even the most empirical research into international politics (1962, 237) and lie at the heart of each decision made by practitioners (1962, xiv). The decision is not between atheoretical objectivity and theoretical interference, but the conscious or unconscious application of theories, and thoughtful or crude levels of sophistication (1962, 238, xiv). Cynthia Enloe's argument for a feminist view of international relations begins with a critique of the "comfortable assumptions" of power operating in masculinized spaces that effaces the role of gender in international politics (2000, 4 and *passim*). Asking feminist questions instead of masculinist ones transforms the research enterprise. And a critical tradition from RW Cox (1981) through Steve Smith (2004) and beyond has consistently argued for the inevitability of perspective's influence on thought: theory is always from somewhere, and for some purpose. We cannot avoid our entanglements with the world of ideas, but can only interrogate our position and how we came to hold it. More recently, we find these insights given voice Yaqing Qin's poetic statement that "culture leaves an indelible birthmark on a social theory though shaping the mind of the cultural beings who produce knowledge and develop social theory" (2018, 25), Peter Katzenstein's (2018) argument that tacit knowledge constructs a worldview that then delimits our sense of the possible, and Bentley Allan's (2019) own case for cosmological influences on theories and practices of international politics.

Despite the novelty of concepts like "entanglement" or "nonlocality," the transformative claim of quantum IR should be at least *structurally familiar* to scholars of International Relations in a meta-theoretical sense. As with theory, gender, critique, culture, worldviews, and cosmology, a pre-theoretical framework of physical assumptions delimits what is imaginary within our social-theoretic and -scientific endeavours regardless of our desire to be limited by physics. The choice around quantum theories is not

one of "adding physics" versus "not adding physics." Instead, the choice is between taking physics *seriously* or taking physics *for granted*.

Opportunity Cost and Questions for Quantum

When we move from an additive logic to a transformative logic, we can recognize the scope of quantum's contribution to International Relations. In this light, we can recognize that neophiliac[10] criticisms of quantum IR miss the transformative contribution that a quantum imaginary makes (to say nothing of potential add-on benefits that quantized theories may offer in terms of future research directions). Alexander Wendt and Laura Zanotti have both admirably demonstrated the Newtonian influences on existing social science. For Wendt, the entry point is the causal closure of physics, whose hold on the discipline of International Relations he sums up as follows: "I know of no interpretivist, post-modernist, or other critic of naturalistic social science who says that social phenomena can violate the laws of physics" (2015, 10). Similarly grounded in an assessment of closure—although ontological rather than causal—Zanotti's (2018, 2, 16-32) wide-ranging review of existing theoretical perspectives from conventional realism through to critical poststructuralism argues that the shared substantialist ontology leaves a uniquely Newtonian signature on existing social science.[11] I seek here to make an abstract and metatheoretical point complementary to their more specific arguments.

We have, then, two justifications for assessing the quantum leap in transformational rather than additive terms. First, imaginaries are transformative because they shift the boundaries of the possible, and secondly, adopting an "as if not" relation to physics provides only a false objectivity. Recognizing that our choices are to abide an un(der)interrogated Newtonian physical imaginary or a quantum physical imaginary, the most important cost is not the entry cost of learning difficult concepts but the difficult-to-define opportunity costs of remaining Newtonian. While the critiques of Newtonian assumptions of

[10] See Neal (2019) on the dangers of neophilia.
[11] Skepticism of the Newtonian underpinnings of social science predates the quantum revolution in International Relations (e.g., Bernstein et al 2000).

separability, objectivity, and causal linearity and locality have proliferated in the quantum IR literature (Wendt 2015; Zanotti 2018; Murphy 2021c), the uninterrogated space may in fact bear greater opportunity costs—as the relationship between infinite uncertainty and risk tells us.

Decisions around what to study and what *not* to study will always involve costs, as a research project simply cannot at all times consider all perspectives about all events. Does quantum have a cost? Absolutely. But we cannot evaluate these costs independent of their context, and if we have unquestioningly paid Newtonian costs for decades, why would we *not* explore the new quantum world? Similarly, a quantum imaginary also has different limitations built in—while infinite ideas may be developed and explored, this is a bounded infinity just as the Newtonian imaginary is a bounded infinity. But just as is the case with cost, if we are to uncover new ways of understanding the world, then unquestioningly abiding the same limitations radically narrows the scope of the possible for social inquiry. Here, too, it would seem that exploring the quantum imaginary would be a worthwhile venture—trading cost for cost and limit for limit.

Important guides for future research in quantum International Relations include the continued expansion of quantum ideas into promising areas of inquiry (Wendt 2015, 283*ff*; Zanotti 2018, 143-4; McIntosh 2021; Murphy 2021c, ch 6; Yıldız-Alanbay 2021). But the quickly-established practice within the quantum IR community of taking critique and skepticism seriously will also likely lead to the commentaries of Jackson, Allan, Sjoberg, and others serving as profound and thought-provoking works in the continued development of quantum theories of International Relations. In this spirit, I would like to conclude by passing the torch to future quantum works, lit with the still-open questions raised by the authors discussed above:

- From Jackson, how can quantum approaches articulate the need to recognize quantum influences in social sciences without reproducing the problematic fetishization or elevation of sciences over social inquiry?

- From Allan, how can a quantum social theory account for other consciously non-classical approaches that do not abide a quantum ontology or metaphysics?
- From Sjoberg, how can we approach the project of quantum social science ethically, both in terms of critical political projects as well as the history of appeals to science marginalizing forms of knowledge?

As quantum theories of International Relations continue to develop, we will gradually gain a more holistic sense of the benefits and costs of quantum. While it would be impossible, then, to have all the disciplinary-sociological answers about quantum IR, it is my hope that this chapter helps to clarify the questions we ask about the cost of quantum. I remain convinced that there exists a great deal of potential, but as with any wave of potentiality undulating through spacetime, that remains to be observed…

Chapter 2
Quantum Mechanics for Social Scientists: Wave/Particle Duality, Observer Effect, Entanglement[12]

> *"The word 'quantum' refers to this peculiar aspect of nature that goes against common sense."* (Feynman 2006, 5).

Introduction

The early years of the twentieth century saw two major developments in physics, as the discipline split from a single Newtonian model to a field divided between macroscopic physics based on Einstein's theory of relativity and microscopic physics based on quantum mechanics. These two approaches have traditionally worked on different scales—relativistic physics on the very large scale and quantum physics on the very small scale—and one of the major challenges for physicists has been exploring the crossroads between the two approaches (e.g., Smolin 2001). I offer this larger contextual note to emphasize that my focus in this dissertation, about particular concepts within quantum mechanics, represents but one small corner of physics. If we are to update the Newtonian assumptions that have been identified in International Relations theory (e.g., Bernstein et al 2000; Wendt 2015; Zanotti 2017; 2019), then there are multiple paths that may be explored. My argument is that quantum mechanics offers critical scholars a particularly useful set of conceptual tools for the study of International Relations.

Because the purpose of the chapter is to offer interested non-specialists a demonstration of how quantum mechanics might be a useful resource rather than to provide a detailed introduction to the field, I will by way of preface direct those readers seeking a robust initiation into quantum physics towards one of the excellent volumes intended for an audience of non-physicists. As well, from within the quantum International Relations community, Alexander Wendt's *Quantum Mind and Social Science* offers a

[12] Revised from the version published in *Quantum Social Theory for Critical International Relations Theorists: Quantizing Critique.*

thorough review of key experiments and challenges in quantum mechanics in its opening sections. I follow instead the mission found in John Polkinghorne's[13] study of quantum physics and theology, that "perhaps this proffered hors d'oeuvre might encourage some to sit down to a more substantial meal" (2007, xiii). References will direct readers to much more detailed information, including primary materials from early quantum physics where possible.

What follows in this chapter is a brief historical introduction of quantum mechanics and an outline of the three key concepts that will animate the remainder of the dissertation—the wave/particle duality, the observer effect, and entanglement. The concepts are worth reading twice, as their meanings are mutually dependent. For example, the observer effect is necessary to understand particle measurements, but the wave/particle duality must be established for the observer effect itself to be understood. There is a risk of reductionism whenever one introduces quantum mechanics from the point of view of one concept, precisely because the mature form that we now have access to entails an entirely alternative physical imaginary. The ontologically foundational shift from wave to wave/particle may capture one important element of understanding the photon, but a full appreciation of the quantum imaginary requires acceptance of multiple claims. As the two historical sections demonstrate, quantum physics arose not from the proposition of a fully-formed model but from a problem—the problem of light. Both because of this historical-developmental significance and because light will serve as the homological model for the social, much of this chapter will centre on the wave/particle duality. The three sections on the key concepts that will appear throughout the remainder of the dissertation are organized to make sense to the reader, but they are interdependent parts of the whole quantum imaginary. As I will discuss at the end of the chapter, the meaning of that imaginary still remains unsettled among physicists, and rival interpretations drawing on radically divergent ontological and epistemological assumptions leave a great

[13] *Quantum Physics and Theology: An Unexpected Kinship* is a fascinating book, and there is little doubt that Polkinghorne was the ideal author—for the first decades of his career, he was a professor of mathematical and theoretical physics at Cambridge University before leaving to become an Anglican priest.

cloud of uncertainty hovering around the implications of quantum mechanics, over a century after its theorization.

Newtonian and Quantum Physics: The Problem of Light

To understand the rise of quantum mechanics, we must begin with the problem of light, where pre-quantum physicists debated whether light was a wave or composed of particles. Isaac Newton was a major proponent of the particle theory of light, which he called "corpuscles," and offered the image of light as a shower of particles. Measurement has always been on Newton's side, as "every instrument that has been designed to be sensitive enough to detect weak light has always ended up discovering the same thing: light is made of particles" (Feynman 2006, 15). On the other side of the debate, physicists like Thomas Young pointed to experimental results that demonstrated the overall behaviour of light to manifest wave-like tendencies. This comes down to what von Baeyer describes as "the unique signature of waves": "the fact that under special circumstances waves can cancel each other out, leaving nothing behind—a trick called *destructive interference*" (2016, 26). By the mid-nineteenth-century, the preponderance of physicists tended to side with the wave-theorists.[14]

Part of the allure of the wave the wave theory of light came from experiments that demonstrated light behaving in ways that would be unimaginable in a framework that assumed a particle theory of light. Young's oft-described "two-slit" experiment projects a beam of light towards a diaphragm with two slits in it, onto another surface. As many YouTube examples demonstrate, the pattern on the final surface is not—as we might expect—two bright spots directly across from the slits, gradually darkening as distance from the slit increases, but rather a series of bands of light. This is called an *interference pattern*, the signature of waves referred to in the previous paragraph. Because waves emanate with alternating crests

[14] While conventional retellings of the story describe physicists persuaded by the facts in isolation, Jay Buchwald (1989) and Karen Barad (2007, 97-100) paint a more complex picture, including the changing nature of scientific theories as such.

and troughs, interference occurs when simultaneous crests double the waves' height, and overlapping crests and troughs cancel out any amplitude.

A second important experiment came nearly a century after Young, and saw physicists wrestle with the problem of blackbody radiation. While an "ordinary body exposed to radiation absorbs some of it and reflects the rest," this second type of body "is one that perfectly absorbs, and then re-emits, all radiation falling upon it" (Polkinghorne 1985, 5). This discovery of Lord Rayleigh and James Jeans posed a significant problem for classical mechanics, as the existing equations to describe radiation simply could not make sense of the absorption and re-emission of radiation in this manner. Looking back on this period, we might say that the problem emerged from the roughness of the conceptual tools that were available—neither a wave-model nor a particle-model could capture the phenomenon of blackbody radiation alone. Enter now Max Planck, "the reluctant revolutionary,"[15] who proposed that energy was absorbed and re-emitted not as waves or particles consistent across all time, but as "discrete packets"—a new concept which he called *quanta* (Polkinghorne 1985, 6). This idea was not completely wave-like, nor completely particle-like, but a fundamentally new way of describing a small quantity. Soon after, Einstein further developed this concept by postulating that energy emerging from a point does not propagate indefinitely, but is a complete and discrete unit in its interactions with other bodies (2005, 178). What this means is that this small amount of energy—a quantum—will appear as a particle when we measure it, because it is discrete in its interactions. But when we are not measuring it, the quantum of energy will move like a wave, propagating until its next interaction.

While Young's experiment led scientists to state that light was a wave, the lesson of blackbody radiation was that at the smallest level, light had the properties of both wave *and* particle. The smallest unit was a contradiction in terms, and completely alien to the established physical imaginary, which had

[15] This title was given by Helge Kragh (2000) in a profile marking the centenary of Planck's solution to the problem of blackbody radiation.

models of particle-only and wave-only. But the discovery of quantum properties of light did not mark the final step in the development of quantum physics. For just as the problem of light being either a wave or a particle was "solved," physicists encountered a new puzzle of how something could paradoxically hold contradictory states.

The Old Quantum Theory and Quantum Mechanics

In their oft-cited 1935 textbook *Introduction to Quantum Mechanics with Applications to Chemistry*, Linus Pauling and E Bright Wilson sketch out two eras in the development of quantum physics. The first phase, beginning with Max Planck's identification of the *Planck constant* in 1900 and Albert Einstein's introduction of the *quantum* in 1905,[16] progressed slowly over the next two decades, theorizing the wave/particle duality, correspondence, and modelling the atom, among other applications to physical phenomena (Pauling & Wilson 1985, 25-49). The formalization of "quantum matrix calculus" in 1925 by Werner Heisenberg and Erwin Schrodinger's "wavefunction equation" of the following year marks the generally-accepted rise of quantum mechanics.[17] What separates the post-Heisenberg/Schrodinger-era from the "old quantum theory" is that those earlier ideas tried to make sense of the weird features of the quantum world without completely revising the theory. Put differently, they tried *modifying* their theories instead of *revolutionizing* them. The advent of new mathematical foundations by Heisenberg and Schrodinger led to a radical rethinking of the world—or, perhaps more precisely, the microscopic world of atoms and photons. Quantum mechanics were a radical break with the past that the "old quantum theory" tried to save.

Those early insights that led to the first quantum theories of physics approached physical phenomena in a manner that resonated with experience but without the formal mathematics required for sufficiently reliable predictions. The old quantum theory has an odd status in the history of quantum

[16] These papers are accessible to an English audience as Planck (1967) and Einstein (2005).
[17] These papers are accessible to an English audience as Heisenberg (1967) and Schrodinger (1926).

physics—despite the common knowledge that "the old quantum theory…is not a proper basis…there are many phenomena which receive at least a qualitative explanation in the old quantum theory" (Ter Haar 1967, vii). The general concepts remain useful in explaining some phenomena in a general way, even if the models of quantum mechanics are much more reliable experimentally. In short, the complexity of the search for proper modelling of the weird quantum world led mechanistic models to be cast aside in favour of mathematical ones (von Baeyer 2016, 41-51; Pauling & Wilson 1985, 48).

From this point onwards, I will use "quantum physics" in a generic term to refer to the home field of concepts derived from either the old quantum theory or from quantum mechanics, whereas those two terms will refer specifically to either pre- or post-wavefunction versions of quantum physics. For quantum social theorists who seek to stake claims about reality, grounding the conceptual models clearly within the most recent work in quantum mechanics (rather than the old quantum theory) is more important than for those who mine quantum physics for productive metaphors. In the current investigation's search for viable conceptual tools, specificity in the genealogy of particular concepts is less important than their meanings. The presentation that follows largely fits within the epistemological Copenhagen Interpretation (Hebert 1987), though this is one among many respectable positions taken in the debates on quantum reality.

The Wave/Particle Duality

As was referred to above, the wave/particle duality lies at the heart of quantum thinking, and is the fundamental differentiator between quantum and Newtonian physics. One of the most important mysteries remaining within quantum physics is the relationship between the wave-state and the particle-state, including the shifting from one state to the other. As simply summarized by Marcus Chown, "although naively we may think of quantum behaviour as a property of small things…this is not necessarily so. Quantum behaviour is actually a property of isolated things" (2007, 34). When the photon—the word meaning one unit of light—is isolated from interacting with all other systems, it behaves as a wave and

can be modelled probabilistically by the wavefunction equation; when the photon interacts with a measurement device (whether an optical nerve or a photographic plate), it is in a particle-state and precise measurements are possible.

As might be expected, the particle-form is more similar to Newtonian physics. Particles can be measured, although with one important caveat—in the case of particular related measurements (called complementary variables), the greater the certainty of one measurement, the less certainty for the other. When we design an apparatus to measure the position of a photon, the interaction between the photon and our measurement apparatus means that we cannot measure the momentum of that photon with certainty. Or, rather, our margin of error in the measurement of momentum is infinite because we have fundamentally disrupted that momentum in our measurement of position. But we are able to identify characteristics of the photon through observation and measurement.

Knowledge about the wave is much less direct than the discrete measurements possible in the case of the particle. Indeed, the wave-state of the photon is represented by a mathematical description called a *wavefunction*. Carlo Rovelli explains the difficulty of understanding what the wavefunction "is" because it does not fit what we might call the linguistic imaginary of everyday experience:

> In quantum mechanics no object has a definite position, except when colliding headlong with something else. In order to describe it mid-flight, between one interaction and another, we use an abstract mathematical formula which has no existence in real space, only in abstract mathematical space. But there's worse to come: these interact[ions]…do not occur in a predictable way but largely at random. It is not possible to predict where an electron will reappear, but only to calculate the *probability* that it will pop up here or there. (Rovelli 2014, 15-16).

Whereas Newtonian physics described particles that deterministically followed from laws of motion et cetera, the new quantum world can only offer probabilistic predictions. When we are not directly observing a photon, we can only fully account for its wave-state by calculating all possibilities.

The theorization of what the wavefunction *is* was most infamously discussed in Erwin Schrodinger's so-called "cat paper." In outlining the situation of quantum mechanics at that time,

Schrodinger describes how the classical model allowed for neat predictions of values with claims of certainty in a way not possible in the quantum mechanical models. While the classical form of reality remains present in the particle interactions of quantum mechanics, the wave-state is, fittingly, modeled with a wavefunction that offers a "kind of blurring of *all* variables in *one* perfectly *clear* concept" (Schrodinger 1980, 327). The particle behaviour is observable in a manner similar to classical physics, but the only way of determining that we have captured the full picture of the unobserved wave is to include in our calculations—as Schrodinger says—all variables. While the wave nature of a photon is[18] a description of the unobserved photon, the wavefunction is the mathematical abstraction of that wave. These calculations turned out to be highly accurate, "imag[ing] the blurring of all variable at every moment just as clearly and faithfully as the classical model does its sharp numerical values" (Schrodinger 1980, 327). The wave/particle duality thus has implications both for the reality of the microscopic world and for the way that we study it. Waves are unobserved phenomena that interfere and particles are precise and observable entities; while the latter can be measured, the former can only be modelled.

What does it mean to say that all variables are blurred? While Newtonian models of a photon in motion would track a series of positions that the photon is said to occupy across time, the quantum explanation describes not a series of single positions but a *super*position of all potential positions at the indicated time. Rather than knowing that the photon will definitely be in one position at the future time *t*, there is instead a simultaneous consideration of all potential future states, in relation to the probability of each of those simultaneous potential positions. Polkinghorne summarized the superposition principle as such: "states can be combined…with a probability interpretation of the result" (1985, 19). Lacking the certainty of a series of sequential positions, all the possible states modelled by the wavefunction are considered until such time as measurement (through the phenomenon of observation described below) registers the position of a particle.

[18] *Nota bene* that this applies in most explanations of quantum mechanics, but not all.

One way of considering the difference between the wave behaviour (reality) and the wavefunction (representation) is to consider Schrodinger's best-known anecdote. The example of Schrodinger's cat describes an experimental apparatus where a cat is placed in a steel cage with a device called a "Geiger counter" and a small amount of radioactive substance, connected to a small hammer suspended near a small flask of hydrocyanic acid. There is a possibility that after an hour, the substance will decay, releasing the hammer, shattering the flask, and killing the cat:

> The ψ-function [wavefunction] of the entire system would express this by having the living and the dead cat (pardon the expression) mixed or smeared out in equal parts. It is typical of these cases that an indeterminacy originally restricted to the atomic domain becomes transformed into macroscopic indeterminacy, which can then be *resolved* by direct observation. That prevents us from so naively accepting as valid a "blurred model" for representing reality. (Schrodinger 1980, 328).

In this clearly representationalist account, the dead cat and live cat are smeared together in the wavefunction model, but by that Schrodinger does not mean that there is an actual smearing of cats within the box. Rather, the uncertainty surrounding the microscopic radioactive substance casts profound uncertainty upon the "real" state of the cat, which can only be modeled through a wavefunction until such point as we open the box. The cat may be "smeared" epistemologically as a manner of expressing this fundamental unknowability; common sense dictates that any attempt at actually smearing a cat will certainly produce a dead one.

Our core takeaway from the wave/particle duality is that microscopic particles—photons, electrons, etc.—have a dual nature. When light hits a photographic plate, it is always as a shower of particles. However, when light is left to its own devices, diffraction patterns—the signature of waves—emerge. These patterns become visible through experiments like the two-slit experiment, where the end-state particle measurements allow for conclusions to be drawn about the wave behaviour necessary for their creation. The uncertainty of the wave means that it cannot be calculated with the specificity of particles in motion, but modelled through a wave*function* that takes into consideration all potentialities. This key journey from wave superposition to particle position brings us to the idea of the observer effect.

Observer Effect and the Copenhagen Interpretation

One of the enduring questions haunting the metaphysics of quantum mechanics asks why the measurement of a quantum entity always registers a particle. A variety of interpretations exist, ranging from "collapse from wave into particle is spontaneous" to "every potential state in superposition severs into a new universe." While these interpretations are fascinating from both a philosophical and a mathematical standpoint, the version of the measurement problem that I will be discussing is the so-called "Copenhagen Interpretation."[19] There are different varieties within this interpretation (with different points of emphasis on epistemological or ontological implications) depending on the specific interlocutor, but the general version of the Copenhagen interpretation followed herein states that it is the interaction with the measurement device that causes the collapse from superposition wave to single-position particle. The observer's effect on the system is creative of either reality itself or the conditions of the imaginability of reality. In either case, measurement leads to the collapse of the wave.

The observer effect, in this model, is an important part of the quantum story, because it provides a clear answer to the problem of measurement. Simply stated, the "effect" refers to the way that the activity of the observer always entails the collapse of the wavefunction. The outcomes of measurement always describe particles because the interaction of measurement can only happen with particle participants. Remaining agnostic about the most specific *why*'s of wave function collapse, the Copenhagen interpretation of the observer effect believes that measurement matters because of its creative agency, while remaining agnostic about the powers that cause it. In his work introducing the metaphysics of quantum mechanics, Nick Herbert explains the substance of the observer effect with reference to an old Sidney Harris cartoon where an equation's second step is written as "and then a miracle occurs" (1985,

[19] As discussed later on in the chapter, there are multiple interpretations of quantum mechanics, and metaphysical debates are ongoing. I proceed with the Copenhagen Interpretation both because it is the most commonly-held among physicists, and because of the philosophically sophisticated writings of Niels Bohr which are insightful on their own terms and redoubled in light of Karen Barad's commentary.

147). We remain on solid scientific footing to remain agnostic to the content of the miracle of measurement in our search for tools, as this has been the standard practice of quantum physicists from the 1930s onwards.[20]

But these tools that physicists developed—even if they were at first known primarily for the beauty of their mathematical proofs—had also to be recognized for their observer effects. Precisely because new measurement apparatuses and similar devices produced the expected results, the contribution of the devices to the construction of those realities becomes all the more important. Bracketing the metaphysical implications of the observer effect did not move quantum physics away from it, but instead led to the proliferation of new measurement apparatuses which were themselves engaged in an unseen and unquestioned metaphysical effect. In contrast to many of his successors, Nils Bohr reflected closely on the philosophical implications of the physical principles of quantum mechanics, leaving the Copenhagen Interpretation with a wealth of philosophical problems to ponder. In an address to the Danish Academy of Science in 1955, Bohr highlights the importance of the measurement apparatus in creating the substance and not just the conditions for the measured characteristic:

> Every experimental arrangement permitting the registration of an atomic particle in a limited space-time domain demands fixed measuring rods and synchronized clocks which, from their very definition, exclude the control of momentum and energy transmitted to them. Conversely, any unambiguous application of the dynamical conservation laws in quantum mechanics requires that the description of the phenomena involve a renunciation in principle of detailed space-time coordination. This mutual exclusiveness of the experimental conditions implies that *the whole experimental arrangement must be taken into account* in a well-defined description of the phenomenon. The indivisibility of quantum phenomenon finds its consequent expression in the circumstance that every definable subdivision would require a change of the experimental arrangement with the appearance of new individual phenomena. (Bohr 2010, 89-90, *emphasis added*).

Results are inextricably linked to the experimental apparatus designed for their registration, and they must fundamentally—Bohr repeats "in principle"—be considered as part of the complete description of

[20] As Adam Becker has recently explored, despite serious debates on the implications of quantum mechanics at the very moment of its founding, "the rest of physics simply moved on" (2018, 4).

the phenomenon. The centrality of the idea of a complete description may be lost to the contemporary reader, but in the early debates between Bohr and Einstein on the validity of quantum mechanics, it was precisely this ability to give a "complete description" of atomic phenomena that Einstein questioned.[21] Even after Einstein's death, Bohr returned to the terms of this foundational debate frequently in his continued reflections on the metaphysics and meaning of quantum mechanics, and his repeated statements throughout his career that a full description of quantum phenomena include the measurement apparatus should be read with the gravity that this gigantomachy demands. The measurement problem is central not only to the description of quantum phenomena, but—through the "completeness" debate—the disciplinary progress of quantum physics itself.

A second, related phenomenon that occurs in measurement is described by Werner Heisenberg's uncertainty principle. The uncertainty principle has to do with the fact that there are pairs of qualities that may be measured, but where the precision of one entails obfuscation of the other. Heisenberg asks us to consider the example of an electron in flight, and the measurement of either the position or momentum of that electron (through the microscopic interaction of a photon). He continues:

> At the instant when position is determined…the electron undergoes a discontinuous change in momentum. This change is greater the smaller the wavelength of the light employed—that is, the more exact the determination of the position…Thus, the more precisely the position is determined, the less precisely the momentum is known, and conversely. (Heisenberg 1983, 64).

The change in the momentum of the electron is greater the more precisely we measure its position, rendering it impossible to have knowledge of both qualities. We might have rough calculations of these pairs of attributes, but attempts at correcting for greater precision in one aspect rapidly renders increasing uncertainty—perfect knowledge of one aspect would be infinitely uncertain! (Feynman 2006, 6). The observer effect that "collapses" the potential states of a wavefunction thus also collapses the potential measurements that might be taken.

[21] See Einstein et al (1935); and the reply Bohr (1935).

Bohr's response to the measurement problem figures centrally in Karen Barad's *Meeting the Universe Halfway*, as the physicist-turned-philosopher explores the implications of the measurement apparatus. Because the measurement marks the point where superposition collapses into precise position, the apparatus of measurement itself must be considered as part of the phenomenon being measured—not in the sense typical of the academic paper, where an experimental design is merely discussed, but in a more epistemologically profound way where that apparatus is creative of the conditions of possibility for meaning. In Barad's reading of the Copenhagen interpretation, "as a matter of principle, there is no unambiguous way to differentiate between 'object' and 'agencies of observation'" meaning that "no inherent/Cartesian subject-object distinction exists" (2007, 114). The quantum measurement, in this light, is not an objective view from nowhere, but a constituent of the phenomenon that permits meaning to be made. The knowable quantum world is not a world "out there" that we interact with using measurement devices. Rather, the knowable quantum world is the one that we create with the construction and operation of apparatuses of observation (whether experimental or quotidian).

Entanglement; or, "Spooky Action at a Distance"

Of all the weird features found in quantum mechanics, entanglement is perhaps the most extreme. This weirdness derives perhaps from the way in which entanglement breaks a sacred barrier familiar both to Newtonian physics and everyday experience—the speed of light. For the Newtonians, the rule that no thing[22] can travel faster than the speed of light implied an important limit for causation, called locality. What this principle means for causality is that for something to "cause" an "effect" on something else, there is a limit to how far away it can be. Specifically, the time taken to cross the space between the action and the effect (or the chain of events) cannot imply motion faster than the speed of light. That is to say, nothing can travel faster than the speed of light, so things that are not *local* to one another—we might

[22] The version of this chapter published in Murphy (2021c) reads "nothing" rather than "no thing." Newton's calculations assume gravity's force to be instantaneous, although subsequent experimentation and more precise mathematical analyses have revealed gravity to abide the speed of light (Haug 2021).

colloquially say “close”—cannot *cause* anything to happen to one another. Causes that we perceive as instantaneous in reality only *appear* to be that way, as the time scales relevant for local causation can be compressed beyond recognition by the naked eye.

Like it does with the notions of superpositionality and the observer effect, quantum mechanics throws a wrench into the simplicity of locality by allowing non-local causation through a phenomenon called entanglement. This phenomenon describes the connection between two substances such that they remain connected regardless of distance between them, and can continue to “act” on one another in an immediate way despite the distance separating them (thus breaking the limit of the speed of light). Originally hypothesized as an answer to irregularities appearing in the mathematical models of quantum mechanics, entanglement was originally theorized through thought-experiments, where physicists followed the implications of the theory through logical deductions. Dismissed by Einstein as ‘spooky action at a distance,’ entanglement became an *idea non grata* in the mainstream of physics that cared more about exploring quantum ideas experimentally than philosophically, and was left to the mystic types who saw quantum mechanics as describing a new religious consciousness.

This changed somewhat in the early 1980s, as the principle of entanglement was proven by a research team led by Alain Aspect, who set out to experimentally verify the earlier thought-experiments of Einstein, Podolsky, and Rosen (Aspect, Dalibard & Roger 1982; Aspect, Grangier & Roger 1982). Through to today, work continues to push the experimental boundaries of entanglement, which will be an essential feature of quantum computer networks. Recent advances include an electron spin entanglement observed at a distance of 1.3 kilometres (Hensen et al 2015), and a satellite-based experiment which demonstrated entanglement effects over 1200 kilometres apart (Yin et al 2017). Despite the mysterious—and seemingly magical—properties of entanglement, such experiments demonstrate its veracity at larger and larger scales.

But this scale expansion is not only occurring in terms of the distance over which entanglements are found, but also in the bodies exhibiting entanglement. Provocative work in biology demonstrates how quantum entanglement occurs in the wet and warm bodies of living animals—orders of magnitude beyond the scale of a photon pair. In a popular science primer for quantum biology, Johnjoe McFadden and Jim Al-Khalili (2014) set entanglement front and centre, describing how the migration patterns of European robins demonstrate entanglement effects between the so-called 'avian compass' and the magnetic field of the landscape below. Breaking with the safe and familiar laws of force that seem to describe the macroscopic world which we inhabit, entanglement reveals a web of powerful and mysteries connections able to act in unseen and instantaneous ways at great distances—potentially across the universe itself!

The Ongoing Debates in Quantum (Meta)Physics

While earlier I noted that my discussions throughout the dissertation are broadly in line with the Copenhagen interpretation, and the social-theoretic translation of these ideas, it is important to note that these ideas are far from universally accepted. Kathryn Schaffer and Gabriela Barreto Lemos (2019) argue that a common failure in non-technical quantum writings—whether pop science or social theory—is glossing over the multiple forms of contestation within the scientific community on what we might call the "true meaning" of quantum physics. But academic honesty demands this recognition: "if you are interested in asking about the meaning of quantum physics 'outside the lab,'" they argue, "it is important to acknowledge that there is no consensus on the meaning of quantum physics 'inside the lab'" (Schaffer & Lemos 2019, 7). Indeed, this poses a particular challenge to authors seeking to translate or take seriously the importance of quantum thinking beyond physics, as "it is hard enough explaining the weirdness of quantum physics within a single interpretation, much less trying to explain that everything could be completely different if we picked another" (Schaffer & Lemos 2019, 7).

But rather than a drag on our development of a Copenhagen-inspired critical-quantum framework to be used in International Relations, Schaffer and Lemos' warning should be taken as wind in the sails of the quantum IR community. Der Derian and Wendt, of course, call for "quantum approaches (in the plural) rather than…a quantum theory (in the singular)" (2020, 11), and as I will argue in the next chapter, this pluralism is an all too often overlooked characteristic of the quantum IR community. The variety in interpretations of quantum mechanics means that quantizing International Relations can take that many more approaches. While the applicability of some approaches may be more readily applicable to world politics than others, the pluralism is a strength rather than a challenge.

Hans Christian von Baeyer's *QBism: The Future of Quantum Physics* offers an accessible introduction to five interpretations of quantum physics. Four, including the Copenhagen interpretation, appear in an appendix.[23] The second interpretation is the Many-Worlds interpretation, which solves the problem of collapse by replacing it with a continual division of reality into multiple alternative paths, with the observer remaining in only one of the paths. The pilot-wave interpretation posits that there is a missing variable, a quantum force that operates like gravity to control the motion and position of particles in a deterministic manner. The idea of the pilot wave is that there is "a physically real wave satisfying Schrodinger's equation…along with a particle following a well defined trajectory" (Bohm & Hiley 1982, 1002). The wave/particle duality is a delayed rather than paradoxical relation. The final alternative interpretation introduced by von Baeyer is the suite of spontaneous collapse theories, which claim that wavefunction collapses "are natural events that need no human-induced triggers" and "happen spontaneously but so rarely that they don't affect the interaction of individual small quantum systems" (von Baeyer 2016, 239). Quantum Bayesianism, or QBism, is the favoured interpretation and subject of von Baeyer's book, which claims that "quantum probabilities are numerical measures of personal degrees

[23] The following summaries appear in von Baeyer (2016, 235-239) except where otherwise noted.

of belief" (2016, 131). The calculations on a quantum system, then, do not for the QBists reflect the reality of that system, but only the observer's confidence in knowledge about it.

There are many more interpretations of quantum mechanics than would fit the scope of this dissertation. My development within the Copenhagen paradigm is not to discount the legitimacy of any other interpretations within the laboratory or in translation to a form of quantum social theory. Rather, it is my belief that the kind of pluralistic conversation that the quantum IR community seeks to open up may best be accomplished through the exploration of this multiplicity of interpretations. QBism may be particularly interesting to projects dealing with the influence of new ideas, cultures, and norms, while the Many-Worlds Theory may be a productive point for efforts to pluralize and diversify disciplinary debates. As noted in the introduction, my particular approach—driven by an imaginary rather than claims of actuality or analogy—seeks to explore the fundamental philosophical assumptions of quantum theory, and the Copenhagen consensus provides a productive thinking-partner in this enterprise. Yet, in the spirit of openness characteristic of quantum approaches to International Relations, I do not seek to foreclose engagement from alternative interpretations.

Chapter 3
Quantum Social Theory and Translation-as-Method

> *"Will an adequate translator ever be found among the totality of its readers? Or, more pertinently: Does its nature lend itself to translation and, therefore, in view of the significance of the mode, call for it?" (Benjamin 2007, 70)*

Introduction[24]

Translation as an approach to quantizing International Relations focuses on identifying what we might call quantum-like concepts in those previously existing theoretical frameworks or identifying concept-pairs that draw homologies (Murphy 2020d; Owens 2015) between quantum and critical concepts. To this end, translation seeks to explore how the language of quantum social theory can help explain, and expand the utility of, existing concepts in critical International Relations. As I argued in *Quantum Social Theory for Critical International Relations Theorists,* the technical language emerging from critical theories of IR often becomes so technical precisely because it must express a kind of hidden complexity that lurks beneath simplified (Newtonian) reality, and despite an *apparent* complexity, a quantum translation in fact facilitates the *clear* expression of ideas because we need not think around Newtonian strictures. For example, the paradoxical nature of the wave/particle duality can offer a homological model for expressing complexity that critical theory identifies as hidden beneath parsimonious approaches to International Relations.

A powerful example of the power of language in limiting the possibility of meaning-making is found in Carol Cohn's (1987a) landmark article in feminist security studies, where she highlights how core concerns of peace and humanity become unthinkable once assimilated into the common parlance of the defense and security establishment. While the explosion of critical approaches to International Relations

[24] The introduction includes several revised paragraphs from Chapter 4 of *Quantum Social Theory for Critical International Relations Theorists: Quantizing Critique* (Palgrave Macmillan, 2021c).

brings a number of new terms that allow for new questions to be asked about different aspects of world politics, remaining within the bounds of Newtonian social science means that the limits of that physical imaginary have not been transcended. While this may be inconsequential for problem-solving theories in search of predictability and regularity, approaches which seek to recognize and disentangle complexity should recognize the dangers of remaining within the constraints of a Newtonian imaginary. While that Newtonian imaginary may work well for problem-solving approaches that seek to improve function or predict regularities, the critical quest for questioning problems and recognizing complexity is seriously hindered by the constraints imposed by Newtonian assumptions of lawlike regularities, the objective observer, and so on.

When ideas are moving in a quantum-like direction—recognizing paradox, in search of complexity, and beginning with an acknowledgement of uncertainty—translating them into the vernacular of quantum social theory permits a new set of questions to be asked in the diagnosis of the existing world and the imagination of alternative and emancipatory political futures. In short, quantum social theory dovetails with the broad aims of critical International Relations in a way that Newtonian social science does not—rather than speak within the limits of a Newtonian vocabulary (and therefore imaginary), the translation to quantum social theory frees the concepts to explore the complexity, uncertainty, and paradox that critical IR theory seeks to identify. Because the pair are related homologically—that is, they share a common form are not merely similar—the shift in language and adoption of a quantum imaginary is primarily a matter of fit. While Newtonian language must be pushed against for the development of critical scholarship, within a quantum imaginary, the door is open.[25]

This chapter will explore the motivations and principles of translation as a method for "quantizing" International Relations. Turning first to the motivations underlying the theory, I will reflect

[25] The same openness may provide substantial benefits for non-critical scholarship seeking to understand complexity, uncertainty, and paradox; however, given the place of criticality in this dissertation discussed in the introduction, such an investigation would be beyond the scope.

on the three key philosophical motivations for translation as method: Walter Benjamin's meditation on the task of the translator in his commentary on Baudelaire, the dualism embedded in translation as revealed by actor-network theory, and the writing of Karen Barad—drawing on Donna Haraway—on the ethico-methodology of diffraction. With the motivations canvassed, I turn in the second section to the three principles of translation-as-method in quantum International Relations: identify homologies, translate imaginaries, and explore interactions. The final section of the chapter demonstrates the insights of translation-as-method through three proof-of-concept cases: borders, autoethnography, and assemblages. As sufficiently familiar cases within critical IR, these are meant to offer short vignettes, setting the stage for the more significant conceptual case studies found in the chapters that follow. The conclusion provides summary reflections on the practice of translation.

Philosophical Motivations

Walter Benjamin and the Task of the Translator

Benjamin's reflections on translation-as-mode occur in an essay called "The Task of the Translator," originally appearing as an introduction to a translation of Baudelaire's *Tableaux Parisiens*. In this essay, Benjamin draws clear distinctions between understandings of translation as mere transmission of content, and speaks to the *mode* of translation as a kind of recognition and representation of the inherent translatability of the work. He calls this quality of translatability the "law governing the translation" (Benjamin 2007, 70). The concept of translatability is central to my approach of quantizing-through-translation because it describes the significance of quantum-like ideas existing already in International Relations theory and, furthermore, suggests the status of the work in its translated form.

When setting the stage for his reflections, Benjamin justifies reflection on the theme of translation by a pair of questions. The treatment of the two possible questions justifying the translation of a work indicates Benjamin's focus on translatability over the translator (despite the essay's title): "The question of whether a work is translatable has a dual meaning. Either: Will an adequate translator ever be found

among the totality of its readers? Or, more pertinently: Does its nature lend itself to translation and, therefore, in view of the significance of the mode, call for it?" (Benjamin 2007, 70). In his consideration of the questions, he suggests that human error or incapacity at a given time should not interfere with the judgement of the translatability of the work. Indeed, he argues that "the translatability of linguistic creations ought to be considered even if men should prove unable to translate them" (Benjamin 2007, 70). This is a key distinction for Benjamin, which recalls Aristotle's critique of the Megarians in Book Theta of the *Metaphysics*—just as Aristotle argued that the builder of a house is still able to build houses when not actively engaged in building, so to is a work translatable when not actively being translated.[26] Indeed, in a metaphysically anti-Megarian[27] move, Benjamin insists that this translatability inheres even without its actualization: "Translatability is an essential quality of certain works, which is not to say that it is essential that they be translated; it means rather that a specific significance inherent in the original manifests itself in its translatability." (Benjamin 2007, 71). The translatability is an essential feature of the thing itself, independent of its actualization by a translator into a translation.

What happens, then, when a work is translated? We find two distinct approaches to this question. In the first instance, Benjamin considers what happens to the work in translation through a commentary on its life. His reflection, ultimately arguing that the translation is a kind of afterlife, merits reproduction in full:

> Just as the manifestations of life are intimately connected with the phenomenon of life without being of importance to it, a translation issues from the original—not so much from its life as from its afterlife. For a translation comes later than the original, and since the important works of world literature never find their chosen translators at the time of their origin, **their translation marks their stage of continued life**." (Benjamin 2007, 71)

From the work's perspective, translation is not a continuation of life but a fullness of afterlife: a novel period of existence. It is not that the work takes on an *entirely* new meaning, but that its articulation in a

[26] See Aristotle 2016, IX, 3 1046b29-33; Murphy 2020c,207*ff*.
[27] See Murphy 2020c; Agamben 1999.

new language brings with the complementary and supplementary contributions of that new language. The concepts of the work become entangled with the fabric of that language.

Benjamin's second approach to considering what happens to the work in translation addresses the intended effect—or *intentio*—of the work. Here, we similarly see Benjamin reflect on how the translated work is differentiated from the original work. Yet, the language he uses to address the relationship of the original to the translation is that of music rather than life. In the translator's approach to the work, the first imperative is to reach to the core of the work. As Benjamin tells us plainly, "the task of the translator consists in finding that intended effect [*Intentio*] upon the language into which he is translating which produces in it the echo of the original" (Benjamin 2007, 71). The core concern in the second imperative is that of fidelity to that *intentio* rather than direct reproducibility of the original or pure sameness of the language. Benjamin's musical description returns again: "The language of a translation can—in fact, must—let itself go, so that it gives voice to the *intentio* of the original not as reproduction but as harmony, as a supplement to the language in which it expresses itself, as its own kind of *intentio*." (Benjamin 2007, 79). That Benjamin eschews the equation of translation and reproduction should perhaps be predictable, given his harsh critique of reproducibility in the aesthetic realm, and it is important as a guide to the method of quantizing through translation. The project is not merely one of repeating in a new vernacular, but of recognizing the core intention of the idea and—by moving to a quantum register—produce a harmonious supplement to the original. It is not merely a matter of expressing in quantum terms as a substitution of Newtonian signs for quantum signs; a translation is powerful when that new language offers a harmonious afterlife of novel ideas, insights, intuitions, and connections.

As a sort of disciplinary-sociological statement of purpose, quantizing critique adopts the task of the translator by guiding the concept to a new quantum language. This critical-quantum is intended as harmony for the critical, shifting substantially from Newtonian to quantum imaginary in a manner that

opens up scholarly potentiality and transcends Newtonian limits. The reference to music is particularly insightful here because—just as each instrument provides an infinite expanse of musical potentiality, such that a guitar cannot sound a trumpet blast—Newtonian and quantum imaginaries provide different socio-political and philosophical limits. Especially in the many projects of criticality, the ill-suited limitations of a Newtonian imaginary demand a ceaseless fight against them. However, as argued in chapter one, our choice is whether we want to choose unfriendly territory or welcome lands.

Actor-Network Theory and the Sociology of Translation

A second theoretical influence on the method of quantizing through translation is found in the sociological discussion of translation developed in actor-network theory. Here we find a broader case and a more precise case—the former referring to movement of ideas and the latter referring to the practice of bringing things into relation (including the enrollment of interests). What inheres in both meanings is an emphasis on the relationality in translation. Thus, in the discussion of translation and networks, Callon et al tell us that "translation stands in for all the mechanisms and strategies through which an actor—whoever he may be—identifies other actors or elements and places them in relation to one another" (Callon et al 1983, 193). Latour, similarly, refers to translations as mechanisms for mediating associations (2005, 108), and techniques of bringing into relation, e.g., equations (Latour 1987, 238-9). Translations are not about effacing differences but about recognizing relationality and, in a memorable definition from Callon, underlying unities: "Though translation recognizes the existence of divergences and differences that cannot be smoothed out, it nevertheless affirms the underlying unity between elements distinct from one another" (Callon 1980, 211). It is from this point that we reach Callon's statement of the tactics of translation, which align precisely with the discussion of homologies which I have imported from theological approaches to International Relations:[28] "Translation involves creating convergences and homologies by relating things that were previously different" (Callon 1980, 211). The first lesson to draw

[28] See Murphy 2020d.

from actor-network theory's approach to translation for the quantizing-by-translation methodology is that the tracing of homologies is a key tactic of translation.

But the theoretical reflections of the actor-network theorists on translation also highlight two further conceptual elements, beyond the tactical aspects of methodology. First, the displacement effects of translation; and secondly, the procedural and progressive nature. In *Science in Action*, Latour draws attention to the underappreciated translation-as-displacement meaning: "In addition to its linguistic meaning (relating versions in one language to versions in another one) it also has a geometric meaning (moving from one place to another)" (Latour 1987, 117). He then draws a dual implication from the linguistic/geometric duality of translation: "Translating interests means at once offering new interpretations of these interests and channeling people in different directions" (Latour 1987, 117). In Callon's best-cited sociology of translation, the geometric nature of translation is similarly central. As he draws conclusions towards the end of the piece, he states that: "First, the notion of translation emphasizes the continuity of the displacements and transformations which occur in the story: displacements of goals and interests, and also, displacements of devices, human beings, larvae, and inscriptions" (Callon 1984, 223)—or, more succinctly, "to translate is to displace" (Callon 1984, 223). The second lesson to draw from actor-network theory's approach to translation is that translation marks a displacement.

We move now to the movement embedded in translation considered not in terms of geometry but in terms of process and progress. Callon's sociological and socio-legal accounts of translation in particular offer strict rejections of fixity in translation. He tells us that "translation is a process before it is a result." (Callon 1984, 224), and that they "are never a foregone conclusion" but are instead "formulated as hypotheses which will be judged convincing or otherwise" (Callon 1980, 211). The work of translation is an uncertain process of discovery. Adopting a geographical language, Callon states that "translation asserts the necessity for some detours, and indicates the required changes of route" (Callon 1980, 212).

The process proceeds through space and time, with the "problematic zone" representing "a zone of *fusion* where the cognitive and social mingle in the same logic" (Callon 1980, 212)—that is, where the translated and the translation come into contact.[29] The third lessons to draw from actor-network theory's approach to translation is that the journey of translation is not predetermined, but an exploratory process.

Barad, Haraway, and the Ethico-Methodology of Diffraction

The final philosophical influence on the quantizing-through-translation methodology that I employ here is the ethico-methodology of diffraction described by Karen Barad. Inspired by Donna Haraway's use of diffraction in posthuman and queer theoretic works of the 1990s, Barad takes an ontological turn in arguing for a framework of 'agential realism.' While that specific ontological approach is beyond the scope of my dissertation, it nevertheless does influence Barad's unique twist on diffraction.

Let us begin, then, with Haraway's approach to diffraction. Dissatisfied with epistemological reflectivism, Haraway introduces diffraction as an alternative approach similarly inspired by an optical metaphor: "The rays from an optical device diffract rather than reflect. These diffracting rays compose *interference* patterns, not reflecting images" (Haraway 1992, 299). Elsewhere, Haraway describes the diffraction/reflection comparison in terms of difference: "diffraction, the production of difference patterns, might be a more useful metaphor for the needed work than reflexivity" (Haraway 2018, 34). From these introductory statements by Haraway, we can appreciate the fundamentally metaphorical approach to quantizing a worldview that she employs. It is not a matter that *we are essentially quantum*, but that a quantum metaphor recognizes patterns of different-ness.

But there is a secondary—and no less significant—point that we must attend to in Haraway's treatment of diffraction, that undergirds the metaphorical preferability. Namely, diffraction exists as a process and production of difference itself, and diffraction supersedes reflection precisely because of this attention to difference-production: "a diffraction pattern does not map where differences appear, but

[29] One might describe this zone in Agamben's terms as a zone of indistinction.

rather maps where the *effects* of difference appear" (Haraway 1992, 300). Furthermore, Haraway's appreciation for the diffractive metaphor is expansive in temporality and scope:

> Diffraction patterns record the history of interaction, interference, reinforcement, difference. Diffraction is about heterogenous history, not about originals. Unlike reflections, diffractions do not displace the same elsewhere, in more or less distorted form, thereby giving rise to industries of metaphysics…Diffraction is a narrative, graphic, psychological, spiritual, and political technology for making consequential meanings. (Haraway 2018, 272)

The application of diffraction at the level of metaphor offered Haraway a novel and powerful descriptive framework to explore the posthuman cyborg reality of *ModestWitness*, and it is little wonder why this metaphorical uptake of a quantum idea would appeal to Karen Barad as a physicist *en route* to philosophy. But Barad's ontological intuition of an entangled ontology leads from quantum metaphor to quantum reality.

Indeed, while we do find in Barad similar language around the preferability of diffraction over reflection (e.g., 2007, 81), a distinct difference between Barad and Haraway is the former's quantum realism. As they state directly in *Meeting the Universe Halfway*, "diffraction is also more than a metaphor"—and the impact of a diffractive reality is profound—because "diffraction is a quantum phenomenon that makes the downfall of classical metaphysics explicit" (Barad 2007, 72). More than mere metaphor, diffraction marks the signature of quantum mechanics itself!

In line with Haraway, Barad highlights the queerness of quantum as the duality of wave and particle radically rejects the structure of binary itself. To this end, Barad argues that "the quantum understanding of diffraction troubles the very notion of *dicho-tomy*—cutting into two—as a singular act of absolute differentiation, fracturing this from that, now from then" (Barad 2014, 168). As quantum physics extends—via the agential realist ontology—from the laboratory to the lived world, Barad maps this queering of subatomic state binaries onto social reality, such that "diffraction queers binaries and calls out for a rethinking of the notions of identity and difference" (Barad 2014, 171).

But the most important use of diffraction by Barad is in describing their methodological approach to quantum social theory. Interestingly enough, here they play the role of their own metaphor-maker, while also describing their diffractive methodology as more-than-metaphorical. In a metaphorical introduction, Barad states that "diffraction is also an apt metaphor for describing the methodological approach that I use," defining their approach as "reading insights through one another in attending to and responding to the details and specificities of relations of difference and how they matter" (Barad 2007, 71). But again, the connections and patterns of difference that she pursues are not confined to the terrain of the metaphorical, but abide a homological relation (if not more):

> My diffractive methodology maintains a standard of rigor that enables me to return to my starting point and address anew unsettles questions in the foundation of quantum physics…What is at issues is not mere homologies between different subject matters of different disciplines, but rather the specific material linkages and how these intra-relations matter. (Barad 2007, 94)

While *Meeting the Universe Halfway* may, as a lodestar of quantum social theory, be read primarily for its guidance in bringing quantum insights to bear upon the social world, Barad's own explanation of their method clearly stakes out an equality between science and society in their goals. The aim is not to offer a quantum scientism for social analysis, but to explore the patterns of difference created at the intersection(s) of ideas. The insights of agential realism are just as applicable for the physicist as the philosopher.

While Barad is clearly addressing conventionally separated fields, there remains some tension in the idea of interdisciplinarity. On the one hand, they are explicitly interested in "thinking insights from different disciplines (and interdisciplinary approaches)" (Barad 2007, 93), and yet the parentheses remain in their description that "my approach is to place the understandings that are generated from different (inter)disciplinary practices in conversation with one another" (Barad 2007, 92-3). What does it mean to parenthesize the (inter)? We would do well to recall that Barad replaces the familiar "interactions" with "intra-actions," as a call to recognized that the object of study is always and already entangled as a

phenomenon. So, while some theoretical approaches may self-style as interdisciplinary, that is not Barad's own project. Rather, Barad's diffractive methodology begins with the theoretical phenomenon, and different disciplinary or interdisciplinary insights come together in a kind of intra-disciplinary or transdisciplinary dialogue, focusing not on final synthesis or pure and accurate reflection, but instead "diffraction involves reading insights through one another in ways that help illuminate differences as they emerge: How different differences get made, what gets excluded, and how those exclusions matter" (Barad 2007, 30). Rather than accuracy, objectivity, or ontological parsimony, rigorous attention to the production of difference is Barad's methodological principle. Barad's approach to quantum social theory is wide-ranging, and their diffractions on diffraction offer a firm theoretical foundation to approach the coming-together of quantum ideas and social phenomena in the method of translation. The next section outlines a three-step process of quantizing through translation as a method of analysis for quantizing International Relations.

Translation-as-Method: Three Key Steps

The process of translation-as-method includes three key steps: identifying homologies, translating imaginaries, and exploring patterns. I will briefly discuss each in turn, relating their content to the philosophical motivations above.

1. Identifying homologies

   The first step in quantizing-by-translation seeks out quantum-like phenomena. Like the actor-network theorist tracing homologies, translation begins with a search for the significantly similar. The complexity, uncertainty, and entanglement of the social world is replete with such phenomena whose description is delimited by a Newtonian imaginary. As with any act of translation, the identification of a homology begins as a hypothesis, a quantum wager that the Newtonian description of a social phenomenon misses significant details. To state the claim in its strongest form, we might—following Benjamin—say that the homology between a social

phenomenon and the core concepts of quantum social theory are the quantum-like nature that calls out to the translator and demands to be translated. The homological relation is more than mere analogy, and instead speaks to the structural and functional similarity between the social phenomenon and, for example, the duality of the wave/particle. As discussed in the introduction, the identification of homologies within a quantizing-by-translation permits the quantization of existing theoretical perspectives as a mid-level theoretical investigation. A reader familiar with Barad's critical commentary on analogical argumentation may be somewhat surprised to see diffractive reading and quantizing through translation coming together in one methodological apparatus. Indeed, in *Meeting the Universe Halfway*, they differentiate their diffractive methodology with reference to homologies directly: "My aim is to disrupt the widespread reliance on an existing optical metaphor—namely, reflection—that is set up to look for homologies and analogies between separate entities. By contrast, diffraction…does not concern homologies but attends to specific material entanglements" (Barad 2007, 88). However, upon closer consideration of the function of the homology in quantizing through translation, we can quickly see that just as Barad distinguishes between the objectivity assumed by Newton and the quantum meaning of objectivity in agential realism, the role of the homology in quantizing through translation does not hold the representationalist assumption that Barad finds so objectionable in Newtonian reflectivism. While featuring in a broader criticism of analogous methods, Barad's specific opposition to the homology is found in their rejection of "mere homologies between different subject matters of different disciplines" (2007, 94) which focus on an "objectivity [that] is about reflections, copies that are homologous to originals" (2007, 89). Indeed, this Newtonian and representationalist homology is in clear conflict with a diffractive reading! However, the process of identifying quantum-like homologies in quantizing through translation does not fall into these same conceptual pitfalls. Instead, the identification of quantum-like homologies in tension with a

Newtonian imaginary is *precisely so that* the practice of translation can attend to the difference-making possible through the process of a relational reimagining in terms of an entangled ontology. While homologies may foreclose or forestall attention to differences, they may also—when employed as a starting point from which different understandings are then explored (e.g., Murphy 2021c)—further the diffractive project. Furthermore, it is also worth considering that Barad does not carefully differentiate between analogy and homology, which may lead to an undue amplification of this tension. Consider, for instance, Patricia Owens' careful delineation of homology from analogy in *Economy of Force*:

> We can say that there is a homology when there is a correspondence of type or structure—although not necessarily of function—between things. To make a claim of homology is obviously a much stronger argument than analogy, to claim a resemblance, a likeness in form or function, as in the domestic analogy. (Owens 2015, 7)

Therefore, while Barad does in fact provide a strong argument against theoretical approaches that seek to reach an analogy, the present design does not meet the criteria for that objection, first because the homology is taken as entry-point rather than end-point and secondly because of the homology/analogy that Owens clarifies.

2. Translating imaginaries

The middle stage of quantizing-through-translation involves bringing into conversation what I have called the quantum social imaginary—that underlying set of physical assumptions that describe the social world in terms of quantum concepts rather than Newtonian concepts—with the quantum-like social phenomenon. Non-local causation complexifies Newtonian localism; the duality of wave and particle queers binaries; temporal linearities twist and turn to permit reverse and delayed causality; diffractions and entanglements reveal the fundamental connectivity of society; and, the observer effect imbricates the social and scientific, natural and cultural, knower

and known. This is the period of fundamental movement described by actor-network theorists, and stable Newtonian concepts experience the undulation of a fuzzy quantum imaginary.

3. Exploring patterns

   The project of quantum social theory is not merely the thought-play of identifying interesting overlaps. Indeed, while the mastery of a set of ideas does afford this pleasure to the learner,[30] the real analytical value in quantizing-through-translation is the improved analytical, descriptive, or prescriptive purchase offered by the quantized understandings of social phenomena (or, indeed, social-theoretical frameworks). Following Benjamin, the quantized concepts then take on an afterlife, offering a quantum complement, supplement, and harmony to the Newtonian original. Not merely a reproduction, the quantum imaginary infuses the translation with a new attentiveness to the diffraction patterns of everyday life, mapping complex, uncertain, and entangled social relations.

Three Applied Cases[31]

Wave/Particle Borders

Borders are a familiar subject of investigation in International Relations, as they mark the spaces where claims of territorial sovereignty abut one another. But while this brief definition may work well in the abstract, or for approaches built on assumptions of Westphalian sovereignty, borders are often more complicated than a line in the sand. Contested borderlands (e.g., Bouzas 2012; Mukherjee 2015; Zarinebaf 2019) are places where ongoing border disputes lead to overlapping rather than abutting claims to sovereignty. Even when borders become more well defined, as through the construction of border walls, the effects produced through walls are complex, as they can produce new sites of resistance, data sources, and an object of new political discourses (e.g., Pallister-Wilkins 2011; 2016; Rosière & Jones 2012).

[30] See Cohn 1987a, 1987b on the pleasure learning technostrategic language.

[31] The following four sections originally appeared in Chapter 4 of *Quantum Social Theory for Critical International Relations Theorists: Quantizing Critique* (Palgrave Macmillan, 2021c).

Arguments around the deterritorialization, offshoring, and extension of the border (e.g., Mountz 2011a; 2011b) further complicate any idea that the border is simply a line between two sovereign nations when the functions of borders occur at "airports, rail stations, cruise line terminals, prescreening points [in addition to] the physical frontier" (Salter 2008, 366). While there is an abstract notion of the border as a physical barrier where claims to sovereignty are enforced, the reality underneath the surface demonstrates that the border is a much more complicated phenomenon with messier boundaries and many connected practices, constituent elements, and nonlocal connections.

While borders may appear in the problem-solving literatures on security and strategic studies—especially in the context of "stopping threats at the frontier" (e.g., Flynn 2000)—critical approaches to the study of borders highlights the complexity of the topic beyond the assumption of discrete and objective physical entities. But this does not mean that there is only one way to study the border 'critically.' Indeed, the research community known as "critical border studies" includes approaches using securitization theory (e.g., Salter & Piché 2011) or drawing explicitly on theories of sovereignty (e.g., Murphy 2019), which have highlighted the macro-social nature of borders as social institutions and instruments of power, whereas more fine-grained analysis of the materiality (e.g., Nyers 2012) and technologization (e.g., Bourne et al 2015) of the border draw attention instead to the constituent parts that construct the border. This separation between macro and micro approaches to border studies highlights how there is a constitutive paradox in the ontology of the border—that is to say, the heart of how critical scholarship understands the border holds tension at its deepest level.

This perspectival fracture can be easily understood as a macro/micro divide. The macroscopic analyses typically focus on how the invisible social structures interact with the border, and draw on familiar concepts of state theory such as security, sovereignty, and territorial control. While singular events such as policy announcements may be recognized as key shifts in these social-structural aspects of the border, macroscopic analyses are more likely to take place either through abstract theorization or

analysis of a longer time-scale. In both cases, we might say that they are focused on that patterns and global impacts of changes in governance rather than precise differences from one place to another. Conversely, microscopic analyses proceed by unpacking the complex reality into its constituent parts, tracing precise developments, and uncovering connections from the spatiality of the border into procedural manuals, laboratories, and beyond. The border as understood in conventional and macroscopic-critical analyses may very well disappear from view, as the focus turns from the structural effects over time to the precise details of practical and material construction of borders.

Phrased in terms of patterns versus precision, the perspectival fracture in critical border studies has a clear parallel with the wave/particle duality introduced at length in chapter 2.[32] The macroscopic, pattern-focused analysis is homologous to the wave-focused recognition of interference patterns in Young's Two-Slit Experiment. Understanding the role of sovereignty at the border requires abstraction—the social-theoretic equivalent of mathematical modelling of the unseen variables that Schrodinger 'blurred' together. The microscopic analysis, instead, focuses on particularities of complex interactions. But, in so doing, the careful focus on minute details renders invisible the structural dynamics discovered in the first instance. Just as a photoelectric plate interacts only with the particle-form of the photon, the research apparatus designed for the microscopic study of the border can only ever find the small interactions that constitute it. This perspectival fracture is a problem of measurement, in the quantum sense, as prioritization of patterns over precision can only ever reveal structural over agential dynamics (and vice versa).

Translating critical border studies into quantum terms, then, relieves a serious tension within that field. The border, understood as a social wavefunction exhibiting properties of both wave and particle reorients the relationship between macroscopic and microscopic analytical frames as measurement problems. The paradoxical nature of the border is identified through these two radically different

[32] I have made a similar argument about the market as a social wavefunction in Murphy (2021a).

approaches, and it is—referring to Benjamin's remarks—as if that inner tension calls out to be translated into a new physical imaginary that clearly and cleanly expresses that constitutive tension. Once we enter into the quantum realm, we gain an entirely new vocabulary to explore key issues. How do policies destructively interfere to limit our freedom of movement in the borderlands? How do the prejudices circulating through society diffractively differentiate the experiences of some border-crossers from others? By identifying the wave/particle duality as a powerful frame for drawing research perspectives together, we can also ask a whole new set of questions about how quantum phenomena become visible in the subject matter of border studies.

Autoethnography, Reflexivity, and the Observer Effect

The next example of common-ground translation that I would like to discuss is the method of autoethnography, generally understood as an example of narrative and reflexive approaches to International Relations, and how the quantum notion of the observer effect can help strengthen the articulation of reflexive methodologies. Autoethnography was first developed as an anthropological research method (e.g., Hayano 1979) that involves the reflexive study of one's own cultural milieu. In line with other constructivist accounts of knowledge production (e.g., Latour & Woolgar 1986), a central claim of reflexive approaches to research is that the apparent objectivity of positivist epistemologies misses the productive and creative nature of research. In response, a method like autoethnography places the creativity of the researcher front and centre in the understanding of knowledge production.

Before the specific term "autoethnography" was familiar to scholars of critical International Relations, there was already a well-established critique of assumptions of objectivity and detachment in research. One landmark intervention in this discussion is Carol Cohn's (1987a; 1987b) investigation of defence intellectual establishment. Carefully reflecting on her own experiences as a participant in a summer 1984 workshop on nuclear weapons, Cohn discusses—among other issues—the ways in which her engagement with the subjects of deterrence and nuclear warfare was powerfully mediated by the

inner logic of the language spoken by defence intellectuals. Not only is Cohn's article an example of a proto-autoethnographic account because the empirical material comes from her careful reflection from her own experiences—as autoethnography is often casually understood in IR—but the piece is profoundly and reflexively attentive to the ways in which the language and practice of research constrain what is thinkable and knowable.

"The objective of autoethnography," Morgan Brigg and Roland Bleiker state in their framing piece for a *Review of International Studies* special section on the topic, "is to (re-)introduce the self as a methodological resource" (2010, 788). The researcher is significant not only as the name appearing under the title but through the body of the text, which brings "the author into a more fundamental relation with the empirical world" that allows the author to "access important insights that would otherwise remain dismissed or devalued" (Brigg & Bleiker 2010, 789).

Autoethnography also raises important questions on ethics and positionality in research. Elizabeth Dauphinee (2010) argues that autoethnography disrupts the orthodoxy of academic writing that silences the subjects and objects of inquiry, building "a community of interested participants" in place of the previous "dispassionate observers" (817). The autoethnographer recognizes and indeed is inseparable from the complex relation between context, craft, and partners in discussion. Acknowledging and writing from the first-person position allows the autoethnographer "to be forthright about complexity and violence" rather than applying abstract principles from the position of assumed objectivity (Naumes 2015, 825).[33] Sarah Naumes (2015, 831) argues that a key contribution of autoethnography to International Relations is how its narrative method can reveal the dynamic and contradictory nature of world politics. The researcher is an important part of the creation of this knowledge, and ignoring the researcher's own place in the process leaves out key information.

[33] From a perspective of quantum ethics, a key part of Zanotti's (2019) *Ontological Entanglements* is her critique of the application of abstract principles in international interventions.

As discussed in chapter 2, the observer effect in the Copenhagen interpretation of quantum mechanics describes how the act of measurement disturbs a system in such a way that the system is fundamentally altered. Heisenberg's uncertainty principle teaches us that if I choose to measure the momentum of photon, my interaction with the system means that knowledge of the photon's position is no longer possible. In some corners of the Copenhagen interpretation, this goes a step further, and the observer effect is taken to mean that the observer's act of measurement actually *causes* the wave to collapse into a particle. Whether we take the stronger or weaker claim, we are left with a great deal of creative agency on the part of the observer—our intervention through measurement changes the nature of the system in producing that measurement.

While this example may already suggest how autoethnography might be translated into quantum terms, the point is even more strongly articulated in Barad's discussion of the observer effect in relation to the famous Stern-Gerlach experiment. Following the earlier argument of Niels Bohr (e.g., 2010, 89-90) on the importance of accounting for the entire measurement apparatus, Barad (2007) argues that any full account of the research apparatus must always include the researcher—the agency and intentionality of the researcher provides a spark to the whole apparatus that cannot rightfully be assumed away. In general terms, the Stern-Gerlach experiment shot a beam of silver atoms between two magnets, towards a glass recording plate.[34] This experiment was later understood to reveal the important property of electron spin, but at Walter Gerlach's first look at the recording plate, there was no evidence of the silver atom beam. It was only after Otto Stern—smoking a cheap cigar—breathed on the plate while examining it that the high sulphur content of the smoke interacted with the silver on the plate to produce silver sulphide, which was easily recognized by the researchers (Friedrich & Herschbach 2003). There is a first, generic claim, that the construction of the experimental apparatus contributed to the production of the result, insofar as the silver markings on the recording plate would not be there were it not for the practices of the

[34] For a technical discussion, see Schmidt-Bocking et al (2016).

researchers in that particular laboratory. But the more interesting observer effect that Barad draws attention to arises from Stern's ability to see what Gerlach could not. Stern was a junior researcher and his relative impoverishment at that time meant that he was unable to purchase good quality cigars to satisfy his tobacco addiction—but if he had been sufficiently wealthy, there would not have been enough sulphur on his breath to produce silver sulphide on the recording plate and reveal the markings of the experiment. Not only his smoking habit but the specific intersection of the habit with his socioeconomic standing is necessary for the specific sulphur content, and therefore, as Barad argues, "class, nationalism, gender…among other variables, are all part of this apparatus" (2007, 165). Much like Cohn's experience in the rational world of defence intellectuals, results in the supposedly objective world of experimental physics are nevertheless conditioned by the positionality of its participants.

A quantized autoethnography speaks to the entanglement of the observer within the research apparatus and the importance of the observer effect—both specifically and generically—in the production of knowledge. The recognition of complexity in the material (Naumes 2015) or the inseparability of the researcher from research (Briggs & Bleiker 2010) are possible in part because there is a recognition of the broader system of which the researcher is a part as well as the productive difference that the activity of research makes in the system. But it is perhaps the specific observer effect that plays the largest role. It is not only a matter of observation making a difference, but of how *my* observation makes a difference. My positionality across classed, gendered, racialized, and other structures of society participates in the kind of effect that my observation has. The germ of this claim exists in autoethnography, but the lack of a clear explanatory model for why autoethnography centres the researcher led to many critiques of this approach as narcissistic, intellectually lazy, and relying on an unstable self (e.g., Delamont 2007; Gannon 2006; Goode 2006). Quantum social theory's explanation of the entanglement of the observer within the measurement apparatus offers a clear response to these challenges—whether in physical or human sciences, intervention into a system enacts irreversible change and researchers must recognize their

important role in the creation and production of knowledge. To the poststructuralist critique, the acknowledgement of the centrality of the researcher is not a presumption that the research occupies a stable position, but that the continual becoming of the researcher across all planes of existence plays an important role in the production of the researcher (and thereby any research that the researcher conducts).

The chemical production of silver sulphide in the example of the Stern-Gerlach experiment is a clear example, and social scientists will not always have as visible an experience of how their positionality enters into the measurement apparatus. But that is a call to reflexive interrogation, not to bracket that which we do not yet know. Through the observer effect, quantum social theory offers autoethnography an explanation of how both generic and specific effects contribute to the construction of knowledge. While the epistemological argument made by Barad and others is that this entangled and intra-active constitution is always the case, the specific method of autoethnography benefits from the language more than other approaches because of the specific embrace of the positionality and agency of the researcher in this mode of inquiry. Recognizing, with Zanotti (2019), that scientific claims to objectivity proceeds directly from the Newtonian substantialism prevalent across the social sciences, the key assumptions that autoethnography and broader reflexivist approaches bring to International Relations challenge the foundational Newtonian assumption of objectivity.

Entangled Assemblages

The concept of the assemblage has received a great deal of attention in recent decades, drawing on a variety of theorists including Manuel DeLanda, Gilles Deleuze, Bruno Latour, and Saskia Sassen. Defined variably as an “approach” (Abrahamsen 2016), a “thinking tool” (Salter 2013b, 12), and “theory” (Bueger 2018), the concept of the assemblage appears in different places across the research process. Growing in attention since the turn of the millennium, the concept of the assemblage was introduced to many by

Kevin Haggerty and Richard Ericson's (2000) oft-cited article on the "surveillant assemblage,"[35] which argued that surveillance no longer functioned through a hierarchical logic, but as the complex and interwoven network of convergent systems. Rather than an analysis of ontologically separable component parts, the assemblage describes a messy web.

While a full review of how the concept of the assemblage is deployed in International Relations is beyond the scope of this chapter, an examination of the work of Rita Abrahamsen and Michael Williams offers sufficient depth to ground our discussion on the insights that quantum entanglement can offer to the study of assemblages. In the context of research on security privatization, Abrahamsen and Williams argue that the trends are not merely a transfer of power from public institutions to the private sector, but instead encompasses a complexification of security governance and "a broader rearticulation of public-private and global-local relations" where states participate in their own disassembly (2009, 3). Assemblage, in this sense, refers to "these new geographies of power that are simultaneously global and national as well as public and private" (Abrahamsen & Williams 2011a, 175). Whereas the security sector in the twentieth century was commonly understood as state-centric,[36] this concept of the (global security) assemblage calls attention to the complexity and density of relations that stretch across the globe while also producing profound implications for everyday life. Abrahamsen and Williams are clear that part of their call to action is to begin with a different conceptual model of what it means to study security in a way that can understand the complex world of private security:

Situating the emergence of security privatization and global security assemblages within the state draws attention to the inadequacy of explanatory accounts that look at security only in relation to the traditional institutions of the state, such as the police, military, paramilitary forces or ministries of home affairs or

[35] This work continues to drive research agendas in critical approaches to surveillance and security (e.g., Topak 2019). Beyond surveillance, assemblage research has covered a wide variety of topics, such as piracy (Bueger 2018), health (Voelkner 2011), and parasport (Heffernan 2020).

[36] Consider here Max Weber's oft-cited definition of the state.

justice. Instead, it is imperative to examine the relationship between these institutions and other components of the state involved in global processes. (Abrahamsen & Williams 2011b, 95).

We cannot make clean assumptions about state containers[37] preceding interactions, but must prioritize the complex and long-distance relations that produce the "complex hybrid structures that inhabit national settings but are stretched across national boundaries in terms of actors, knowledges, technologies, norms, and values" (Abrahamsen & Williams 2011b, 95). Earlier, simplistic assumptions that describe security in terms of discrete units that can be objectively analyzed within a boundary must give way to a new, assemblage model that recognizes important global influences on local realities, and complex multiplicities of interaction and interconnection.

Translating the assemblage into the conceptual language of quantum social theory involves a recognition of entanglement and its effects. Here, the assemblage can be defined as an entangled system (in opposition to a separable Newtonian entity). Fundamental connectivity between the different elements means that for the entity to be understood in its entirety, the full apparatus—following Barad's (2007) use of the term—must be considered. Hiving off the global dimension to focus on apparently local actors entails a loss of context for the actors and factors under analysis.[38] While Abrahamsen and Williams do not go so far as to claim that relations ontologically precede relata (as we see in Barad's work), they do draw attention to the strength and impact of relationships in the emergence of assemblages. The entirety of the apparatus—read, the global aspects—must be considered precisely because entanglement describes a situation where nonlocal causation can take place. Just as the death of Socrates made Xantippe a widow instantly (Kim 1974), the implications of decisions in a commercial security corporation's office in London have immediate impacts on the lived experience in Nigeria.[39] If we are to

[37] The container model describes the state as a body that contains or captures power and politics within it (e.g., Giddens 1985; Taylor 1994).

[38] See also the work of Patricia Noxolo (2020) on the notion of (post) diaspora read diffractively through local/nonlocal entanglement.

[39] I discuss nonlocal effects in the context of quantum global political economy in Murphy (2021a).

ignore the global in our focus on the local, we miss the nonlocal forces of entangled entities. This is precisely the kind of attention that assemblage-thinking draws to the complex and interrelated entities that must be considered for a holistic view.

The formation of assemblages can be more specifically quantized through Alexander Wendt's discussion of language as an entangled social wavefunction.[40] While his argument is ultimately grounded in the quantum-realist claim that human consciousness *actually is* a wavefunction and entanglement therefore appears as a claim of physical reality rather than as a way of seeing the world, the specific discussion of language is argued in terms of everyday spoken interactions. Wendt outlines a thought experiment where a Vietnamese tourist encounters a merchant in Denmark: at first, their interaction is limited to gestures, but "if one ventures to say 'English?' and the other says 'yes,' then suddenly a new superposition will be created in which the meaning of their potential English speech acts will be entangled with their meaning in the other's mind" (2015, 234). The social wavefunction of language entangles the expression of one with the interpretation of the other, and an isolated assumption focusing only on the language, the speaker, or the listener cannot capture the conversation. "Linguistic competencies," Wendt argues, "are no longer fully separable, but correlated non-locally through an over-arching system of meaning *between* them" (2015, 234). A conversation may be seen as an assemblage of words and their etymologies, sentences and their grammar and syntax, statements and their connotations and logic, as well as interlocutors, their fluidity and vernacular, their familiarity and comfort, and many other factors. To analyze a conversation is to take account of all aspects because they are inseparable from—they are entangled with—one another.

The assemblage—like the conversation—is not a single and discrete *thing* but a complex composite of entangled elements. Assemblages push back against the spatio-temporal limitations of Newtonian social science and call attention to relations beyond contained relata, disabusing the observer

[40] A different approach to the concept of the social wavefunction appears in the next chapter.

of the assumption of separability. But in a Newtonian imaginary, there is a leap of faith necessary to research an assemblage—we suspend our disbelief in nonlocal connections within the assemblage by bracketing certain elements of the Newtonian physical imaginary. But we need not research while holding our ontological noses, as quantum social theory provides the missing physical imaginary for the social arrangements that assemblage-driven inquiry draws attention to. The approach—to borrow Benjamin's turn of phrase—calls out to be translated precisely because of the significance of the difference between Newtonian modes of inquiry and the radical challenge that the concept of the assemblage poses.

Conclusion

As the three examples discussed in this chapter demonstrate, quantizing-by-translation grants critical concepts that reject the assumptions and implications of Newtonian social science an alternative physical imaginary and a powerful new vocabulary. This new conceptual-linguistic mode opens up space for new ways to explain and explore the insights of critical International Relations. From critical border studies, we see how the wave-particle duality can help unpack the relationship between macroscopic and microscopic orientations of critique. In the case of autoethnography and reflexive approaches to International Relations, the observer effect explains the necessity of recognizing the imbrication of the researcher in the creative project of research to appreciate the full apparatus of investigation. And finally, the notion of the assemblage receives a powerful explanatory framework for discussing nonlocality, the necessity of recognizing all entangled elements, and the shared wavefunction produced as a new answer for what the assemblage *is*.

Much of the conceptual heavy lifting that critical International Relations scholars undertake must be heavy because they must bear not only the weight of mainstream assumptions within the discipline, but also the Newtonian physical imaginary that posits a boundary of the imaginable. The partial solutions that can be developed by a perspectival fracture to move beyond a paradoxical object of inquiry, vulnerability to criticism of self-aggrandisement in research, or simply bracketing the question of how it works. All

inquiries following these MacGyvered Newtonian methods entail an authoritative claim by the researcher, that may well become accepted as a critical method but nevertheless is to a greater or lesser extent unimaginable in terms of the physical imaginary.

The strength of quantizing through translation is that each of these approaches can now express itself free from the linguistic limitations of Newtonian social science. Critical concepts that speak to complexity, paradox, and uncertainty can be expressed in the vernacular of a sympathetic imaginary. While the conceptual case study chapters that follow will clarify (when necessary) the specific methodological application in that particular investigation, their main task will be the demonstration of the scope of the quantum question in International Relations, stretching across major subfields of security studies, foreign policy and diplomacy, and International Political Economy.

Chapter 4
Violent Interference: Structural Violence, Quantum International Relations, and the Ethics of Entanglement

> *"So, some of the leaves moved up and down under the influence of two waves that reinforced each other, and some leaves were under the influence of two waves that canceled each other out. This was why the waves moved some of the leaves and left other leaves at rest!" (Malin 2012, 29).*

Introduction

The concept of structural violence arises in a variety of scholarly and activist contexts to identify forms of violence dispersed nonlocally through society. While many different definitions of structural violence have arisen in recent decades, the concept continues to encounter epistemological, ontological, and political challenges from various sources. I suggest that the insights of a quantum imaginary can help to resolve these challenges. Despite each definition highlighting slightly different elements, a general sense of the term may still be distilled: structural forms of violence are less intuitive, less easily categorized, and less visible than individual acts of physical violence. Indeed, physical acts of violence can be attributed to an agent or to a group of agents, isolated from a broader context except where motive or precipitating factors are necessary, and explained in terms of linear and local cause/effect relationships. Even where the violent incidents are psychological rather than physical, violence is intuitive when described in terms of attribution, isolation, linearity, and causality.

Opposition to the idea of structural violence as a whole can be rhetorically justified by questioning the empirical validity of diffuse and non-isolatable forms of violence. Prioritizing the more intuitive and apparent forms of violence over structural violence is strategically employed to discredit structural accounts. A clear account of this rhetorical opposition to the notion of structural violence emerged in Canadian politics, where former Prime Minister Stephen Harper argued against an inquiry into missing and murdered Indigenous women, girls, and two-spirited people by focusing on individual perpetrators of

criminal acts. While other comments on the issue drew more attention in the general population—for example, stating that from the point of view of his cabinet, the murder of Indigenous women, girls, and two-spirit people had been "studied to death," and therefore "isn't really high on our radar" (Onstad 2015)—Harper was strongest in his dismissive rhetoric when he called the suggestion that structural violence was at work in Canadian society an attempt to "commit sociology" (Saramo 2016; Ramos 2017). The first genre of criticisms of structural violence demonstrates a preference—epistemological, methodological, or political—for the visibility of individual agential data points over structural forces in society.

A second genre of criticism towards the idea of structural violence challenges not the possibility of a non-isolatable, non-linear, non-attributable (at least in direct terms) form of violence, but in the notion that structural and individual forms of violence are categorically distinct. Lene Hansen's account of honour killings as an example of gendered insecurity outlines how acts of violence justified in terms of gendered norm transgression cannot be understood as isolated and individual incidents because "a decision to locate this case within the realm of individual security would seriously diminish our possibilities of grasping its collective aspects" (Hansen 2000, 291). Finally, in reflecting upon the moral responsibility for the foreseeable and preventable killing of non-combatants during war, Neta Crawford (2007) argues that narrow attribution to the individual soldiers unduly abstracts them out of their wartime context and thereby ignores the systemic aspect of atrocity. In these and other cases, criticism of structural violence arises from a concern that the categorical separation is a hand overplayed.

The two criticisms challenge the viability of the concept of structural violence on the grounds of its methodology. In the first case, the justification for abstracting a structural force from individual cases is rejected. In the second, it is the justification for *abstracting away* that is challenged, such that even individual acts must be understood in their structural context. Rather than challenge the methodological

construction of structural violence, I propose that we fundamentally re-imagine the *physics* of structural violence.

Specifically, when I call for a reimagination of the physics of violence, I am suggesting that structural violence is non-Newtonian in nature, and that for this reason, all Newtonian explanations will ultimately be unsatisfactory. While we may not begin a specific investigation into International Relations by identifying our physics, the tacit Newtonianism of the vast majority of social-scientific frameworks and vocabularies run aground when discussing social structures—as Wendt (2015, 22*ff*) has argued, with a paucity of plausible and meaningful accounts of consciousness and intentionality in Newtonian physics, immaterial phenomena like social structures are inconceivable. That is at least in part because classical physics begin with objects that then interact according to Newtonian laws of motion and within principles of local and linear causation. The quantum world is radically different when framed in terms of relationality, because, in the framing of Karen Barad, primacy is accorded to relations over relata (Barad 2007-136-7).[41] More than a matter of methodological focus in research design, Barad's claim is far more radical; matter does not produce relations but is produced *through* its relations, as patterns of difference and change create the order from which we can discern reality. Barad "does not take separateness to be an inherent feature of how the world is" while at the same time refusing to "denigrate separateness as mere illusion" (2007, 136). Instead, Barad calls for quantum social theorists to recognize that what we perceive as objects in spacetime are in fact products of the relationality within which they are situated. As will be discussed later on, the ontological primacy of relationality carries with it a new entangled ethics and a responsibility in research design that recognizes how the relationship that the researcher establishes with(in) other elements of the research system has myriad and profound implications for the apparently reality that comes to be observed.

[41] In this Baradian reading, a key distinction between Newtonian and quantum physics is that the former assumes that objects first exist independently and then come into relation, while the latter recognizes that the object (and especially the fuzzy boundaries of the object) emerge from dense networks of relations.

Quantum theory arose in the early 1900s and revolutionized the discipline of physics. While an ongoing debate in physics before the rise of quantum asked if light was fundamentally a wave or a particle, the quantum explanation proposed a "heuristic view" (Einstein 2005) where light was both wave *and* particle. This wave/particle duality was eventually understood to be the foundation for all matter as well as energy (de Brogile 1924), meaning that while the calculations of Newtonian physics at the macroscopic level might function as a rough approximation of reality, the subatomic world for all matter and energy was a fundamentally paradoxical duality of both wave and particle—and sometimes at once. This rupture with our classical and conventional modes of understanding is easily recognizable—and, after all, Richard Feynman was fond of saying that "the word 'quantum' refers to this peculiar aspect of nature that goes against common sense" (2007, 5). The application of quantum theory to the social sciences (Barad 2007; Der Derian & Wendt 2020; Haven & Khrennikov 2013; Murphy 2021c; O'Brien 2021; Orrell 2016; Wendt 2015; Zanotti 2019) explores precisely these apparent paradoxes and complex systems that may well be described—mathematically or conceptually—as wave/particle dualities with related effects of interference, entanglement, diffraction, and so on. Just as the quantum revolution in physics has provided a powerful and insightful model of the "weird" world of the subatomic, a quantum revolution in social sciences and social theory may be similarly revolutionary in their capacity to explain social phenomena.

I turn to quantum approaches to International Relations[42] for an alternative imaginary grounded in quantum physics rather than Newtonian physics. A quantum account does not remove individual agency, but does radically reshape its scope. To quantize ethics through an entangled worldview demands ever greater attention to the ripple effects of individuals' actions. But, more importantly for the present investigation, a quantum ethical model permits an ontologically consistent account of structural violence enmeshed with personal violence, ethics, and privilege. Employing the methodological approaches of "quantizing through translation" (Murphy 2021c) and "diffractive reading" (Barad 2007) I offer a quantum

[42] See Der Derian and Wendt (2020) on the plural naming convention.

re-reading of one of the most influential accounts of structural violence: Johan Galtung's (1969) article "Violence, Peace, and Peace Research."

More specifically—and again in dialogue with my fellow-travellers—this chapter addresses questions of ethics in a quantum world that pose serious challenges not only for the conceptual development of quantum approaches to IR theory but for the breadth of the field. The relationality of a quantum world means that the individual act of violence is inseparable from the entangled social relations that structure the social interaction. And yet, the duality embedded within quantum social theory means that recognizing the entanglement of the individual with the broader society does not erase the agency of the individual violent agent. While the range of potentialities available to me may be fundamentally shaped by my positionality in various social structures (through quantum-like processes of structural interference described below), I am nevertheless responsible for the effects of the agential cuts that I produce in my interactions, the relata emerging from the relations I bring into being, and the structural patterns that emerge through my participation in the broader wave-like interactions of the manifold social relations and interactions throughout society. And if this were not yet complex enough, entangled ethics have implications not only for the agents in society but also for the academics seeking to understand and the activists seeking change. As the production of relations and apparatuses of observation influence the relata to be produced through those observations, the methodological choices of academic researchers in the space of violence are profoundly ethical—what do I choose to study, and how does academia structure economies of privilege and reward for some concerns over others? And for the activists, if structures produce privilege and violence through their interference with a variety of individual waves, then a mere shift will only displace rather than erase interference effects—how can we think a remedial politics that changes rather than shifts destructive interference?

The first section situates the present intervention within the literature on quantum International Relations, including a methodological review of quantizing through translation and diffractive reading.

The second section turns to Johan Galtung's typology of violence on his own terms, both in his key article and in associated readings articulating his structural theory. The third section outlines the key concepts of quantum social theory through which structural violence will be "translated" into a quantum imaginary, while the fourth section undertakes this translation and explores its ethical implications.

Quantum IR: Ontological Frameworks and Targeted Transformations

The development of quantum International Relations since the turn of the millennium can be understood as occurring in three stages: early works, from 2000 to the publication of Wendt's *Quantum Mind and Social Science*; solidification, from 2015 to 2020; and expansion, starting in 2020. While epoch-marking is always fuzzy, and the youth of quantum IR as a field of inquiry makes it only more so, periodizing quantum IR into three sections can help to situate the ethical stakes of this dissertation in the context of an expanding quantum dialogue in the field. While introductory efforts laid the foundation that made quantum IR viable, it was not until the solidification and expansion of quantum approaches that ethical concerns came to the forefront of quantum IR.

Early interventions included Badredine Arfi's (2005; 2007) work on quantum game theory, Alexander Wendt's (2006; 2010) quantum response to constructivism, James Der Derian's (2011p 2013) reconceptualization of speed, virtuality, and visuality in quantum terms, and meditations on complementarity (Ougaard 2004; Roach 2010). The second period begins with Wendt's (2015) *Quantum Mind and Social Science*, which drew greater attention to the many developments of quantum IR both through its publication as well as the symposia which responded to it.[43] Other works of this period include Laura Zanotti's (2017; 2019) work on quantum ethics, K.M. Fierke's (2017; 2018) explorations of quantum theories in dialogue with Buddhism and Daoism, David Orrell's (2018) quantum reimagination of economics and money, and others (Der Derian 2019; Lehtonen 2019; O'Brien 2017; Hamilton 2017). While always difficult to mark turning points, the special issue of *Security Dialogue* on quantum approaches to

[43] Found in *Critical Review,* the *Journal for the Theory of Social Behaviour*, and *Millennium*.

International Relations theory and security studies can be taken as a rough marker that the community of quantum IR moved from solidification to expansion for at least two reasons. First, rather than clear space for a specific project, Der Derian and Wendt (2020) are explicit in their editorial introduction that their interest is not in a unified quantum theory but in a plurality of quantum *approaches*. This commitment is demonstrated by the breadth of topics covered in the issue: agency, systems theory, technology hype, trauma, value, and the rift between social and physical sciences (Orlando 2020; Albert & Bathon 2020; Smith 2020; Fierke & Mackay 2020; Orrell 2020; Grove 2020). Secondly, the expansion of quantum ideas was not limited to the special issue. While new approaches take time to develop a large publication footprint, owing to practical reasons such as the establishment of research projects to produce scholarly articles and the expanded reach of peer reviewers, the growth of quantum IR in 2020 and onwards can be found in the breadth of topics discussed: affect, the Anthropocene, decolonial ethics, gender, holography, markets, temporality, and beyond (Yıldız-Alanbay 2021; Harrington 2020; Zanotti 2020; Prügl 2021; Pan 2020; Murphy 2021a; McIntosh 2021). In addition to the specifically ethical works by Zanotti, Fierke, and others, another key issue of relevance to the present inquiry is the emergence of a debate on the possible relationship of quantum IR and critical IR (Sjoberg 2021; Murphy 2021b; Wendt, *n.d.*).

Quantum IR did not emerge in a vacuum, and influences from a broader quantum social-theoretic tradition, in addition to writings of early quantum physicists such as Bohr and Heisenberg, influence different developments in quantum IR. Wendt's *Quantum Mind and Social Science* is a tour-de-force in this respect, drawing on a variety of literatures that apply quantum physics to topics in biology, game theory, decision theory, consciousness studies, philosophy, and psychology. But the introduction notes that Wendt's quantum journey began with a chance encounter (2015, 2) with the work of Danah Zohar, a management theorist who developed an account of quantum social theory grounded in the idea that new ideas in physics demanded new understanding of the world around us (Zohar 1990; Zohar & Marshall 1994). Karen Barad's (2007) quantum theory—drawing together physics, ontology, queer theory, feminist

thought, and agential realism—provides a rigorous basis for considering the implications of entanglement in the world. The quantum-like paradigm in economics, finance, and psychology applies the equations of quantum mechanics to model and predict phenomena in the social world (Haven & Khrennikov 2013; Khrennikov 2010). Social-theoretic investigations by Patricia Noxolo (2020), F. David Peat (2002), Norah Bowman (2021), Glenn Aparacio Parry (2006) and others examine the possibilities for quantum theory to engage with postcolonial, decolonial, and Indigenous thought. These different strands of quantum social theory beyond IR serve as important conceptual reservoirs from which future investigations might draw.

As was mentioned above, the specific quantum approaches to be taken in this chapter are diffractive reading and quantizing through translation. While Chapter 3 outlined the dissertation methodology and discussed the philosophical methodologies that inform this approach, I would like to return to this consideration of diffractive methodology and quantizing through translation in this particular conceptual case study, in part because Barad's notion of diffraction appears here as method and theory. Diffraction is a phenomenon that "has to do with the way waves combine when they overlap and the apparent bending and spreading of waves that occurs when waves encounter an obstruction" (Barad 2007, 74). That is to say, as the wave encounters something else—whether another wave or the environment—diffraction describes the patterns of change and difference observed. Barad's methodology of diffractive reading does precisely this with concepts, and they describe the methodology of *Meeting the Universe Halfway* as "reading insights through one another in attending to and responding to the details and specificities of relations of difference and how they matter" (Barad 2007, 71). Indeed, the transdisciplinarity of quantum social theory relies on the ability to attend carefully to key details of one field when "reading" them through the other, whether a matter of turning to quantum physics to explain social phenomena or beginning with quantum theory to map out social-theoretic extensions flowing therefrom.[44] The methodology of diffractive reading encounters the text as a sort of wave in its

[44] Barad makes a similar point about accuracy in transdisciplinary diffractive reading. See Barad 2007, 25.

own right—to be understood as a conceptual wavefunction—and then observes from within the precise patterns emerging from the intra-action of one conceptual wavefunction with the rest of the conceptual apparatus. For the purposes of our investigation, a schematic representation of the methodology in terms of diffractive reading would take structural violence as our object of analysis and quantum social theory as our conceptual—or, in more familiar quantum-mechanical terms, *measurement*—apparatus. Attending to the details of both the pre-quantum and the quantized accounts, the diffractive methodology demands attention to the object, the conceptual apparatus, and their intra-active encounter.

The methodology of quantizing through translation outlines in more practical terms the intra-action between object and conceptual apparatus. While the many different non-quantum and Newtonian accounts of structural violence may find a way to posit structural effects based on observed patterns, attention to constituent actors requires a leap of faith, because Newtonian social science lacks an ontological foundation for structural claims.[45] Wendt discusses this particular pitfall in *Quantum Mind and Social Science*, arguing that "*any* conception of social structure…will be an anomaly for a classical social science" because Newtonian models lack a plausible description of consciousness as a meaningful and intentional phenomenon (2015, 23*ff*). While ad hoc addenda may produce a functional "MacGyvered Newtonian" ontology, the price is the ontological consistency of the theoretical framework (Murphy 2021c, 77). As Wendt has argued, for example, despite consciousness and intentionality being impossible forces within a strict application of Newtonian physics, a Newtonian social scientist wishing to study human decisions may simply ignore the contradiction between the object of social analysis (decision-making) and the lack of physical basis for its existence (because Newtonian physics lacks a model of consciousness). The researcher might very well produce insightful research by ignoring this physical contradiction, but forgetting a problem is not the same as resolving it. Quantizing through translation begins with those concepts on shaky ontological ground from a Newtonian perspective, which appear to

[45] On this point, see Wendt's discussion of the causal closure and consciousness (2015, ch 1).

be ‘quantum-like’ or homologous to quantum concepts—that is to say, similar in both form and function (Murphy 2021c, 62). The process of translating the concepts into quantum terms is not one that forces quantum ideas, but recognizes that a quantum ontology may be a more natural and empowering physical imaginary than a Newtonian ontology. To that end, the quantum translation is a sort of setting-free of a quantum-like concept from Newtonian restrictions, such that the employment of a concept can focus on the object of critique rather than fighting the twin pressures of conventional narratives *and* Newtonian limitations (Murphy 2021c, 76). Inspired by Walter Benjamin’s (2007) claim that the object of translation calls out to the translator to be translated, the scholar engaging the methodology of quantizing through translation seeks to recognize the quantum-like features of existing concepts (Murphy 2021c, 65), and by expressing those quantum-like features in properly quantum terms permit their full expression.

Heeding the necessity of accounting for detail to permit the diffractive translation to occur, our first step is to explore the object of analysis both in detail and in context. For that reason, not only does the next section speak to Galtung’s theory of structural violence, but also provides the immediate substantive context—the typology offered in “Violence, Peace, and Peace Research”—as well as the conceptual context—Galtung’s associated writings on structural concepts. From that point, the conceptual apparatus of quantum interference and entanglement will be presented, before the intra-active encounter itself takes centre stage.

Galtung’s Structural Theory of Violence

Building on his own prior structural theorization of aggression (Galtung 1964), foreign news (Galtung & Ruge 1965), and integration (Galtung 1968) as well as Stokely Carmichael’s (1968) exploration of ‘institutionalized violence,’ Galtung argued in “Violence, Peace, and Peace Research” that the success of both peace and peace research would require a proper theory of violence in its structural and personal forms, across several levels of analysis. This article is a landmark in the development of peace studies as a field of scholarly development, and Google Scholar records over 10,000 citations—a feat all the more

impressive considering the platform's unreliability for bibliometrics more than 25 years old. While the visibility of the article and the careful theorization of social structure offer two reasons to approach a quantization of structural violence that takes Galtung as conceptual case study, this is only a preliminary opening into the question of how structural violence may be understood in quantum terms. Quantizing more recent developments in the study of structural violence will doubtlessly advance the dialogue between quantum social theory and the study of peace and violence.

The essay begins with a comment on the utility of the term "peace." Galtung is conscious of the fact that the term's meaning is less than perfectly clear, and suggests that peace researchers may be in the best position to pursue a definition of "violence." The solution to this problem is first to define peace as the absence of violence, in turn opening another definitional problem (Galtung 1969, 167-8). The body of the article sketches out a theory of violence, before turning back to the question of peace (in positive and negative forms). Galtung begins this pursuit of specificity with the broad definition that "violence is present when human beings are being influenced so that their actual somatic and mental realizations are below their potential realizations…Violence is that which increases the distance between the potential and the actual, and that which impedes the decrease of this distance" (Galtung 1969, 168). The entire exploration of the concept of violence is, I would argue, captured in this statement, and it is clear that this understanding of violence is highly structurally informed.

Galtung offers six distinctions between types of violence: physical and psychological, negative and positive, damage and threat, personal and structural, intended and unintended, and manifest and latent.[46] While the fourth distinction will be our key focus, the others are worth briefly reviewing.

- The physical/psychological divide recognizes that not all violence impacts the biological life of the individual. While the obvious harm of physical violence may be more readily apparent,

[46] See Galtung, (1969, 168-174).

psychological violence like brainwashing, indoctrination, threats, et cetera serve to limit the mental potentialities that an otherwise free and unaffected individual would enjoy.

- The distinction between negative and positive violence speaks to the ability of influence to limit mental potentialities. That is, while negative violence punishes an individual when the influencer is displeased, positive violence occurs when the influencer offers a reward for following his interest rather than the individual's own.
- Third, accounting for both objective damage—that is, violence occurring directly to an object—and threat—where the looming possibility of physical violence exacts a mental toll—makes it possible to account for the violence of forces like intimidation. Galtung also offers the balance of power—and we might suggest deterrence more broadly—as an example.
- While I will speak at greater length about the separation of personal and structural violence, Galtung's most concise approach to their disentangling states that personal violence is a direct act of an identifiable individual, whereas structural violence is indirect and does not require an individual. Rather, the unequal design of society is such that the average expected potential of any given individual is unattainable for certain segments of the population by virtue of their place in the structure.
- The fifth distinction is the relatively straightforward separation between intended and unintended violence. Galtung notes that the focus on guilt in terms of intention leads many ethical systems to downplay or ignore the force of structural forms of violence that may be unintended, while capitalizing on the smaller instances of direct, personal violence. He likens this practice to "catching the small fry and letting the big fish loose."
- Finally, the discussion of latent and manifest violence adds the consideration of the violence that may easily come about to more readily apparent forms of violence that are actualized. This is different from the earlier notion of threat as it is not specific but describes the generalization of

an unstable equilibrium. In short, when the normal situation is a hair's breadth from eruption into violence, some or all inhabitants are limited from actualizing their full potential.

Let us now focus in first on the distinction between personal and structural violence, and then on characteristics of Galtung's structural approach in general. After outlining the six distinctions, Galtung returns to reflect again on the personal and structural forms of violence. Here, he argues that we ought not be surprised that personal violence has typically drawn more attention than structural violence—personal violence is visible, in his words like "waves on tranquil waters," whereas "structural violence is silent, it does not show…it is essential static, it *is* the tranquil waters" (Galtung 1969, 173). Because personal violence by definition occurs in particular moments, it is highly visible and demands attention. Conversely, structural violence has a certain stability that makes it appear as the normal condition.

Taking the language of an essay on structural-analytic method, Galtung defines a structure "as a set of elements with an accompanying set of relations" (1976, 1). The elements, in a social structure, are the individual actors. Relations emerge between the actors through their interaction, and may result in the capacity to compare one or some actors to one or more other(s) (Galtung 1976,1). Whereas an incident of personal violence occurs in a given interaction, structural violence obtains in the pattern.

In a follow-up piece written by Galtung and Tord Hoivik (1971), we receive a common metric for comparing direct and structural violence—number of years lost. "If society has the resources," they say in the context of structural violence, "to give an *average* life expectancy of *c* years to its members, then the question is whether the average life expectancy of social groups is correlated with social position, so that the lower the social position, the lower the life expectancy" (Galtung & Hoivik 1971, 73). The measurement of directly violent incidents can be measured by subtracting the resultant age at death from the life expectancy at birth, while structural violence can be measured by comparing the life expectancy of a given social group with the whole of that society. While it remains unclear how this measure would account for forms of latent, psychological, and positive violence (as well as threats), the basic statistical

argument that structural violence is a non-predictive, aggregate measure of years lost captures in a rough way Galtung's theory of structural violence. By definition, it is not concerned with particular incidents of violence, but with the patterns in aggregate terms.

Another important element of Galtung's conception of structure in general is found in his reflections on imperialism, found in the Millennium conference address in 1981. He begins by explaining why his theory of imperialism should be understood as structural, stating:

> There are two main reasons for this: it is structural in the sense that *no specific actors* are indicated, and also in the sense that for the concrete actors that happen to be performing roles in the structure in question *no specific motivation* is necessary. The basic assumption is that the structure…is extremely strong and has its own internal logic so that once it has started operating it is not necessary for those who are acting within in it to desire all the consequences…In short, the structure simply goes on by itself, creates wealth for some nations, poverty for others, wealth for some classes, poverty for others, and does not ask for much in terms of motivations. (Galtung 1981, 183).

This statement highlights how intended and unintended forms of structural violence can coexist. In a sense, structural violence has sufficient momentum that unless its internal logic is obstructed, it will go on by itself, repeating its patterns of inequality and oppression.

The reflection on internal strength of the structure arises also in the 1969 article when Galtung discusses mechanisms that support inegalitarian distributions. As may be expected from an account that constructs a bifurcation between agent and structure, none of the six mechanisms are agent-driven:

1. *Linear ranking order* – the ranking is complete, leaving no doubt as to who is higher in any pair of actors;
2. *Acyclical interaction patterns* – all actors are connected, but only one way – there is only one 'correct' path of interaction;
3. *Correlation between rank and centrality* – the higher the rank of the actor in the system, the more central his position in the interaction network;
4. *Congruence between the systems* – the interaction networks are structurally similar.

5. *Concordance between the ranks* – if an actor is high in one system, then he also tends to be high in another system where he participates and
6. *High rank coupling between levels* – so that the actor at level *n*-1 is represented at level *n* through the highest-ranking actor at level *n*-1. (Galtung 1969, 176).

As we can see here, structural strength comes from clearly hierarchical positionality and homological arrangement across systems. It is difficult to discern how exactly one of these factors would speak directly to an incident of personal violence[47]—and though Galtung's conclusion is that personal and structural violence are "empirically independent" (Galtung 1969, 178) it seems also that the specific description of mechanisms and definitions of categories situates them also as conceptually and categorically distinct phenomena.

Whereas the identification of personal violence is fairly simple—the kind of violence that can be seen on a camera, as Galtung states—structural violence is about trends and patterns in aggregate terms. While some degree of intentionality is necessary, the actions or intentions of any particular actor within the structure are not as important as the interactivity of the structure and its self-perpetuation. Defining structural violence as the macroscopic pattern of groups and classes having their potentiality limited compared to greater relative freedom of the whole of society allows for many new types of violence to be analyzed. Reframing the issue in quantum terms permits a clearer realization of the relation between violence, privilege, and peace.

Quantum, Interference, and Entanglement

Having now introduced the theoretical model of structural violence that will later be quantized, we move now to a description of the quantum conceptual apparatus. As introduced above, the two guiding methodological approaches for this chapter are diffractive reading and quantizing through translation. In

[47] With perhaps the exception of an incident of violence resulting from the rejection of an acyclical interaction pattern.

both cases, we begin with a fulsome account of the Newtonian version of the theory to be quantized. The next step—which will be explored in this section—is to describe the conceptual apparatus. In our case, the key conceptual apparatus is *interference*,[48] a quantum phenomenon observed when waves interact. Interference plays an important role in the conceptual development of quantum mechanics, as the phenomenon was actually noted centuries before the quantum revolution in physics, but could not be explained fully through classical models.

From the time of Isaac Newton, physicists debated the nature of light, with some (following Newton) arguing that light was a shower of particles, and others arguing that light must be a wave. A famous experiment lending credence to the latter interpretation was Thomas Young's 1801 "two-slit experiment."[49] Essentially, when observing light passing through two slits in a barrier onto a screen, we might expect to see the two brightest spots on the screen directly in line with the slits. Indeed, when only one slit was open, the light passed through the slit and the light was brightest directly across from the slit, fading into darkness above and below. However, when both slits were open, something surprising happened. Rather than a bimodal distribution with two brightest spots and a gradual darkening between and beyond them, Young observed a series of bands of light. He had discovered the phenomenon of interference. The discovery of interference was significant because this phenomenon could not be explained through the particle model of light. At first, this was taken to disprove Newton's theory, but eventually the wave model ran into its own problems, such as black-body radiation and the photoelectric effect. Max Planck and Albert Einstein proposed two versions of the same solution to this problem in 1900 and 1905, respectively, suggesting that light was both a wave and a particle.

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[48] As a reviewer for the article-version of this chapter aptly noted, interference and diffraction are often used as synonyms in discussions of quantum theory. This occurs most notably in Barad (2007), whose diffractive methodology is explicitly attuned to analyzing diffraction in society. I thank the reviewer for highlighting the homology of this application of a diffractive/translational methodology to interference, on the one hand, and Barad's diffractive analysis of diffraction.

[49] See a longer explanation in Wendt (2015).

This synthetic account, known as the wave/particle duality, serves as the foundation of quantum mechanics. When quanta are isolated, they spread out and behave as waves diffused through space and time; when quanta are observed (or interact with another system), they behave as particles with identifiable characteristics. Therefore, while the particle may be measured definitively, the wave must be *represented* by a wave*function*, which stands in as the mathematical representation of all possible values of the wave (for example, all possible positions that a wave spreading through a room might occupy).[50] While the ontological significance of the wave-to-particle transition is hotly contested, it is called the 'wavefunction collapse' because—whatever the ontological meaning—the mathematical representation goes from the inclusion of all potential measurements to one defined measurement. John Polkinghorne (1984, 32) describes the moment of collapse in the following manner: "probability, which was originally spread out in a wavefunction…covering 'here', 'there' and perhaps 'everywhere', is now all concentrated 'here.'" The interference effects created through wave interactions are only noticeable when the wavefunctions have "collapsed" through measurement.

To explain this in terms of the two-slit experiment, we might first consider a particle passing through the barrier. Because a particle, in crude terms 'has' a definite position, it can only pass through one slit or the other; because a wave, on the other hand, is understood in terms of probability, we must consider the wave's passage through the barrier not in terms of passing through the position of slit 1 or the position of slit 2, but a "superposition" of both slits *at the very same time*. This remarkable, paradoxical, and impossible representation captures the uncertainty of the wave. While we can determine the ultimate pattern of the wave passing through the two slits by the outcome (the visible bands of alternating light on the screen), the actual interaction of interference is invisible. "Evidence" of interference—so to speak—emerges only in the form of different outcomes for the whole system of light.

[50] This was the sort of definition preferred by Erwin Schrodinger (e.g., 1980, 327).

At the extremes of the phenomenon of interference, we find what we might call its two pure forms. When two waves of the same amplitude meet such that their crests overlap, we say that they interfere constructively. When two waves of the same amplitude meet such that the crest of one meets the trough of the other, they cancel each other out, or interfere destructively. Shimon Malin explains this with the example of walking by a pond where leaves have fallen onto the surface of the water:

> There were small waves traveling along the surface, and, watching the leaves as the waves passed them, I noticed that some leaves were moving up and down, while others, close to them, were hardly moving at all! My curiosity was aroused; I watched two waves approaching a leaf from two different directions, so that at a certain instant it was under the influence of both. Each wave, acting separately, would have caused the leaf to be displaced upward by about an inch. Following the principle of superposition, the actual displacement of the leaf, due to the combined effects of both waves, was about two inches. The two waves "interfered constructively" with each other: They pushed the leaf in the same direction, and their effects added up. Then I watched another leaf, under the influence of two different waves. This time one of the waves would have imparted a displacement of an inch upward, while the other would have imparted a displacement of an inch downward. In this case, again following the principle of superposition, the effects of the two waves canceled out, and the leaf did not move at all. This is called "destructive interference." So, some of the leaves moved up and down under the influence of two waves that reinforced each other, and some leaves were under the influence of two waves that canceled each other out. This was why the waves moved some of the leaves and left other leaves at rest! (Malin 2012, 29).

The brilliance of Malin's everyday example of interference is its intuitive representation of such a complex phenomenon. While even the leaf example can be made infinitely more complex—with many waves meeting at different points in their cycle creating terribly difficult calculations to predict the ultimate height of the leaf at any given point—we can nevertheless see the idea in the mind's eye.

In the application to social theory, we are concerned not with waves of water or light, but social wavefunctions—representations of the directly invisible social phenomena, like institutions, organizations, identities, norms, et cetera. Wendt argues that because social science is fundamentally attuned to meaning and mind, investigating properties such as agency, structure, and practices, we are concerned with phenomena that "can only be 'seen' if you already know they are there" (Wendt 2015, 24). If social phenomena are invisible but recognizable through the patterns and effects they produce,

then social wavefunctions are the description of the directly invisible entities (Murphy 2021a, 2-9)—a philosophical corollary to the mathematical description of the original wavefunction. At the individual level, my identity is a composite wavefunction of all constituent elements and influences, each inseparably related—that is, entangled—with the cultural significance of those identifiers. At a larger level, institutions of all sorts can be understood as social wavefunctions—languages, communities, religions, cultural groups, and associations but also patriarchy, racism, sexism, and bigotry. When a social interaction occurs, then, it is not merely the biological beings making noise or moving, but a whole host of "entangled" social wavefunctions interacting with one another, collapsing for each participant in the interaction into one understanding—or, in quantum terms, "measurement."

The role of entanglement must be specified in terms of the construction and definition of social wavefunctions. Just as the terms "social structure," "nation," "market" and myriad other names for social phenomena stand in as a description of the phenomenon as a whole, so too does the wavefunction stand in as the (mathematical) description of the quantum phenomenon. As Schrodinger (1980) argues, we can only ever consider that description complete if it describes all elements. Since one photon of an entangled pair cannot be completely described without reference to the other, then the entangled state of the two can only be completely described as a wavefunction of the system. The notion of wavefunction as complete description operates across levels of analysis in the model of quantum social theory employed in this chapter, with the key caveat being that my goal is not a mathematical *quantification* but conceptual *quantization*. What we might conventionally call a social structure—defined perhaps in Galtung's terms as the ensemble of relations in a network—is a terminological descriptor playing the same semiotic role as Schrodinger's mathematical formula. One major differentiation in the quantum sense is that these social wavefunctions will adapt to include in their full description the social relations entangled within a system. So an individual's social wavefunction will be entangled within systems of class, identity, nation, et cetera, while each of those systems will subsequently be constructed through the relations of their

constituents and be mediated by their interactions with other such systems.[51] The practices of research include the ethico-methodological decision to attune our descriptive apparatuses to certain social wavefunctions and not others, which makes visible some relations and relata rather than others. A project methodologically constructed to evaluate economic status as a univariate cause will result in the observation of radically different entanglements than an intersectional analysis.

Prima facie, such talk of a quantum 'description' of social entities may appear to recreate the Newtonian model of objective descriptions of ontologically separable units. However, as Barad adeptly explains throughout *Meeting the Universe Halfway*, objectivity is a radically humble claim within an agential-realist world. The researcher is—recalling the Stern-Gerlach experiment—entangled within the observation apparatus and therefore also an integral part of the description of the phenomenon. A measurement is an agential "cut," that may produce replicable and reliable readings; yet the replicability and reliability can only be understood within relational context. Simply put, when a quantum social theorist refers to an "objective description," a whole host of relational and contextual assumptions are already baked-in.

Understanding interference as a key interaction effect for the analysis of social phenomena, we can begin to sketch out ideal-type and complex forms. For example, if an individual is wealthy, then we might understand their interaction with the social wavefunction of wealth to interfere constructively in their life, as the interaction provides a wider scope of possibilities. Conversely, an individual encountering the wavefunction of poverty would experience destructive interference, with a reduced overall scope of possibilities. The general categories of advantage/disadvantage, as well as the associated concepts of privilege, marginalization, discrimination, exclusion, oppression, and inequality can help understand how

[51] A second would be that the entanglement of the measuring apparatus—in this case the descriptive methodology—with the phenomenon under observation (e.g., Barad 2007) implies that the terminology is not an objective and neutral descriptor as we might find in representationalist epistemology. These descriptions instead mark agential cuts on the part of the research that contribute to the entangled phenomenon's ongoing process of becoming.

complex and composite forms of interference operate—a complexity only redoubled through the indeterminacy of quantum theory, which leads us to believe that even in the same conditions a superposition of multiple outcomes may be possible. For one example, Kimberlé Crenshaw's (1991) explanation of intersectionality explains a kind of doubly-destructive interference, where women of colour experience the negative effects of both racism and sexism, which can be framed as multiple forms of destructive interference operating simultaneously (thereby producing a superposition of multiple subaltern positions). Alternatively, the superposition of many privileged societal positions—taking paradigmatic form in the well-to-do WASP male—has the opposite effect, with the superposition of multiple privileged positions producing a much greater scope of possibilities.[52] In between these ideal types, we find an infinite array of multiple forms of privilege and oppression interacting to produce many different scopes of possibilities.

Violent Interference and Entangled Ethics

To sketch out this new quantum paradigm in peace theory, we now observe as the object encounters the apparatus. Specifically, I would like to discuss the distinction between personal and structural violence, and how by identifying the embedded Newtonian assumption we might translate the concept into quantum terms. In this distinction, Galtung separates violence into personal and structural violence, where both are distinguishable forces in the world. Personal violence abides a linear logic of cause and effect, with one separable and definitive entity acting upon another entity. Separability, definitive borders, and linear causality are key features of Newtonian physics, identified by Laura Zanotti (2019) within the ontological framework of Newtonian substantialism. The embedded Newtonian assumptions of structural violence are somewhat more difficult to identify, but can be found through attentiveness to Galtung's discussion of water.

[52] Galtung offers "concordance between the ranks" as a descriptor of the likelihood that high position in one system increases the likelihood of high position in another (Galtung 1969, 176).

Galtung presents episodes of personal violence as waves on tranquil waters, and the tranquil waters themselves as the water's equilibrium state. While both forms of violence are described as water, the idea that structural violence is a resting state displays the Newtonian limitations of Galtung's theory. For violence to be structural, its causation is the equilibrium state; for violence to be personal, its causation is the disruption of the equilibrium. In Galtung's accounting of structural violence, we are only ever searching for evidence of unequal outcomes between a general societal mean and an individual case. Within this framework, we can only assume structural violence to be a design, as acts of violence are excluded—ripples that break the water's tranquility.

To quantize, let us assume first that a social structure is not a set of relationships between individuals but an entanglement of individuals' social wavefunctions. To define the whole system, then, we would have to reconceptualize the social structure as a new wavefunction encompassing all entangled entities. Whereas the Newtonian definition permits that the design (structural violence) can be separated from individual actions (personal violence), the quantum model does not separate. Instead, a fulsome description of the individual requires consideration of the structures to which the individual is entangled, while at the same time recognizing that the agential decisions of the individual contribute to the continued evolution of social reality. Let us first consider the interaction of two individuals, who can be described as two wavefunctions, coming to a violent interaction. Beginning from the position of the victim's social wavefunction, the interaction results in destructive interference patterns that constrict the range of future possibilities in a variety of respects. To explore some of Galtung's types of harm in terms of individual acts of destructive interference, we might say that physical harm (e.g., a limp resulting from a kick to the knee) limits the mobility of the individual, psychological harm (e.g., humiliation) diminishes the self-confidence and assuredness of the individual, and threats (e.g., potential of future violence) produces an underlying state of unease and discomfort. Each of these aspects of harm limit the range of future possibilities available to the individual, meaning that there are fewer potentialities to be accounted for

within the social wavefunction. We can therefore conclude that following the incident of personal violence, the reduced spectrum of the social wavefunction indicates an event of destructive interference.[53]

In the case of structural violence, the victim again encounters a social wavefunction, but in this case it is not one directly attributable to an individual. Instead, the individual encounters the entangled wavefunction of a social structure. In the first instance, we can see that this model is still able to explain Galtung's paradigm of the individual whose social position in society results in a lesser outcome relative to the social mean. However, because the assumptions are grounded in a theory of social structures as entangled wavefunctions rather than a definitive set of relationships, there is a significant shift in *how* we are able to explain Galtung's case. Namely, instead of analyzing the effect of structural violence in terms of the outcomes associated with an isolated individual occupying a fixed and definite position within a network of relationships, the quantum analysis of structural violence describes an interaction between social wavefunctions producing destructive interference. In a case of structural violence, when a social structure's wavefunction (e.g., patriarchal societal norms) interacts with the social wavefunctions of all members of a subaltern subgroup of the population, each of those individuals' wavefunctions are destructively interfered with such that the scope of their future possibilities is reduced through the interaction. That is to say, the social structure limits what is possible, not merely in terms of future planning or personal fulfilment, but as a matter of *social ontology*.

While some may see the cost/benefit analysis of a quantized account of structural violence as roughly equal at this point—especially if the benefits of interaction-effect explanations seem marginal

[53] We might further note that in addition to a shift in the potentialities contained in the social wavefunctions, there is also a shift in the distribution of *probabilities*. A normally peaceful person might have the *potentiality* to hit (possessing the necessary musculature, skeletal structure, nervous system, and knowledge of causation) but this act would be almost infinitely *improbable* without some kind of provocation. The prior violent act may increase the *probability* of future violence on the part of the victim. As with the broader phenomenology of violence, this shift in the distribution of probabilities would be more visible in the individual case than at the structural level of analysis.

given the addition of a quantum vocabulary to a discipline like International Relations, already replete with the specialized vocabularies of numerous "isms" (Lake 2011)—there are two additional benefits of quantizing the concept of structural violence: locating structural violence within incidents of personal violence, and understanding the relationship between privilege and oppression as a structural phenomenon (one raising important ethical questions). The discussion of these benefits will clarify the implications of quantum theory's less rigid approach to structures, abiding not a binary of agent/structure, but an enfolding and an enmeshing of agent and structure together.

Taking seriously the concerns raised by Lene Hansen, Neta Crawford, and others that were discussed above, a strong argument in favour of the quantum explanation of structural violence is that it avoids the problem of binary thinking that assumes a stark divide between personal and structural violence. Context matters, and because the individual's social wavefunction is perpetually and limitlessly entangled in broader social-structural wavefunctions, even the most material example of physical violence can hardly avoid the meanings attributed to all elements of the interactions. The social wavefunction of patriarchy may, as we saw in Hansen's (2000) argument, interfere with certain forms of gendered violence to not only to inform the individual acts of violence, but also limit the agency of women to identify gendered insecurity. The contextual-temporal context of a war may, following Crawford's (2007) argument, similarly alter the question of causation when innocent civilians suffer violence. Because the social wavefunctions of many institutions, structures, contexts, events, and other social forces are always and already entangled with individuals' social wavefunctions, careful accounting of seemingly individual and isolated interactions will doubtlessly reveal interference effects that made nonviolent alternative possibilities less likely and contributed (directly or indirectly) to the incidence of violence. Beyond a Newtonian model where the actor is responsible for outcomes related to intentional (agentic) acts, this quantum model identifies the multiplicity of forces operative in a given phenomenon. Person A may be narrowly responsible for the impact of a violent action against Person B, but if that violence is facilitated

by social structure X that places A in a position of power vis-à-vis B, then the social wavefunction of society itself is ontologically and unbreakably enmeshed in the drama of A and B. Attributing 'blame,' then, becomes radically more complex as a process, reflecting not only on the entangled effects of an agent's actions, but also of the conditions of possibility set out by the social wavefunctions that provide sociocultural context for the act of violence. A quantum model of structural violence blurs the boundary of agent and structure.

Consider that the relations structuring particular hierarchies in society will inform, in different ways and to different degrees, the continued composition and recomposition of an individual's social wavefunction. In the positive case, we might say that if a certain prejudicial norm dissolves, a member of that previously marginalized group may experience less structural harm from the relation to that social structure. In the case of violence, we can see how the different social-hierarchical relations that construct different positionalities of power can also inform individual interactions by baking-in a set of social hierarchies, norms, and assumptions that are not inherent to the individuals involved but emerge as relata from the web of social relations. Recalling the ontological flatness of Karen Barad's quantum social theory, we can also recognize the participation of materiality in establishing the spectrum of potentialities and distribution of probabilities in a given milieu (for example, a physically strong individual has the potential for different kinds of physical violence than a physically weak individual). The significance of Barad's argument that relations precede relata (2007, 136-7) is not, however, a dead-end of determinism destined for the continued destruction of constructed prejudices, oppressions, and structures of violence. Rather, the notion of entangled ethics that calls for the agent to recognize the ethical responsibility for the entanglements and agential cuts in whose enactment we participate (Barad 2007, 382). Understanding that the relata of violence as products of relations rather than producers of relations embeds the ethical question within every descriptive effort. Especially in a Baradian reading, this provides a clear distinction between a quantum approach and a Newtonian one.

Considering the ethical stakes of privilege in social structures offers another example of the ability of a quantum imaginary to push beyond description. While structural violence may offer a description of some individuals' experiences with given social structures, this will not be universal. We might say that those who experience violence and oppression from social wavefunctions of a structure are "out of phase" with the structure; conversely, for those who are "in phase," the exact same social structure that diminishes the future possibilities available to others will instead expand the social wavefunctions of those who stand to benefit—*constructive* interference, rather than destructive.[54] The in-phase/out-of-phase positionality of any single individual is not necessarily 'caused' by the individual but follows from the cyclicity of the particular structure. Indeed, as the social structure's wavefunction is constituted through the entanglement of successive constituents, its cycle will align with those individual wavefunctions benefiting and directing it. That means that correcting the destructive effects of structural violence is not merely a matter of effecting a phase shift, as this will merely result in a different alignment of the patterns of privilege and violence with the destructive/constructive cyclicity of the wavefunction continuing unhindered. Structural privilege and structural violence are ontologically entangled as two ideal-type interference effects following from interactions with a social structure's wavefunction. A quantum account of structural violence demands a fundamental re-evaluation of privilege, as the greater the constructive interference for the privileged, the greater the destructive interference for the oppressed.

Further, as Laura Zanotti argues in *Ontological Entanglements, Agency and Ethics in International Relations*, the move from separability to entanglement has important ethical ramifications (2019, esp. chs 8, 9). While Newtonian assumptions of separability and linear causation lead to some consequences being "unintended," negative effects cannot be brushed off as accidents in a quantum world. Because the very concept of the wavefunction calls on the analyst to consider all potential states, the act of collapsing one's

[54] With similarly intersectional effects in terms of privilege as Crenshaw identifies in cases of violence, producing structural effects in line with the phenomenon that Galtung calls "concordance between ranks" (see above).

wavefunction entails a taking of responsibility for all interaction effects that follow therefrom. The quantum world is one where “probability tends to replace reality” (Agamben 2018) and the convenience of assuming external costs away appears as empty as nonlocal causation radically redefines the scope of the responsible. My gain is not the loss of another in the sense of zero-sum competition, but my gain does proceed from the same wavefunction that produces the loss of another. While the quantum subject may enjoy the privileges of the wavefunction, the violence of the structure (as well as the object of that violence) is entangled with the privilege. To recognize our position in a quantum social system is to acknowledge the complexity of our intra-actions within the multitude of social wavefunctions with which we are entangled.

Conclusion

As this adventure into translation and diffractive reading has demonstrated, one of the key contributions that a quantum approach to International Relations can offer is the significant ethical stakes inherent in any entangled system. It is my hope that this intervention demonstrate the powerful ethical contributions that can emerge from the project of quantizing IR. Far from an abstract exercise of analogical creative writing, quantum social theory permits a thoughtful discussion about the ways in which we understand our intra-actions in society. Even if a similar argument can be made by developing a patchwork of existing social theories, a quantum alternative may be preferrable for a number of reasons, especially when considering structural theories: 1) the ontological possibility of structures in quantum social theory, 2) a cooperative linguistic/physical imaginary, 3) the powerful conceptual reservoir of quantum ideas, and 4) the elegance of all three moves occurring in one move. This is perhaps clearest when the quantum intervention is to quantize an existing theoretical framework, revealing the conceptual purchase to be gained through a quantum reimagination.

A quantum perspective on violence further contributes to the broader and ongoing debates around the relationship between individual and structural violence through the relationality of entangled

ontology and ethics. In a Baradian imaginary where relations precede relata, individual intra-actions take place within an entangled web of social relations that inform the contours of what is possible and the distribution of probabilities therein. As agential participants, we are responsible for not only the potentialities which we make probable and actual, but also the relations that we help to create, which may strengthen or weaken the many waves rippling across the surface of social reality. As Laura Zanotti (2021) tells us, this new ethics of entanglement calls attention to specifics over generalities, thereby generating a new ethical imaginary. But this ethical imaginary is also political, and Karen O'Brien (2021, 48-9) demonstrates how recognizing the centrality of relationality to being is a key step in pursuing social change. Without a new imaginary, we can shift but not fundamentally rethink. And, as discussed above, shifting a wave only displaces or reorganizes structural violence rather than remediating the arrangements causing violence. Reimagining the world in its relationality becomes necessary to think of new projects for change.

The specific utility of a quantum imaginary in understanding structural forces is by no means exhausted by the present investigation. As noted above, Galtung is only one of many interpretations of the concept, and engaging with more recent works may help to elucidate different elements of structural violence. Similarly, much work remains to be done to develop quantum understandings of the myriad other structural forces operative in our world. While I have demonstrated through this chapter the potential insights to draw from Karen Barad's interpretation, theirs is not the only option. Future works in quantum IR would do well to explore how the fascinating world of quantum theory can offer thought-provoking challenges to the familiar assumptions of International Relations. Like Barad's inversion of relations and relata, these foundational questions of ontology and metaphysics force a reimagination of the world and our place in it—both as social beings and social scientists!

Chapter 5
Track Two Diplomacy as a Quantum-Like Strategy: Social Entanglement, Quantum Game Theory, and Quantum IR

> *"As violence phase-shifts at light speed from states to sub-states, local to global, public to private, organized to chaotic, virtual to real—and back again—the transparent words, sequential numbers, and discrete images of war superposition into the wholly new phenomenon of quantum war." (Der Derian 2013, 582).*

Introduction

The continued development of quantum approaches to International Relations theory has resulted in a conceptual cornucopia of reimaginations, demonstrating the implications of quantum ideas on concepts including ethics (Zanotti 2021), time (McIntosh 2021), gender (Prügl 2021), trauma (Fierke & McKay 2020) and beyond. Within this broader camp of so-called quantum IR, the present investigation joins a camp of quasi-applied interventions demonstrating the applicability of quantum ideas to empirical phenomena, already occupied by investigations of language used in Chinese foreign policy (Fierke & Antonio-Alfonso 2018), introspection as social research methodology (Orlando 2020), climate change activism (O'Brien 2021), and Indigenous sovereignty (Bowman 2021). Following the methodology of quantizing through translation (Murphy 2021c) as a path to overcome deep-seated conceptual problems in the understanding of empirical phenomena, this chapter offers a quantum explanation of Track Two diplomacy as social entanglement.

While classical diplomatic efforts presume the negotiation of official actors on behalf of unitary and separate states, "Track Two diplomacy" describes a loose constellation of conflict resolution practices seeking instead to set the groundwork for future peace. As the prior sentence indicates, Track Two diplomacy has been dogged by definitional issues (Jones 2015), as a phenomenon focused on shaping potentiality that one must know to see.

Just as other quantum social-theoretic investigations have identified the homology between social phenomena knowable only through their end-states and effects and quantum behaviour of light (e.g., Murphy 2020), so too does the present investigation begin from the possibility that Track Two diplomacy may best be understood from a quantum imaginary rather than a Newtonian one. Drawing on insights of social entanglement from quantum game theory, I argue that the shaping of potentiality present in Track Two diplomacy abides a quantum-like strategy, and should be seen as a quantum path to peace different from the conventional models. The two sections of the chapter elucidate the paper's conceptual framework, first in terms of quantum-like social phenomena and quantum social theory more generally, before turning to the specific nexus of quantum game theory and International Relations. The third section outlines the (meta)physical Newtonianism embedded in conventional diplomacy, before the fourth section presents Track Two diplomacy in historical context and with reference to the definitional problem. The fifth section then presents three distinct shifts from conventional to Track Two diplomatic efforts that demonstrate the quantum strategy embedded within the latter. The conclusion reflects on future directions of research related specifically to Track Two as a quantum phenomenon and more generally on the process of phenomenon-first quantization.

Quantum-Like Social Phenomena and Quantum Social Theory

In a response to the proliferation of quantum approaches to social theory and social science, Kathryn Schaffer and Gabriela Barreto Lemos suggest that there are four main answers to the question about the applicability of quantum theory to the macroscopic world. First, that there is no relevance; second, that technological hardware requires quantum processes; third, that quantum demands a wholesale revolution in philosophical language; and fourth, that quantum physics offers powerful analogies to the macroscopic world (Schaffer & Barreto Lemos 2019, 16-17). While this typology is useful for sorting many quantum approaches to social phenomena, it does not work cleanly for all developments in this intellectual arena—from Danah Zohar's approach which makes claims on both sides of the

actuality/analogy border (see 1990, 11) to approaches to quantum thinking grounded in critical IR theory (see Murphy 2021b). But what these reviews[55] demonstrate that the core conceptual move made by quantum social theorists is to lift conceptual claims from quantum physics (or, on occasion, the branch of philosophy of science related to quantum physics) and put them to work—by various means and under various assumptions—in the analysis of the social world. This is not a homogenous bloc but a pluralistic intellectual community.

While many interventions into quantum social theory have proceeded from abstract theorization, applying abstract concepts of quantum physics to enrich existing social-theoretic debates, a separate tradition at the intersection of mathematical psychology and financial modelling has operated under the moniker of quantum social *science*. Dominant work in this field is the "Quantum-Like" or QL paradigm, centring on the work of Andrei Khrennikov, Emmanuel Haven, and others (e.g., Khrennikov 2010; Haven & Khrennikov 2013; 2018). Grounded in the mathematical formalism of quantum mechanics and the tradition of econophysics, quantum-like social science seeks to develop robust statistical analyses of the more quantifiable aspects of the social world. Wendt (2015, 35 & *passim*) refers to the approach of the quantum-like theorists as being ontologically *agnostic* as to the deeper philosophical implications of their work. In short, we should be happy that quantum modelling may generate more robust statistical predictions instead of focusing our efforts on an untestable and unverifiable hypothesis about quantum processes in brain tissue.

The matter of identifying a social phenomenon as being "quantum-like," then, has typically involved analogical reasoning and rigorous application of quantum formalism. Andrei Khrennikov describes this process as uncovering the ubiquity of quantum structure beyond physics, and offers the following definition:

[55] See also chapter 3 of *Quantum Social Theory for Critical International Relations Theorists*, which surveys existing quantum approaches to social theory and International Relations.

> The *Quantum-like paradigm* (QL) is based on understanding that the mathematical apparatus of quantum mechanics (and especially probability) is not rigidly coupled with *quantum physics*, but can have a wider class of applications. (Khrennikov 2010, 1).

The efforts of social scientists working within the fields of econophysics, financial modelling, and mathematical psychology to import key equations and models from quantum physics to mathematized social sciences plays an important conceptual role in clearing a path for quantum social theorists to follow. Just as analogical reasoning identifies potential avenues for the application of the mathematical tools of quantum mechanics, so can the identification of quantum-like social phenomena clear ground for social-theoretic analysis.

Quantum Game Theory and International Relations

Within the quantum-like paradigm discussed above, financial modellers have explored the explanatory power of quantum models in game theory. The development of so-called quantum games (e.g., Piotrowski & Sladkowski 2002; 2003a) follow the quantum-like paradigm by identifying interactions whose mathematical expression can be put into quantum terms. Economic interactions such as supply/demand or price arbitration are, for these theorists, more readily explained in quantum terms because the interaction effect of multiple simultaneously considered potential prices more accurately corresponds to the superpositionality of quantum mechanics than the positionality of Newtonian mechanics. The potential impacts of this quantization of game theory in financial modelling are impressive, specifically because of the feedback effects of expectations in the market. As Hanauske et al (2010) argued, while classical (Newtonian) assumptions may predict the same kind of aggressive strategy found in the 2008 financial crisis, the entanglement of all actors within a quantum system may lead to evolutionarily stable equilibria that are cooperative rather than aggressive. Greater entanglement in the system—that is, greater humanization and connectivity between traders in addition to the subsequent attitudinal and

educational changes that follow therefrom—lead to cooperative equilibria stabilizing (see Hanauske et al 2010).

The insights of quantum game theory have also entered into discussion of International Relations in the work of Badredine Arfi in the early 2000s. In an important article on the "trust predicament," Arfi (2005) suggests that the core problem operative in the game—that the optimal outcome of trust/not-exploit is irrational if A assumes B to be rational. Arfi argues that "strategic entanglement allows trust to emerge between the two actors without a need for signalling, third-party, correlation, or any other form of communication between the players" (2005, 131). Strategic entanglement means that instead of individual actors defining single-shot plays per round, they may also choose a superposition (of cooperate and defect, for example), which achieves optimality through a bond imaginable in Newtonian game theory. In a subsequent article, Arfi (2007) clarifies that this strategic entanglement involves no cheap talk, third-party mediation, strategic reassurance, or signaling between official decision-makers involved in the game. By coming together into a quantum game rather than a classical game, quactors (quantum actors) have access to "strategic outcomes that are unpredictable or even forbidden in conventional game theory" (Arfi 2007, 795). Bringing together the modelling of quantum physics as well as quantum-like social science, Arfi demonstrated the mathematical promise of quantum game theory and strategic entanglement for International Relations theory. What I seek to do here is—following my comments above on the extension of quantum-like conceptual move through social theory rather than quantitative modelling—consider how quantum-like social entanglement can help explain the particular case study of Track Two diplomacy.

In *Quantum Mind and Social Science,* quantum game theory serves as a crucial bridge between quantum models of decision making and Wendt's broader quantum model of humanity. As Wendt notes, quantum decision theory is further advanced as a field of study, including not only a mathematical model but also decades of literature empirically testing the novel framework of cognition (2015, ch 8). The

quantum model of decision making is entangled with is context and provides an elegant solution to the behavioural anomalies identified by Kahneman and Tversky that plagued classical models of cognition and decision. Quantum game theory, on the other hand, is somewhat earlier in its development than the mathematical-psychological work of quantum decision theory, and emerges not from cognitive science but cryptography and computation (Wendt 2015, 169). The quantum game-theoretic model favoured by Wendt understands the actor as a quantum agent, entangled in the context of the game as well as with the fellow-players (2015, 170). The games, then, always take place within a shared context that binds the players—translated by Wendt as the shared norms that "are not only internal but also connect individuals in a non-local, holistic way, making them no longer fully separable" (2015, 172). In Wendt's quantum world, not only are individual decisions understood as quantum phenomena fully described only through their entanglement to past, present, and future, but the social actions modelled by game theoreticians are similarly quantum phenomena where the shared normative and social context of the game itself exists as a kind of fundamental and insurmountable connectivity between the actors.

My approach in this chapter, alternatively, does not begin with the mathematical foundation of quantum decision theory but with the identification of a quantum-like phenomenon—Track Two diplomacy—that exceeds the Newtonian imaginary of classical diplomacy. Rather than a general social theory, this translation from one imaginary to another unpacks the physical assumptions that structure the strategies employed in game-theoretic explanations. While this may at some further point be tested through the mathematical modelling of quantum game theory, taking the imaginary as our conceptual entry point avoids Bentley Allan's critique of quantum models of social action shoehorning complex reality into conformity with the mathematics of quantum mechanics.[56] As I will discuss below, while Newtonian assumptions of separability, causality, and the event permit classical diplomacy to be understood in terms

[56] For Allan's critique of Wendt's model of quantum social action, see Allan (2018).

of classical game theory, the strategic logic of track two diplomacy instead abides a physical imaginary of entanglement, interference, and superpositionality.

Diplomacy, Strategy, and Physics: The Classical Case

As we move towards an exploration of the physics of Track Two Diplomacy, it is important to set out our philosophical-methodological guard rails that will guide the remainder of our investigation. Namely, if we accept the claim of quantum IR theory[57] that ignoring the assumptions that we make about physics does no more to erase those conceptual influences than ignoring conceptual forces like cosmologies (Allan 2019), culture (Qin 2018), gender (Enloe 2000), language (Cohn 1987a), moral philosophy (Wolfers 1962), race (Vitalis 2000), or worldviews (Katzenstein 2018). Therefore, bound up in the argument that Track Two Diplomacy abides a quantum-like strategy is a set of assumptions about the relationships between diplomacy, strategy, and physics.

To set the stage, we can turn first to conventional diplomacy. Itself a modern phenomenon, diplomacy as a term of political art arose in the last quarter of the eighteenth century, "build[ing] on existing terms and practices" and giving "a new name to something which has not been collectively named until then" (Leira 2016, 30). Halvard Leira situates the emergence of the concept of diplomacy within a broader context of intellectual transformation in Europe at that time: "the emergence of 'diplomacy' was part of a much larger shift in political languages replacing the understandings of absolutism with the new understandings of the enlightenment" (Leira 2016, 28). Significantly, this is the same period where Bentley Allan (2019, ch. 3) tracks the displacement of aristocracy and a divine providentialist cosmology with a professional diplomatic corps informed by Newtonian physics. The strategic balancing of powers was profoundly shaped by the Newtonian understandings of the physical world during this period, as the enlightenment extended into the international political domain.

[57] See chapter 1 on "The Cost of Quantizing International Relations"

However, as Leira notes, these ideas did not emerge *ex nihilo*, and James Der Derian's conceptual framing of diplomacy argues that the practices recognized by that modern term in fact should be recognized as a broader phenomenon with deep philosophical roots. Namely, Der Derian argues that "diplomacy is demarcated by alienation" and "the history of diplomacy is the history of the mediation of estrangement" (1987, 107). Assumptions of separatedness emerge from a long-running philosophical tradition, and Der Derian is correct to highlight estrangement as a foundational assumption of this constellation of practices. While his later arguments will highlight how the hyperconnectivity of global media produce a quantum diplomacy (Der Derian 2011), it is notable that even before Der Derian's own quantum turn, his theorization of diplomacy identifies this Newtonian assumption of separatedness as a foundation of his object of critique.

The recognition of the (meta)physical foundations of diplomacy is shared by Costas Constantinou, whose *On the Road to Diplomacy* argues for the always and already theoretical character of diplomacy. Understanding diplomacy as "a regulated process of communication between at least two subjects, conducted by their representative agents over a particular object" (1996, 25-26), Constantinou demonstrates that the practice of theorization is required by each step of the process—the assignment of the diplomat requires the conceptualization of the diplomatic function of representation, the conceptualization of sovereignty to define the sender and receiver of the emissary, and the conceptualization of the representative as such. Although not framed as a critique of Newtonianism *per se*, Constantinou does highlight key Newtonian assumptions embedded within that theory. Taking three key citations of metaphysics, we can highlight directly the Newtonian elements distilled from Der Derian and Leira (via Allan):

- Our understanding of diplomacy has been arrested by the metaphysical categories that are technically employed to do the explaining. (Constantinou 1996, xiv)

- Grounded in the picture of Western metaphysics and representative thought, diplomacy is primarily intersubjective. (Constantinou 1996, 25)
- Its association with Western metaphysical thought suggests that it functions through acts of sovereign representation as is the case with diplomacy. (Constantinou 1996, 63)

Conventional diplomacy, we can surmise, arose during the ascendancy of a Newtonian cosmology in international politics. Assumptions of states as discrete units represented by diplomats entails three clearly Newtonian claims and implies a further one. Conventional diplomacy's assumption of states as discrete units requires an assumption (1) of separable objects with definite limits (in contrast to the quantum notion of entangled phenomena) as well as (2) a primacy of relata over relations (cf. Barad 2007). The notion that a diplomat can represent further entails (3) a representationalist epistemology, and the actions of diplomats causing effects implies a local causality in their interactions with other diplomats. In addition to the representationalist claim, then, we can further recognize that an approach that takes diplomats as mediators of estrangement presupposes the separability of state units as a condition of possibility for inter-state estrangement. Whether named as diplomacy or disaggregated into the proto-diplomatic practices, this conventional model is imbued with Newtonian precepts.

While we may be able in Newtonian modes of social science to smooth over the physical assumptions present in analyses and accounts of conventional diplomacy, game theory, and strategy, our inattention does not produce ontological erasure. Rather, I would like to suggest that conventional diplomacy and classical game theory share a common set of classical-Newtonian assumptions about causality, agency, separability, locality, et cetera. Furthermore, players in those games and agents in those diplomatic efforts typical follow classical-Newtonian strategies that best fit their classical-Newtonian assumptions. As we shall see, one of the problems identified in the literature on Track Two Diplomacy has been the difficulty to define a strategy that seems to follow a different set of rules. The power of a quantum-like reading of Track Two Diplomacy is therefore first definitional: quantum assumptions and

quantum strategies can better explain quantum games and quantum diplomacy. This primary definitional effort will be the primary project of this chapter. But what this definitional effort opens up is the possibility of quantum social theory then back-filling into Track Two Diplomacy efforts the concepts, theories, and predictions that apply to that strategy (in place of ill-fitting Newtonian alternatives better suited to conventional diplomatic efforts). That field of promise and potentiality is what relies upon and awaits the successful definitional and descriptive efforts of early adopters of quantum theory in International Relations.

Track Two Diplomacy: Concepts and Cases

Generally attributed to American diplomat Joseph Montville as a term to describe unofficial conflict resolution efforts, Track Two diplomacy is a broad category of efforts seeking to resolve conflict or build peace outside of the traditional channels of diplomacy. This early definition describes "unofficial, non-structured interaction" that is "always open minded, often altruistic" and abiding the "underlying assumption…that actual or potential conflict can be resolved or eased by appealing to common human capabilities to respond to good will and reasonableness" (Davidson & Montville 1981, 155). From its definition, Track Two has held this unique place of general, gradual, and unofficial movement to a better place.

While the recognition of conventional diplomacy emergence from a constellation of related (but theretofore uncategorized) practices required the careful historical work of later IR scholars, Track Two diplomacy has always been described with reference to its antecedents. Davidson and Montville (1981, 153) highlight the work of social psychologist Herbert Kelman in addressing the psychological barriers to conflict resolution through what he called "interactive problem solving" (Kelman 2002). In his book *Track Two Diplomacy*, Peter Jones sketches a longer pre-history of the practices, beginning with the pre-World War One "peace society" meetings in The Hague, through the elite meetings of the Moral Rearmament group in the aftermath of World War Two, and a series of conferences that permitted unofficial dialogue

between peace-oriented elites (Jones 2015, 12-13). Despite radical differences in the *dramatis personae*, structures, and scopes, all of these antecedent practices share an intuition that the conditions of possibility for peace can be shaped by societies coming together outside of the pressures of formal diplomatic negotiations.

Jones identifies John Burton's "controlled communication" as the first example of modern Track Two diplomacy (2015, 13). Reflecting on a definition of controlled communication reveals the similarities with the formal idea of Track Two that would emerge in the decades following Burton's first effort: "Controlled communication is primarily a social-psychological device for altering the attitudes and perceptions of the representatives of states in conflict, so that on the basis of reduced hostility and tension they may be able to come together for serious and productive negotiations" (Yalem 1971, 263). These facilitated discussions bring together representatives outside of formal and action-oriented responsibilities to build understanding. Or, in Yalem's summary, "the objective of controlled communication is to develop knowledge about the analysis and resolution of interstate conflict, not to resolve conflict itself" (1971, 266). There is a deferral of the event of conflict resolution and a favouring of expanding the possibilities of future peace.

Kelman presents interactive problem solving as a conflict resolution approach influenced by Burton's controlled communication, and acknowledges the personal inspiration gained from his invitation to one of Burton's mediation efforts in the mid-1960s (Kelman 2000, 274). Interactive problem solving workshops bring together participants from different societies in conflict who are not currently officials, but who occupy positions of societal influence.[58] Confidential discussions are facilitated by neutral

[58] For example, Kelman reports "They may be parliamentarians, leaders and activists of political parties or political movements, journalists, editors, directors of think tanks, or politically involved academicians—i.e., scholars who not only write academic papers but also write for newspapers and appear in the media, who serve as advisors to political leaders, and some of whom move back and forth between government and academia. Some of our participants have been former diplomats, officials, or military officers, and many later became negotiators, ambassadors, cabinet ministers, parliamentarians, and leading figures in the media and research organizations." (2000, 274-5).

mediators, following a predetermined agenda that promotes analysis and understanding. Despite *problem solving* appearing in the title of the approach, Kelman does not see an actionable or formal plan as a desirable outcome—indeed, "with one exception…we have been very clear that there was no expectation of a joint product…[or] agreement" (2000, 278). Instead, the focus is on the development of ideas that can be returned to societies that could—if implemented—produce conditions for future peace and conflict resolution.

While we can find in these examples of early forays into Track Two (or Track Two-like) diplomacy a set of rules, guidelines, or regularities, the unique design of each framework makes it difficult to define in the abstract what Track Two *is*. Precisely because this category is comprised of so many different approaches—some driven by researchers and others theorized by activists and diplomats—the strategy of Track Two is difficult to define concisely. Jones notes a litany of approaches that are connected in one way or another to Track Two, including: Track 1.5, "hard" Track Two, "soft" Track Two, controlled communication, interactive problem solving, interactive conflict resolution, multitrack diplomacy, circumnegotiaion, and even broader social efforts such as transnational citizen peacemaking, Track Three, and conflict transformation approaches (Jones 2015, 23). This produces a fundamental definitional challenge, as "the field of Track Two is multifaceted and fluid," and "the terminology is far from fixed" (Jones 2015, 24). Working definitions can provide anchors for specific efforts, but the finding a comprehensive definition that balances inclusion and specificity is a difficult task.

For his part, Jones does offer a definition of Track Two[59] along the lines noted above, but what emerges through his descriptive chapter conceptualizing Track Two is that the key characteristic that differentiates Track Two from conventional diplomacy is its focus on process and possibilities rather than

[59] I have come to define the term "Track Two" as *unofficial dialogues, generally between two antagonistic parties, and often facilitated by an impartial Third Party and involving individuals with some close connections to their respective official communities, focused on cooperative efforts to explore new ways to resolve differences over, or discuss new approaches to, policy-relevant issues*. (Jones 2015, 24).

outcomes and finalities. In a sense left undecided and to be determined through classical diplomatic interactions, Track Two contributes in a new manner. It is worth reflecting on this matter at length:

> Track Two often plays its greatest role in assisting the *process* of developing new ideas and incorporation them into negotiations, rather than in necessarily providing specific *outcomes* to officials. More broadly, Track Two can help the two sides learn more about each other and develop more accurate understandings of the complexities each side must deal with. In this sense, Track Two is useful in breaking down previously monolithic interpretations each side may have held of the other, and allowing for learning and differentiation about the deeper realities and constraints that the other faces. (Jones 2015, 147).

As emphasized in our review of proto-Track Two efforts above, we find again a focus on potential future states rather than delineated solutions of the present. In addition to the more idea-centric changes in understanding, the conditions of peace can be fostered by the building of *relationships*, as participating "individuals forge bonds that can later lead to peace and security, laying the groundwork of cultural learning that makes later peace possible" (Jones 2015, 71-3). Again, we find—in stark opposition to conventional diplomatic negotiations judged on the content of their resolutions—that Track Two efforts are focused on means rather than ends, setting the stage for a future act.

But this fuzzy focus only further contributes to the definitional problem of Track Two diplomacy, manifesting as an "inability to explain or define itself in terms that can be measured or quantified" (Jones 2015, 33). Indeed, while philosophers from Aristotle to Agamben have at times called attention to the *importance* of potentiality, empirical research in social science has largely focused on actualities rather than shifts in potentiality. Allan and Sharp (2017) suggest that this has led to a bias within the evaluative literature on Track Two towards efforts that led to actualized outcomes evaluated in terms of conventional diplomatic metrics—such as the Tajikistan civil war and Oslo Accords—rather than a comprehensive view of a representative range of Track Two diplomatic projects. Others have approached Track Two by evaluating how the elite-ness of participants impact the directness or indirectness of the mediation's contribution to conflict resolution (e.g., Cuhadar 2009). But analyzing Track Two only in service of conventional diplomatic outcomes seems to miss the unique difference of the strategy, reducing

it to a Megarian world where only the actualizations matter. In practice, this may lead to the framing of Track Two in terms of its contributions to conventional diplomacy (Chataway 1998), while in theory it may lead to the misassessment of the value of Track Two and misdefinition of its nature. Yet, because the shift from conventional to Track Two diplomacy bridges the metaphysics of the actual to the potential, models of social science relying on Newtonian metaphysics will face as similar a set of difficulties as conventional diplomatic evaluation models.

Track Two Diplomacy as a Quantum-Like Diplomatic Strategy

Drawing on the above discussions of conventional and Track Two diplomacy, this section will outline a *prima facie* case for why Track Two can be understood as a quantum-like strategy. This process will involve a comparative homology-tracing with conventional diplomacy and Newtonian (meta)physics counterposed with Track Two diplomacy and quantum (meta)physics. This comparative method builds on previous efforts of homology tracing for the purposes of quantizing through translation (e.g., Murphy 2021, ch 4). Such a *prima facie* identification can serve as a starting point for future research. In this case, future work may be inspired either by applying the models of quantum game theory or another branch of quantum social science to assess particular aspects of quantum-like behaviours in Track Two—which may be particularly interesting for a scholar-practitioner community in search of evaluative models that reach beyond those employed in the assessment of conventional diplomatic efforts—or, in a more policy-oriented fashion, drawing strategic advice from the game-theoretic or otherwise social-theoretic models accessible through quantum social science. While these investigations are beyond the scope of the present paper, this connection between translation and future research directions is discussed in the conclusion. Table 1 below summarizes the three key shifts present in the conventional-to-Track Two change, framed in terms of a strategic reorientation from *strategies for separatedness* to *strategies for entanglement*. The remainder of this section discusses the individual points of comparison.

Table 1: Conventional and Track-Two Diplomacy

	Conventional Diplomacy **Strategies for separatedness**	Track Two Diplomacy **Strategies for entanglement**
Primary units	Interacting representatives	Social intra-actors
Metaphysical focus	Achieving actualities	Shifting potentialities
Temporal scale	Temporally-local events	Temporally non-local relations and understandings
Physical imaginary	***Newtonian***	***Quantum***

Primary units

It may come as no surprise that the primary units of Track Two diplomacy differ from those engaging in conventional diplomatic efforts, as the change in *dramatis personae* is bound up in the definition of Track Two efforts. My concern in highlighting the point here, however, is not merely repetition but to reflect upon what this shift reveals about the broader social-theoretic assumptions about how social change occurs. As we heard above from Costas Constantinou, the sending of a diplomat from one country to another entails a series of theoretical moves. For example, if we are to say that in a given negotiation Mélanie Joly acts in an official diplomatic capacity as Canada's Minister of Foreign Affairs, then we have necessarily made a series of assumptions. To offer just three of these: 1) the existence of Canada as a social object that can be defined; 2) that this object can be represented; 3) that the actions of the person can stand in as actions of the social object. The same would necessarily be true of the diplomatic interlocutor, such that the interaction of the two individuals stand in as a local exchange representative of the interactions of two defined social objects. The replacement of Minister Joly with an unofficial member of Canadian society, then, is far more revelatory in terms of an ontology of social change understood by the Track Two effort compared to the invitation list for the discussion itself.

Participants in Track Two diplomacy are elite members of the conflict-affected societies rather than official representatives, a shift that changes the status of all three assumptions discussed above. Because the participant is a member of the society rather than a representative of the country, the country does not need to exist as a defined, separable, and objective social entity. The individual emerging out of society does not require the same exhaustive definition of the boundaries of the country as the

representative of the container model does in the case of the official emissary. Similarly, the Track Two participants need not represent the state apparatus and thus their involvement does not presuppose the representability of the state. Finally, because the Track Two process seeks to build connections and understanding rather than achieve definitive outcomes, the actions of the participants do not harness the causal agency of the state. Instead, we encounter elite participants whose connections within societal networks make their relationships and understandings potentially impactful for the society *writ large*. This entails an entirely other set of three assumptions in contradistinction to the conventional assumptions: 1) societies are networks with many multiple connections; 2) social relations are more important than the official status of the individuals coming into relation; and 3) new connections can produce new future potentialities for peace. This leads to a quantum description of the primary units of Track Two as social intra-actors (actors entangled with their social context and always action from within that context) compared to the Newtonian description of representatives interacting in place of defined objects.

Beyond a shift in the cast of characters, then, the difference in primary units presents a quantum shift in the notion of social change, abiding a new and quantum strategy. As argued by Karen O'Brien, quantum accounts of social change are fundamentally different because they recognize actors as entangled entities, and recognizing our entanglement with our social relations may open up new opportunities for transformative change (O'Brien 2021, ch. 6, *passim*). We can identify Track Two as a quantum-like phenomenon by its recognition of the power of social connectivity and relationality in producing transformative change. But this entanglement of the primary units operates in fact on two distinct levels. First, quantum game theory would encourage us to recognize the entanglement of the actors with one another: this establishment of relationality—or building of relationships, in a more common parlance—is precisely what distinguishes the entangled quantum actors from classical actors assumed to remain separate throughout the game (Arfi 2007). Second, as Wendt (2015) suggests through his discussion of language, the quantum game itself is a form of entanglement as a "shared normative

order"—which appears to be a rather apt description of the shared pursuit of peace shared among Track Two workshops and the antecedents.

The shift in primary units speaks to the difference between conventional and Track Two diplomacy in terms of their ontology of social change assumed. As becomes a common theme across the three dimensions discussed, the Newtonian physical imaginary demands a world of separatedness to be managed through diplomatic strategy, whereas the quantum world demands strategies of entanglement. As the comparison of primary units displays, this is true not only because a key part of the strategy of inviting participants is their entanglement within their own societal networks, but also that the entanglement of Track Two participants is necessary for the process itself, and—most impactfully—that the social entanglement of Track Two participants can lead, through relationality and understanding, to an entangled peace.

Metaphysical focus

In Book Theta of the *Metaphysics*, Aristotle defends the reality of potentiality against Megarian accounts that seek to establish the actual as the only realm of reality (2016, IX). Specifically, when considering a thing's potentiality to do something, the Megarian[60] view is that "something possesses a capacity at t if and only if it is exercising the capacity at t" (Makin 1996, 254). Aristotle responds that this cannot be true, as the builder remains capable of building a house even when not actively engaged in building a house (2016, IX, 3, 1046b29-33). Aristotle does in the end express a preference for the actual over the potential (2016, IX, 9, 1051a3-11), a view which became so philosophically widespread in the West that the Megarian precursor was cast aside and received little consideration (Makin 1996, 253).

[60] The philosophical school at Megara is less well known than the Platonists, Stoics, Epicureans, and other Greek approaches. The Megarians are perhaps most visible in contemporary scholarship in their role as Aristotle's object of critique through Book Theta of the *Metaphysics*, where Aristotle refutes their argument that only the actual is real. As noted below, the adjective Megarian is now sometimes used to describe actuality-limited understandings (e.g., Agamben 1998).

Aristotelian metaphysics become immediately relevant to our consideration of diplomacy and quantum social theory via two significant conceptual moves made by Giorgio Agamben in his commentaries on Aristotle. First, *contra* the trend toward a rejection of Megarianism identified in philosophical circles, Agamben argues that the totalizing power of contemporary sovereignty in fact displays a Megarian logic, such that the constituent power of the citizenry is reduced and only matters in its actualized form of constituted power (1998, 44-45). Agamben's political philosophy can be understood as part of a larger metaphysical commentary (Murphy 2020b, 369) that argues against Megarian echoes to defend potentiality in a variety of fields. But for this first conceptual move, it is sufficient to distill his descriptive argument of reductionist tendencies in politics as being metaphysically Megarian. Second, we can turn to his reflection on quantum physics to find his framing of quantum physics as a fundamental reversal of Aristotelian metaphysics—as a science of the possible and probable, "it is a potency emancipated from its hierarchical subjugation to the act" (2018, 40). In a manner "unthinkable to Aristotle" quantum physics "considers possibility as such," creating thereby a world in which "pure possibility…replaced reality" (2018, 40). To summarize these two conceptual moves, we live in a world where the politics of sovereign agents can remain Megarian, focused only on the actualities, but also in a world where quantum physics calls for the primacy of the potential.

It is my hope that the lesson of this brief metaphysical digression is now readily apparent for our differentiation of conventional and Track Two diplomacy. Namely, in the case of conventional diplomacy, the evaluation depends on the actuality itself (e.g., a ceasefire or treaty). We can understand this as a Megarian evaluation because the diplomatic reality is limited to the actual outcome achieved. Cooperation is only possible if cooperation is ongoing. In the case of Track Two, conversely, the focus is instead on shifting potentialities for peace, thereby entailing a prioritization of the potential over the actual (as we will discuss next, the temporal extension of potentiality is significant here as well). We find a remarkable similarity between Kelman's (2000) remark above that with only one exception was an

actuality set as the primary outcome and Arfi's (2005) description of quantum game theory as holding potential moves in superposition. The Newtonian game of classical diplomacy is about achieving actualities, whereas the Track Two game is one of superposition and potentiality—the very hallmarks of quantum metaphysics! The metaphysical focus of each game reveals a significant break between the two, suggesting that classical diplomacy is not only Newtonian but also Megarian, marking the metaphysical move of Track Two diplomacy as doubly daring (not merely an Aristotelian rejection but an Agambenian one).

Temporal scale

The difference in what I am calling 'temporal scales' reveals the narrower scope of conventional diplomacy as compared to Track Two diplomacy. Newtonian assumptions about time as clock-time have long structured social-scientific inquiry and conceptualizations of the social world (McIntosh 2015, 470), with quantum social science offering a novel model (McIntosh 2021, 167). In line with the presentation of conventional diplomacy as a Newtonian strategy and Track Two diplomacy as a quantum strategy, I would like to suggest that conventional diplomacy assumes a local, linear, and presentist temporality while Track Two abides a non-local, non-linear, and quantum conception of time. The argument for conventional diplomacy can be drawn almost directly from the former two explanatory points. Because the local actions of representatives of social objects are focused only on achieving actualities, the temporal focus of conventional diplomacy is on the here-and-now happenings of diplomatic exchange.[61] Alternatively, Track Two is not bound by success being defined by temporally-local actualities. Rather than the temporally-local causation of Newtonian physics, we find in the case of Track Two temporally non-local causality that can produce effects in the past as well as the future.

[61] Critical contributions to the temporal turn in IR theory provide much thought-provoking commentary on the present that would problematize the conventional model (Hom 2018; McIntosh 2015).

The changes vis-à-vis the future provides the clearer case, so we will begin there. As Arfi (2005) discusses, entanglement in quantum game theory allows trust to emerge over a time scale extending forward into the future. In the case of Track Two, this entanglement concretizes in the form of new relations between the participants. As discussed above, the description of the Track Two effort as focusing on potentiality instead of a particular actuality is homologous to the description of the unperturbed wavefunction remaining in superposition instead of collapsing into a discrete particle-form. This point has an important temporal dimension, as well, given that the continued propagation of the wavefunction through spacetime produces a social wavefunction whereby the outcome of the Track Two effort can only be understood through the blurring together of all *potential future states* (Murphy 2021c). As Schrodinger (1980) has argued, only through the consideration of all potentialities blurred together can we claim a full description of a quantum phenomenon.

Temporally non-local causality changing the past may seem unimaginable to our Newtonian-trained minds, but quantum physics has experimentally demonstrated the possibility of this temporal arrow reversal. In *Quantum Mind and Social Science*, Wendt provides an introduction to these experimental findings before later returning to the point of temporal non-locality and backward causation. Central to this discussion is the "Delayed-Choice Experiment," originally theorized by John Archibald Wheeler, which describes a photon being shot at a half-slivered mirror (one where there is a 50% chance of the photon continuing on [path A] or being deflected [path B]) and then entering a larger apparatus.[62] So long as the photon wave remains unperturbed, the photon's path is a superposition of path A and path B. A simplified version appears below (adapted from Malin 2012):

[62] For greater detail, see Malin (2012).

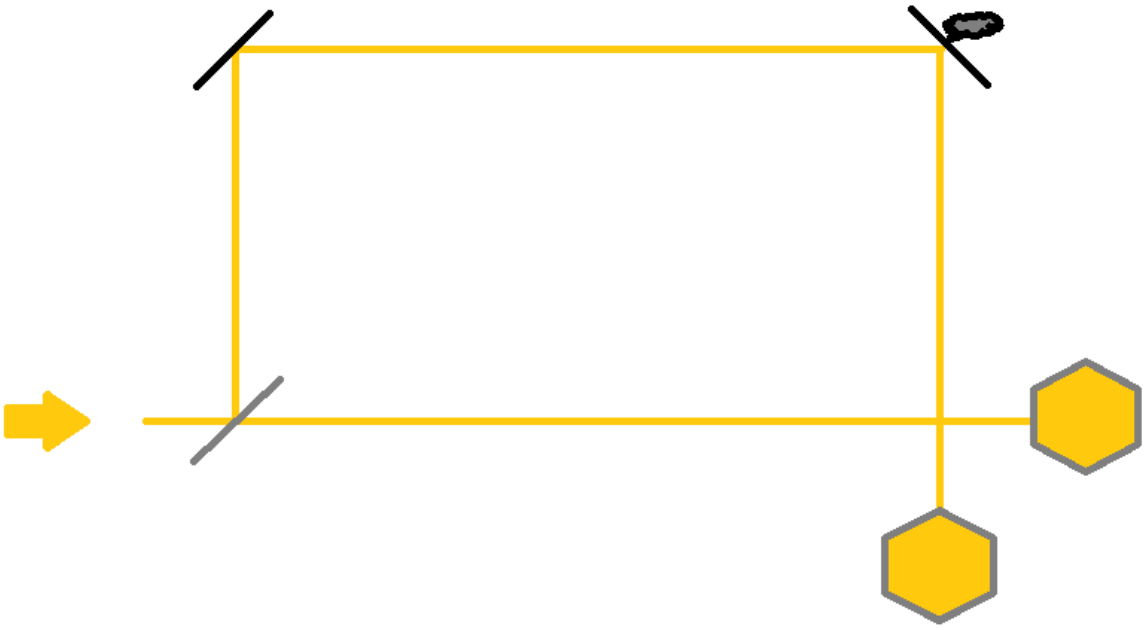

Figure 1: Simplified Delayed-Choice Experiment

The "delayed-choice" comes into effect where if a mirror further along path B is spring-loaded, such that it is sufficiently sensitive to observe the location of the photon, then the definitive measurement collapses the wavefunction of path A and path B *after the photon has passed through the half-slivered mirror*. Because the path A/path B superposition holds true until the moment of observation, the observation through the spring-loaded mirror—in common parlance—changes the past. Drawing on David Weberman's (1997) theory of the nonfixity of the past, Wendt (2015, 193-196) argues that social equivalents of the delayed-choice experiment take place whenever future events change the meaning of the past: the future death of a gunshot victim transforms a shooting into a homicide *ex post* and military skirmishes in 1618 become the start of the Thirty Year's War only in hindsight. These retroactive constitutions of meaning represent fundamental alterations of the ontology of events, acts, and entities.

The lesson from the delayed-choice experiment and Wendt's discussion of retroactive constitution reveals that social actions in the present can have temporally non-local effects because *they can change the past*. If the future-oriented temporal non-locality is through the pursuit of potentialities for peace and building relationships that entangle conflicted societies, the past-oriented temporal non-

locality instead functions through the second key output of Track Two efforts defined by Jones—understandings. Dispelling with worst-case assumptions of motivations for past conflict and malfeasance can retroactively reconstitute historical tensions through a mitigation of societal prejudices.

This shift in temporal scales is a radical one, because it disrupts convenient assumptions around linearity and presentism that abound in conventional and classical social science (to say nothing of mainstream political discourses). In a high-pressure negotiation where official actors are forced to make a decision, presentist assumptions of history and one-shot game-theoretic incentive structures limit the potentialities for cooperation. With decisions remaining in superposition, non-officials can learn about each other's pasts, changing their own and building understandings for the future. This particular path opens possibilities of alternative futures that depend upon the nonfixity of the past.

Conclusion

Track Two diplomacy has previously presented a problem for theorists and practitioners of International Relations, and the evaluative criteria developed from the positionality of conventional diplomacy misses entirely the unique practices and outcomes of Track Two. As our comparative homology tracing has demonstrated, one approach to disentangling conventional from Track Two diplomacy can be found in the shift in physical imaginary from Newtonian to quantum physics, entailing a strategic shift from separatedness to entanglement. As previous interventions into quantum International Relations have suggested, one way to transcend these theoretical stumbling blocks is through a shift from Newtonian to quantum social theory. A preliminary analysis of the conceptual structure of Track Two reveals significant similarities with the core assumptions and strategies of quantum-like game theory. Understanding Track Two as a quantum-like alternative to official diplomacy is an intuitive proposition whose further exploration requires further analysis, including the testing of Track Two efforts through the models of quantum-like game theory in addition to the interpretivist analysis of case studies as viewed through the lens(es) of quantum social theory.

The *prima facie* findings of a quantum-like nature to Track Two entails two future research directions. First, if quantum social science (and specifically quantum game theory) offer a closer approximation of the units, metaphysics, temporality, and strategy of Track Two, then further investigation of Track Two efforts from a quantum perspective is warranted. The formal models of quantum game theory may guide the development of the elusive evaluative framework for Track Two diplomacy at a research level, while also informing strategic moves towards ideal game-theoretic outcomes. Quantum social theory may help to provide a clearer articulation of the social dynamics at play in the construction of Track Two workshops, and the transformational message of quantum social change (e.g., O'Brien 2021) may help to promote the promise of Track Two as a path for further conflict resolution. A second implication of the findings is a more general commentary extends from the methodology of quantizing through translation (e.g., Murphy 2021c), suggesting that other social phenomena that exceed the evaluative methodologies of conventional strategic studies may be assessed for their quantum-likeness. Particularly when social phenomena entail entanglement, non-locality (temporal or spatial), and a prioritization of potentialities over actualities, the early insights of quantum social science offer encouragement to their further exploration.

Chapter 6
Markets are Constantly Collapsing: Reconceptualizing 'The Market' as a Quantum Social Wavefunction[63]

> *"The Renaissance, World War II, or the Cuban Missile Crisis…were not 'events' at all. This is not to say that [they] have no material basis, since of course part of what constituted WWII as an event is that people met violent deaths. But by themselves, those deaths were just that, separate deaths, which in no way add up to 'WWII.'" (Wendt, 2015, 194).*

Introduction

The challenge of reconceptualizing markets calls attention to one of the most ubiquitous but simultaneously undertheorized ideas of global political economy—the market. While consideration of "the market" and *specific* regional or commodity-based "markets" appears frequently across economics, political science, international relations, development studies, and far beyond, the concept lacks clarity. Is "the market" different from a *particular* "market"? What are "market forces"? *Where* is "the market"? By privileging empirical analysis of particular issue areas—say, the impact of new tariffs on the North American aluminum market—over a theorization of "market(s)" able to encompass both its general and specific invocations, we have gained clarity in specific issue areas while bracketing our understanding of "the market" as such.

Taking my cue from the recent "turn" to quantum social theory in International Relations (Der Derian 2019; Der Derian & Wendt 2020; Grove 2020; Murphy 2021c; Orlando 2020; Wendt 2015; Zanotti 2019), I would like to explore the possibility that the difficulty of understanding markets comes from a more general failure of Newtonian models to explain the social world. In the attempt to historicize, refine, decentre, and investigate the concept of the market from multiple epistemological, ontological, methodological as well as paradigmatic perspectives, this contribution focuses centrally on a new *physical*

[63] Revised from the article of the same title published in *Competition & Change* 25, no 5 (2021): 561-579.

imaginary for the conceptualization of the market. Indeed, just as Alexander Wendt has previously argued about the social structure of the state being logically incommensurable with the assumptions of a Newtonian physical imaginary, the invisible market cannot abide Newtonian logic. The model of the social wavefunction seems to make sense for the market—though scholars often talk about patterns and effects of the market, or examine key constituent actors, a market itself is invisible, just as a wavefunction is directly invisible, but measurable in particle-form and behaviourally observable through patterns.[64]

Quantum physics was born out of a tension between competing conceptualizations of light as either a wave or a particle—wave-approaches focused on larger patterns, which particle-approaches focused on specific data points. The conceptual synthesis of micro and macro in the wave/particle duality of quantum mechanics provides the model for quantizing the market. After all, the same sort of macro-versus-micro split exists in the disciplines surrounding the market concept. Macrostructural conceptions, including global value chains and structural power, focus on large-scale dynamics and patterns of interactions, whereas microfoundational approaches, such as open economy politics and actor-network theory, focus on a smaller scale and precise units. Just as Albert Einstein proposed that the competing conceptualizations of light might be unified in what he called a "heuristic view," so I suggest a quantized physical basis of the market—where macrostructural and microfoundational approaches are understood as describing complementary characteristics rather than as competing models. Methodologies attuned to the minutiae produce measurements of constituent parts, just as measurement devices record photons in their particle-state, and structural accounts highlight the patterns through which structures are manifest in the world. When we recognize patterns, we discern the structure's effects; when we

[64] Measurement and observation take on important meanings in the so-called "Copenhagen interpretation" of quantum mechanics. Waves "collapse" from a superposition of all possibilities to a single particle at a defined position during the act of measurement, producing defined measurements despite disparate waves. Some interpretations see the measurement as causing the collapse as an "observer effect," while others suggest that it is something closer to a correlation. The remainder of the article follows this form of the Copenhagen interpretation of quantum mechanics. For a recent discussion of the connection between observation and quantum social theory, see Fierke and Mackay (2020).

investigate closely, the market undergoes a "wavefunction collapse" and we observe its constituent part(icle)s. Rather than choose between a microfoundational account that requires ad-hoc solutions to account for structural effects, or a structural account that glosses over physical incoherence, the quantum social-theoretic account of the market brings a fundamentally new worldview to bear on the question. The constant interaction of markets with other social entities means that markets are constantly collapsing, but the patterns that can be discovered over the long run reveal the structural/wave-like properties. Indeed, this is the core justification for my quantum reimagining of markets: it is not the case that Newtonian approaches misindentify feature X or relation Y, but that the very imaginary of binary over duality forces a choice between a macrostructural or microfoundational approach that necessarily downplays the ontological importance of the other. A quantum imaginary offers a radical alternative that preserves and foregrounds duality, allowing simultaneously contradictory features to be embraced and interrogated.

To venture into a complex field like IPE, I turn to the person "almost single-handedly responsible for creating 'international political economy'" (Brown 1999, 531)—Susan Strange. For Strange, attention to International Relations is insufficient to understand the way the world works because of the important influence that market economics and politics have on one another. Indeed, one of the great failings that she draws attention to from her earliest writings is the effective separation between the study of international economics and international relations (Strange 1970). Political and security relations at the international level "cannot realistically be separated from…the market economy" (Strange 1999, 345), and the 20th century saw an important "shift in power from states to markets" (Strange 1995b, 296) to the point that states had lost control over the market economy they worked to foster—leading European politics from Westphalia to "Westfailure" (Strange 1999, 346). Even in the case of the United States, whose political promotion of structural changes to a globalized world economy led to the current market economy's development (Strange 1994b, 213), the market still "can be an effective actor" on its own

(Strange 1975, 220), and "like Frankenstein, the United States has created a monster almost beyond its control" (Strange 1995a, 294). Thus, even though the United States still possesses the lion's share of structural power—"the power to choose and to shape the structures of the global political economy within which" all relevant actors "have to operate" (Strange 1987, 565)—the market itself has taken up a position "at the centre of the system" (Strange 1984, 282). Taking globalization and structural power as focal points, more detailed discussions below will explore how an innovative quantum account of the market in IPE can be put to work in translating existing conceptual material from the work of Susan Strange.

As discussed in the methodology chapter and the two preceding conceptual case studies, my approach to quantizing employs a method of *translation*. In the case of this investigation of the market, the translation process is by necessity less sustained than in the case of structural violence and Track Two diplomacy. While the work of Susan Strange is translated in subsections dedicated to globalization and structural power, the failure of Newtonian social science to systematically conceptualize the market in a manner that encapsulates the micro/macro tension rather than collapsing under dialectical tension means that a direct translation of the concept itself cannot be undertaken. The disparate attempts to define the market produce interesting and insightful thinking-tools for different aspects. However, the clear translatory method is unfortunately beyond the scope of the literature. Instead, this chapter proceeds by introducing the stakes of quantization, the key concepts of quantum social theory that apply to the conceptualization of the market (specifically) and IPE (more generally), and the translatory power as applied to the work of Susan Strange.

The first section of the chapter offers a justification for quantizing social science in general and the market in particular, as well as a brief introduction of the particle/wave–micro/macro homology. The three next sections outline core concepts of quantum social theory for our physical reconceptualization of the market, with each concept explained first in physics, then in quantum social theory, and finally

applied to the reconceptualization of the market. Because superpositionality is necessary to understand the idea of a social wavefunction—the quantized social entity—we begin there. Two further concepts of quantum mechanics—entanglement and interference—are then discussed to demonstrate how quantum social theory can help us understand market forces and events. In each case, a subsection dedicated to translating Strange's IPE theory demonstrate the translatory capacity of the quantum framework. The final section offers a series of summary statements on the quantized conceptualization of the market, and notes potential applications to two approaches to global political economy—open economy politics and global value chains. This intervention's attempt to reconceptualize markets from a quantum perspective is intended to spark conversation rather than to offer a conclusion to the theoretical exercise. Whether the reader is more or less sympathetic to the project of quantum social theory, the exercise of radically reconceptualizing markets from a physical perspective poses important questions of ontology, agency, and relationality for Newtonian and non-Newtonian social theory alike.

Quantum? Aren't We *Social* Scientists?

Difficulty around conceptualizing the market is not a new problem for scholars interested in the social world (Massot 2021; Eagleton-Pierce 2021). However, this lack of conceptual consistency has done little to lessen the symbolic power of the idea of the market (Chessé, n.d.). The market posed problems long before the rise of global political economy as a field of study, and, as with any concept that receives such variegated attention, part of this issue is the lack of agreement about fundamental characteristics of the object of study. The social arrangement of economic activity into a market is circumscribed differently depending upon the disciplinary background, core ontological and methodological assumptions of the researcher(s), and the historical or case study context. The discipline of economics, according to Dumez and Jeunemaitre "emerged as a social science with the theory of markets," (1998, 222) and since its rise, many theories have described the invisible agency of markets as pressures, forces, corrections, and—in Smith's notable image—the hand. Economic classification of practices has shaped markets' socialization

(Callon 1998), and individual spaces of market activity have architecturally reformulated their environs (Fligstein & Calder 2015). Thus, whether the market is visible—as a farmer's market table of fresh produce or an oil tanker passing through the Strait of Hormuz—or invisible—through e-commerce and stock trading—there is a sense that those "in the know" can recognize when a social arrangement is "a market," even if every instantiation looks different. The common link of a "market" between these examples is virtually impossible to define in a Newtonian social science, because we are either left with a definition that we accept on faith by *someone who knows* what the category of market "is" in its many different forms, or we split social relations from their physical reality as either an illusory or super-natural force. The market is not entirely unique in its rejection of the bounds of a Newtonian physical imaginary, and reviewing the incongruity of other examples may be important.

The idea that some social phenomena which social science assumes to be true but which do not abide Newtonian logic was powerfully articulated by Alexander Wendt in *Quantum Mind and Social Science*. There, Wendt (2015) argues that consciousness—an invisible yet crucial aspect both of our experience of reality and of the study of the social world—has in the past only been bracketed or insufficiently addressed by social theory. He argues that no current explanation that abides Newtonian laws of physics is able to explain human consciousness, and develops a panpsychist theory of consciousness rooted in the macroscopic coherence of quantum properties. By "quantizing" our approach to the social world, we find a new physical imaginary where the invisible social phenomena can be understood in a radically new way.

One objection to the quantum leap in social theory often comes from scholars who consider their study of the social world to be entirely separate from particle physics, or are at least skeptical that a revolution in the latter demands one in the former.[65] This criticism would seem to reject the necessity for

[65] A second, and important, objection is that the current scientific consensus holds that quantum coherence (which would be a necessary property for quantum behaviour) breaks down at any scale larger than the atomic (Little

quantum social science at least within the paradigms for which it holds. Indeed, while some social studies explicitly modeled after scientific approaches—Wendt highlights game theory and Bayesian statistics (2018, 193), while others point to the branch of economics called 'econophysics' (Haven & Khrennikov 2013, 37-53)—it may not be immediately clear for more interpretivist, critical, or philosophical traditions. Within the interpretivist and philosophical schools of thought, it may be useful to recall the warning of Peter Winch, who in his treatise on the relationship between social scientific and philosophical analysis clarified that the relationship between scientifically- and philosophically-minded social studies was not an opposition with social science abiding natural science and what we might now call interpretivist approaches flaunting experimental results. Indeed, Winch argued that even though these latter approaches did not approach the social world as a science, philosophy "has no business to be anti-scientific…[and] if it trues to be so it will succeed only in making itself look ridiculous" (1990, 2). These approaches ought not flaunt the findings of one another as a matter of course. Further, despite scholars in the interpretivist tradition critiquing—at times harshly (e.g., Latour & Woolgar 1986; Latour 1987)—the claims to objectivity or epistemological exceptionalism in scientific disciplines, no scholar would seriously forward an idea that violates reality—at the end of the day, even the most critical interpretivist approach would not seriously attribute causality to ghosts or consciously reject gravity (Wendt 2015, 11). After all, despite forwarding a devastatingly critical account of social constructivism in science, Bruno Latour calls for "the construction of a *stubbornly realist attitude*" in undertaking that project of critique (2003, 231). To this end, even if they are not *directed by* or *directly following* the precepts of particle physics, interpretivist and positivist social theorists alike do not seek to argue against gravity or other so-called laws of nature (in technical terms, they abide the causal closure of physics).

2018; Waldner 2017). As a full intervention into this debate is beyond the scope of the chapter, and does not impinge of the utility of the starting-point of the metaphor.

So, if social science is a Newtonian enterprise, and if we know that certain core features of the social world are immaterial, invisible, and unable to abide the causal closure of Newtonian physics, the call to quantize social science should be relatively straightforward. In the case of the market, if no successful conceptualization has emerged from the centuries of Newtonian theorization, perhaps what is required in a new physical basis. When considering alternatives, then, there really is only one game in town—quantum. The Newtonian physics upon which contemporary social science rests "is now known to be a limited approximation valid only within a narrow range of our experience" (Zohar & Marshall 1994, 13), whereas the quantum theory of physics has been continuously experimentally verified since its development in the early 1900s, taking in stride the shift from atoms to quarks and gluons as basic constituents of matter—a dizzying ten-million-fold change of scale (Polkinghorne 1985, 1).

While some social scientists may bristle at the idea of taking experimental physicists as a guide, the radical novelty of a quantum view of the social world invites a fresh perspective on social phenomena. A key step in embracing quantum thinking is to accept a fundamentally different relationship between science and sociality than is typically held in what Zanotti (2019; 2020) calls "substantialist" social sciences. Indeed, from the very subtitle of his quantum book, Wendt frames his engagement as "unifying physical and social ontology." But this reframing of science and society is not an easy process, and one major barrier to entry for social theorists into the quantum world is the lack of training in quantum physics in most (if not all) graduate programs in the social sciences. What follows is a focused discussion of key concepts that will be useful in reconceptualizing the market. As my intention here is to speak to social theorists rather than physicists, my introduction of quantum mechanics will be as low-jargon as possible (though some terms are inescapable!)

It is precisely a quantizing of the market's physics that allows for the invisible/macrostructural and the visible/microfoundational to obtain within one ontologically consistent framework—not in an ad hoc or insufficient sense but proceeding from the first principles of the reconceptualized market. To

preview the core argument, modelling the market as a social wavefunction recognizes that its structural effects are "real" but—because, as will be discussed below, measurement always records a particle—close examination will always result in micro-relational activity. Thus, while Susan Strange's (1987; 1994) theorization of structural power may capture the continued hegemony of American-style capitalism through the shaping of international agreements, institutions, and the policy options available to other nations without direct action being necessary, examination of a particular policy decision understood to take place within this framework may ultimately be understood by an open economy politics scholar to merely represent the an aggregate calculation of preferences from relevant constituent firms (e.g., Lake 2009a). Rather than choose between one portrait or the other, a quantum understanding of the market permits the constituent aggregation methodology as an account of particle-measurements in the wave as well as the structural account of broad end-state patterns—with the added bonus of having an ontologically coherent defense of the market existing! The wave/particle duality means that, as a macroscopic social entity, the market is both wave and particle, but in its collapsed, particle-state, it appears as its constituents (e.g., firms).

Superpositionality: Translating the Market as a Social Wavefunction

In quantum physics, modelling the wave-state is radically different from measuring the particle character of the photon. Predictions in classical physics assume from that a measurement at one given location, knowledge of position and momentum (in terms of both translational and rotational velocities) can be used to predict future states. If drawn on a graph, we could at least in principle calculate a series of dots that form a line or curve, depending on the given function (Majorana 2006, 253).[66] However, given Heisenberg's uncertainty principle, that "the more precisely the position is determined, the less precisely the momentum is known, and conversely" (Heisenberg 1983, 62), this same kind of single continuous system is impossible to predict in quantum terms. Instead, *all* potential future positions and momentums

[66] Majorana continues on to note that due to complexity these calculations are not always effectively realizable.

must be considered—and as such "of a complete set…*all* will be known only uncertainly" (Schrodinger 1980, 324). This modelling of the wave is more complex, and given the uncertainty that follows from Heisenberg's principle, attempting to plot dots on a graph that cannot possibly track onto a single continuous system. The mess blurs together, lumps of higher probabilities form, and the "intrinsic fuzziness of the microworld…demolishes the intuitive idea of an electron…moving along a distinct path" (Davies & Brown 1993, 7). The mathematical expression of this system is called a wave function, and is designed "to express the degree and kind of blurring of *all* variables in *one* perfectly *clear* concept" (Schrodinger 1980, 327). The wave function thus models the wave state of a photon, making the uncertainty predictable. The particle is knowable in a way that the wave is not, and if we seek to know something concretely or experientially, then we must observe the particle of a collapsed wave function. While we can learn a great deal about the behaviour of light (for example) from the wave function, measurement, experience, and observation are only possible in the particular and discrete particles present in a wave function's collapse.

The reason that the wave function is necessary to model the unobserved quantum particle is the superpositionality of the unobserved and isolated wave-state. Because we cannot know the precise position (or momentum or other characteristic) of an unobserved electron (for example), we must consider that all potential states exist. By considering all possibilities, we can be certain that we are modelling the entire wave, which eventually collapses into a particle observed in measurement. Superpositionality has been described in a number of ways. Two of the simpler explanations are that of Niels Bohr—who called this consideration of all potential states the "rational utilization of all possibilities of unambiguous interpretation of measurements" (1935, 700)—and J. C. Polkinghorne—who described the wave function as "probability…covering 'here', 'there' and perhaps 'everywhere'" that, upon measurement, "is now all concentrated 'here'" (1985, 32). All potential positions are real as quantum probabilities, and can be represented in measurements called "amplitudes" (Feynman 2006). While a

classically-minded social scientist may balk at the idea that potentialities are real, it is important to recall that quantum physical reality refers not only to the material reality of discrete and measurable particles, but also to this new fuzzy unknown of the unobserved, whose *in*existence cannot be proven.

A common objection to the reality of the wave function proceeds directly from the counterintuitive claim that something necessarily unobservable is real. However, as Wendt demonstrates (2015, 14-25), if we are to reject the reality of quantum waves for this reason, we must also reject intentionality, consciousness, sociality, and all the practices, relations, and institutions related thereto. The objects of inquiry of social science "can only be 'seen' if you already know they are there" because each social entity "is a state of mind…before it is an agent, structure or practice" (Wendt 2015, 24). These entities that are real in an ontologically social way—like markets—are known only by their effects, and this is precisely the way that early quantum physicists deduced the wave properties of light. All the familiar properties of light—interference, refraction, reflection, the tendency of light to bend around corners, etc. (see Feynman 2006)—offer ample proof that physically (in an observable and materialist sense) real effects may be caused by physically real forces that are unobservable—in this case, quantum waves where future states are in superposition.

At a subatomic level, the transition from a wave to a particle can be narrated but not understood. Physicists have long been able to model the collapse of the wave function, without being able to agree on *why* collapse happens. When the position of a photon is measured, for example, we determine a single "eigenstate" of the photon—a particular particle position—which is the observable form of the superposition of states existing prior to that act of measurement (Polkinghorne 1985, 32). When we throw a dice, the six faces are in superposition while the object is in the air—and could be formulated as $p_n = 1/6, 1 \leq n \leq 6$—and collapse to the familiar single outcome when the dice lands, a phenomenon known as a "classical state reduction" (Honegger & Rieckers 2015, 1505). Macroscopically, social theorists may be at a slight advantage over our physicist colleagues given that we can understand in social terms the

becoming of the superposed states that physicists studying photonic electrodynamics can only bracket. For the physicist, the *why* questions remain largely bracketed, but for the social theorist, the why questions abound. The intuition that *we just know* what a state is, despite its direct invisibility, means that we already have the language for invisible entities.

The superpositionality of potential states is precisely that blurriness that gives rise to the wave function. The stumbling block of superpositionality is its counterintuitive logic—it seems profoundly *weird* that potentialities are real if we can only observe them in their end-states. However, an honest appraisal of the ontologically *social* relations studied in social sciences reveals that the same limitation of direct observation to end-states or effects. Wendt's (2015) thought experiment of extraterrestrials observing earth and never seeing a state but only particular effects, such as legislative buildings, police officers, border walls, that we—as social scientists and citizens of states—would recognize immediately as part of the state reveals the commensurability of a socially scientific sensibility with quantum theory. We are *already* analyzing end-states and effects, with speculative appraisals of social "structures," production "regimes," international "institutions," diplomatic "alliances," and many other ontologically social entities that are observable only in their end-states and effects. However, as noted in the preceding section, in order for Newtonian social science to perform these kinds of analyses, the fundamental metaphysical incoherence of that structure's existence must be ignored. Assuming quantum superpositionality for the unobserved potential states of these entities does no damage to the end-state analysis, but allows access to the explanatory power of quantum properties such as entanglement and interference—and remains coherent!

This translation of quantum superpositionality into social-theoretic terms, then, serves as the basis for our new physical imaginary of the market. As diffuse social entities, markets spread out over increasing space, incorporating more and more actors into the structure. However, when we interact—or *observe*—the market at any given moment, we only "see" the particular constituent part of the market

that is physically present. When I fill up my car's tank with gasoline, I do not see the global market of oil, because my localized interaction has collapsed the market into a microfoundational exchange. Wendt (2015) applies the idea of the hologram to express this ability of individual monads within a social wavefunction to represent the whole while acting as segmented part. The market collapses into the point where interaction occurs, only to return to the wave state instantaneously upon completion of the interaction. The ability of markets to constantly collapse without ceasing to exist is a property unthinkable in Newtonian social science, possible only following the wave/particle duality and the principle of superpositionality. But the payoff of this novel physical imaginary is not limited to modelling the constitution of the market. By exploring two of the unique behaviours of quantum phenomena, I will now demonstrate how the quantum-likeness of the market includes its key features. In each case, conceptual focal points from the work of Susan Strange are introduced and reflected upon in subsections.

Entanglement: Cooperation and Nonlocal Causation

In quantum terms, entanglement refers to a mysterious bond between particles such that what happens to one particle can have an effect on its entangled partner non-locally (that is, across distances—perhaps infinite distances—faster than the speed of light permits). The concept of entanglement arose directly from the second debate between Niels Bohr and Albert Einstein, on the completeness of quantum system measurement. In a 1935 paper, Einstein and two colleagues argued that "if, without in any way disturbing a system we can predict with certainty…the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity" (Einstein et al 1935, 777). By analyzing one particle of a pair known to have a total momentum of 0, the other particle's momentum could be predicted without measurement. The ability to predict with certainty violates Heisenberg's uncertainty principle, and, if determined to be true, would entail a deterministic substrate of reality underpinning the world described by quantum theory. Bohr responded with his theory of complementarity, which allows for the kinds of deductive reasoning that Einstein et al argued proved the insufficiency of quantum theory,

saying that this measurement "can mean nothing else than to establish a correlation between its behaviour and some instrument rigidly fixed to the support which defines the space frame of reference" (Bohr 1935, 699-700). In other words, an entanglement that remains a single system regardless of spatial separation (Polkinghorne 2007, 104). The measurement and deduction proposed by Einstein et al is an incomplete description of the observation apparatus—if the knowledge of the system's total momentum of 0 is included, then the measurement of one particle's momentum collapses the wave function of both particles. Also, by measuring momentum the observer will "lose through the uncontrollable displacement inevitable in such a measurement any possibility of deducing…the location of the other particle" (Bohr 1935, 700). Uncertainty remains because position and momentum cannot be measured together. While Bohr's response defends the internal logic of quantum theory, it was Schrodinger who explained the implications of this measurement on the subject of quantum theory—the wave function itself.

Schrodinger's explanation begins from the unification of the system such that a total momentum of 0 can be known thereof. Given that this is a quantum system, only its end-states, effects, or behaviour can be known. In this case, when two particles form a single system that is known to have a total momentum of 0, we can deduce that by "interaction the two representatives (or ψ-functions) have become entangled" (Schrodinger 1935, 555). This intense connection is such that "the systems…can no longer be described in the same way as before" (Schrodinger 1935, 555). If a pair of photons is entangled, then an action upon one of the pair would also entail "an unretarded *actio in distans*" on the other (Schrodinger 1936, 451). Measurement of momentum, for example, entails the collapse of the directly observed wave function and its pair by virtue of their entanglement.

While this may be hard to believe, entanglement has received a great deal of experimental attention as apparatuses designed to measure the subatomic microworld have improved. Perhaps because of the technological development required to analyze the effects of entanglement, a great deal of time passed between Schrodinger's theorization and experimental verification (Bengtsson &

Zyczkowski 2017, 436). Recent experimental tests of entanglement have not only demonstrated that the measurement of one portion an atom split in half alters the "local quantum state" of the second half in a second laboratory (Fuwa et al 2015), but that these entanglement effects extend over large distances—with one recent research project detecting the effects of quantum entanglement from over 1200 kilometres away (Yin et al 2017). The effects of entanglement include the freeing of causality from limitations of locality or communication below the speed of light. As the experiments have verified for physicists, entangled entities can exert nonlocal force on one another.

Entanglement, in this respect, appears not only as a complex and counterintuitive phenomenon, but also a problematically abstract one. Complexity, counterintuitiveness, and abstraction are frequent visitors of that space where society and science overlap. To borrow a parallel from Bengtsson and Zyczkowski, "once upon a time, 'energy' must have seemed a very abstract notion indeed, and now there are thriving industries whose role is to deliver it in precisely quantified amounts" (2017, 436). Similarly, while—like Einstein—we may balk at the initial idea of permanent connections that communicate faster than the speed of light, instantaneous transformations are frequent in the social world.

To develop an understanding of the importance of entanglement for social theory, it is useful to turn first to Wendt's explanation of nonlocality and experience. By this, Wendt refers to the nonlocal entanglement of materiality and nonmateriality in constructing experience. This is intuitive in the case of major world-historical events. Due to their high level of complexity, major events are always somehow *more* than their constituent parts:

> The Renaissance, World War II, or the Cuban Missile Crisis…were not 'events' at all. This is not to say that [they] have no material basis, since of course part of what constituted WWII as an event is that people met violent deaths. But by themselves, those deaths were just that, separate deaths, which in no way add up to "WWII." (Wendt 2015, 194)

Just like social entities, it seems, social events are also only *seen* by their particular material end-states and effects. These social events are, in this explanation, wave functions with which each particular soldier's death is entangled. Even beyond quantum realism, a quantized perspective on events and

temporality radically challenges assumptions based on the clock-time and objectivity of Newtonian models of history.

Wendt's discussion also makes reference to a 1974 article on noncausal connections by Jaegwon Kim. In this article, Kim discusses connected events that cannot be explained as causes in a classically material sense, such as agency dependence. At the moment that Socrates died, Xantippe became a widow; however, given that Xantippe's change in state was instantaneous with Socrates' death but hemlock drinking does not directly cause widowhood, Kim concludes that the event of Xantippe becoming a widow "has no cause" (1974, 49). Rather, the instantaneous connection is "completely dependent on the occurrence of other [events], but this is not to say that they are causally determined by them" (Kim 1974, 49). This rather messy explanation is much simpler in quantum terms. Since Xantippe and Socrates are socially entangled, then a change in one part—poisoning by hemlock—entails an instantaneous nonlocal change on its entangled partner—widowhood. Xantippe's widowhood is true as a social fact even before a "chain of classical events"—an Athenian telling her the news—alerts her to her new social state (Wendt 2015, 270). Similarly, when economic crises happen, these sorts of social changes of state occur where causality takes place nonlocally. Stock prices plummeting nonlocally cause a rich investor to become poor; a bank foreclosure makes a family homeless; a trade barrier makes a product illegal. Entanglement allows us to understand the peculiar reality of these social connections, only seen in their end-states and effects.

One important development in the use of entanglement in quantum social theory has been in the models of quantum game theory, and related efforts in financial modelling. Hanauske et al (2010) extend quantized game theory into economics to suggest that social ties between investors may create more "dovelike" behaviour between traders, because they will constructively interfere with the decisions of one another. While both the theory of diffraction and the mathematical modelling of interference may be debated on normative grounds, their ability to include social ties in inquiries into human interaction offers

a notable upgrade from single-player game theoretical alternatives. Through a quantum modelling of the prisoner's dilemma, Arfi (2005) draws attention to the inability of classical game theory to predict the eventual cooperation of the United States and Soviet Union. Quantum game theory assumes that the choice is not limited to "cooperate" or "defect," but can be superposition of the two until both plays are made. Throughout the entire "game," the "players" are entangled (by virtue of being in the same game). Subsequent "plays" result in an adaptation of probability amplitudes based on past information. An effect of this superpositionality, however, is entanglement—which Arfi terms "'essential dependence' between the strategic choice of the actors" (2005, 130). And, as the actors become entangled, they exert influence—they interfere—with the decisions of the other. This has two important implications: first, "the whole (the game) is more than just the sum of the individual parts (the individual strategies and beliefs of the players)" because their choices become bound up in the strategies and beliefs of the other player (Arfi 2005, 130-131), and secondly, entanglement allows for interference, because "each now has access to a shared entangled state…which gives them some control over *each other's* decisions" (Wendt, 2015: 171). Our social entanglement is only visible through indications—like Kydd's (2000) costly signals or Leeds' (2003) sunk costs—that were only calculable on an ad-hoc basis in classical game theory. Because each decision of each actor exists as a wave of all potential options, interactions that appear to be irrational in a single instance may constructively interfere to create cooperative instances.

In addition to cooperation, entanglement can explain the ability of markets to result in nonlocal causation. Recalling the widowhood of Xantippe as discussed above, we can make a similar argument about the entanglement effects of market crashes. Consider a pensioner in Wisconsin during the 2008 financial crisis. A retirement portfolio invested heavily in mortgage-backed securities during this period would have sharply decreased in value. If the pensioner's retirement portfolio collapses—here meaning both that the superposition of potential valuations has collapsed into one concrete actuality, and that the retirement savings has collapsed in value—at what point does the individual's status change? When

Lehman Brothers filed for bankruptcy, thousands of employees around the world simultaneously faced termination. Were they unemployed as soon as paperwork was filed? Social entanglement and quantum global political economy provide a framework for understanding the massive, nonlocal effects across an increasingly interconnected world.

Globalization as Strange Entanglement

One of the most interesting targets of Strange's biting polemic was regime theory, which Strange regarded as being shallow. Regimes, as well as the actors within, are superficial elements, and rest upon "the underlying structures of a global political economy of which they are the mere reflections" (Strange 1984, 272). Regime theory cannot hope to grasp the full significance of the global political economy because it analyzes only its reflections. Instead, Strange calls for attention to "the determining basic structures of the international political economy, the structures of security, money, welfare, production, trade, and knowledge" (1982, 496). Just as we saw with the nonlocal approach to historical events, Strange is calling attention to a sum that is greater than its parts. The underlying structures of the international political economy are "common roots" for "many seemingly unrelated developments in world politics and world business" (Strange 1992, 1) precisely because the international political economy is an entanglement of its actors—states, firms, markets. States are engaged in the "different competitive game" of "competing for world market shares" instead of battling for territory (Strange 1982, 564) because the world market entangles states together. Globally integrated states are fundamentally different units from states of old because of this entanglement. While entanglement of electron pairs is somewhat mysterious for many socially-oriented scholars, Strange provides an explanation for state-market entanglement.

Strange narrates globalization as a process of international interconnectedness fuelled by technological innovation. Global markets play an important role in this development, because—especially in their financial and banking iterations—they were "so organized as to encourage and reward technical innovation" (Strange 1990, 263). From her earliest writings, Strange emphasized that "changes in

technology can also change the locus of power" (1976, 345). Therefore, we should not be surprised to find that the market, following an encouragement of technological development, expanded its own agency. In industry, technological change "enhanced the capacity of successful producers" (Strange 1992, 3), which enabled mass-scale sale on a global market. Development of financial transaction technologies like SWIFT fostered a "global inter-bank system" between banks in New York, Montreal, Europe and beyond (Strange 1999a, 134). Rapid improvements in communications technologies[67] "have been a necessary condition for the expansion of international trade and for the large growth of international production" (Strange 1995b, 296). The proliferation of new technologies has fundamentally altered those underlying structures, to the point that the "integrated world market economy [is] now quite disproportionate to the capabilities of any national system of government" (Strange 1995a, 294). States were now bound to a system that had exceeded their ability to control it. Their position had changed.

Technology catalyzed the entanglement of globalization. States connected by fibre optic cables, satellite signals, radio waves, as well as supply chains, trade flows, and a myriad of other technologically-enabled connections can no longer—as with Schrodinger's entangled pairs—be described in the same way as before. Changes in one particular state or major firm—or even the fear or threat of changes—can lead to immediate and powerful changes in entangled pairs spread the world over. A housing market crash in the United States can dry up liquidity in London, cause bank panics in continental Europe, and credit crises in Brazil. We recognize the effects of globalization as a state change because the macroscopic social wave functions of states, markets, firms, et cetera entangle into a trend of globalization. They neither erased nor the same as before. As an entanglement, they are vulnerable to the forces acting on

[67] Note that this has only continued in the years following.

one another. By framing globalization as a process of quantum entanglement, the changes in states (as well as nonlocal effects proceeding thenceforth) are not anomalies but necessary.[68]

Interference: Structural Power and Cumulative Causation

Of all quantum effects modelled in these approaches to decision theory, psychology, and game theory, none have been as fruitful as quantum interference.[69] As discussed in earlier chapters, interference describes wave interactions that can either increase the amplitude of wave through constructive interference or cancel it through destructive interference. Proven through the two-slit experiment, interference is recognized through pattern recognition as experimental apparatuses participate in diffractions.

Moving from electrodynamics to society, interference has developed in a social-theoretic account of diffraction, as well as mathematical models accounting for human experience that will be discussed in the following section. Karen Barad develops a theory of diffraction, inspired by wave interference and in response to the idea of reflexivity, on the grounds that the latter concept "takes for granted the idea that representations reflect (social or natural) reality" (Barad 2007, 87). This poses a problem for critical scholarship where reflexivity can be seen merely as multilevel representation, recognizing the inability of pure objectivity but still reifying the idea of a geometric differentiation between subject and object by incorporating the observer into a reified object (Barad 2007, 88). Instead, diffraction proceeds by acknowledging the waves—seeking to "learn about phenomena" by recognizing that, as scholars, we must "understand and take account of the fact that we too are part of the world's differential becoming" (Barad 2007, 91). When we study something, we interact with it, and as such our activity interferes with the

[68] This is not to say that there was no entanglement before globalization—in fact, communal and social arrangements that humans have participated in involve some level of entanglement. The point in this subsection is to clarify how quantum social entanglement can expand upon Susan Strange's account of globalization.

[69] The article-version of this chapter includes an introduction to interference which has been removed for the purposes of reducing repetition.

subject. What is produced in the end is not separate from our activity, but is a product of our intra-action with the world with which we are entangled and in which we interfere constructively and destructively.

Let us begin first with destructive interference—that is, when one wave interferes with another such that the peaks are less high and the valleys are less deep. In a more general sense scientifically, the amplitude is constrained because troughs and peaks are not aligned; in a more general sense socially, the range of potential future states is constrained. The signature feature of interacting waves, destructive interference is one potential outcome of the interaction of two or more social wavefunctions (the other potential outcome being constructive interference). An example of destructive interference is found in conditional loan agreements of the International Monetary Fund, where the social wavefunction of that international institution interacts with the social wavefunction of a borrower nation. "IMF conditionality," as it is known, imposes restrictions on the range of potential future economic policies of a recipient state by requiring policy adherence to a prescribed range of options. The structural power of the market—in this case, through an international institution of the market—thus destructively interferes with the range of options available to the recipient state. Similar practices of conditional assistance from the World Bank, Asian Infrastructure Investment Bank, states, or private lenders may similarly influence policy prescriptions through destructive interference.

The other form of interference—constructive interference—proceeds from the model where troughs and peaks are in phase, such that the maximum low point becomes lower and the maximum high point becomes higher. This notion effectively offers a physical imaginary for Gunnar Myrdal's (1957) theory of circular and cumulative causation. Constructive interference in its negative sense of making low points lower—for example, economically disadvantaged regions having levying less funds for education and healthcare, leading in turn to further future negative outcome. Where Myrdal offered the image of a "vicious circle" (1957, e.g., 23) or a feedback loop, the model of a wavefunction experiencing constructive interference models more clearly the remaining potentiality for amelioration within the system.

Constructive interference between social wavefunctions can also happen in positive forms, reifying privileges, advantages, and concentrations of wealth, power, and so on.

Interference offers a powerful explanatory tool for the description of social interactions between invisible structures, understood as social wavefunctions. Just as was the case with entanglement, social dynamics of markets (and other societal structures) that have been studied while bracketing the concept of the market fit naturally as behaviours to be expected of a social wavefunction. Quantum behaviours translated into social theory will allow for recognition of interference as social wavefunctions meet, entangled connections between actors, structures, and other entities within what Zanotti and Barad call our continual becoming. The quantum-likeness of the market is thus matched by a quantum-likeness of market effects, forces, and behaviours. While none of the foregoing has speculated a quantum reality to the social world as Wendt does via consciousness and quantum brain theory, it becomes ever easier to sympathize with his claim that the quantum hypothesis is "too elegant not to be true" (2015, 35).

Structural Power as Strange Interference

Strange rejected the idea that the United States lost its hegemony because it retained (in large part, at least) its "structural power." As mentioned above, this form of power allows its bearer "to choose and to shape the structures of the global political economy" (Strange 1987, 565). It is important to note, as Strange does, that this power is "less visible" than direct forms because the shaping of options takes place without direct application of power (Strange 1999a, 31). Through a plethora of political, economic, and diplomatic strategies, the United States has championed the waves of "liberalization, privatization, and deregulation" that now define in large part the world economy—demonstrating the capacity "of the United States to change the options open to other governments, to foreign banks and trading corporations" (Strange 1990, 266). Terminology of construction, destruction, and interference grafts well onto discussions of the structural power of the United States, even without the foregoing exploration of quantum theory. Changing the policy options of another government interferes with their policymaking

from the outside, either constructing new opportunities, (effectively) destroying other opportunities, or, more subtly, by exercising influence that is a combination of the two strategies (Strange 1999a, 31).

Given that all entities related to structural power—states, markets, firms, banks—are ontologically social and therefore can be conceptualized as wave functions, it should be no surprise that their interactions produce interference patterns. The logic is quasi-syllogistic. A quantum IPE would predict this behavioural pattern theoretically, and offers a plethora of game-theoretic, decision-theoretic, and cognitive models of calculation for those wishing to engage mathematically with Strange's theory of structural power.

A quantum approach to IPE can also help to understand the effect of a growth in the structural power of the market, and in fact can predict through a thought experiment. If means develop to entangle more social wave functions—in this case, states, firms, banks, et cetera becoming entangled through technological development—then the amplitudes of that wave function will be greater. Consequently, at each marginal case of interference, the social wave function that has entangled more quactors will interfere to a greater extent in its next interaction. Historically, this predicts the United States being "hoist with their own petard" as the market restricts policy options of American lawmakers (Strange 1990, 266). The post-Cold War United States simply could not "without serious damage to its own self-interest, withdraw into isolationism" (Strange 1995a, 293). Further, the strategy of improving one's own position via "bilateral bargains" between two quactors (whether firms, states, banks, et cetera) functions to entangle those two quactors, such that their amplitudes cohere. This is not to replace the market economy's social wave function directly, but to increase their interference capacity when interacting with it. In Strange's analysis, this "interest of both parties" is regarded as "a far more powerful influence on the level, the direction, and the content of international trade than the puny efforts of states to interfere with market forces" (1985, 234). While I am fairly confident that Strange does not mean this in a quantum-mechanical sense, I could not agree more. Individual states attempting to interfere with the

current market economy face are about as likely to succeed as a feather dropped into a lake beside a boulder. However, by seeking bilateral bargains before engaging the greater wave, their amplitudes can at least stand a fighting chance.

Quantizing the Market: Summing Up and Moving Forward

With a basic understanding of quantum social theory, let us now turn to my original proposition—our efforts to reconceptualize the market should include the exploration of alternative physical imaginaries. Non-quantum approaches to global political economy and related disciplines are stuck in the position of an either/or decision when it comes to the investigation of a macrostructural market or its microfoundational constituents because of the limits imposed by the causal closure of Newtonian physics (Wendt 2015). In the new, quantum understanding of the market, the social wavefunction offers an explanatory model that permits due consideration of both (paradoxical) characteristics. The visible constituent actors, factors, and practices are the particle-forms that correspond to the broader invisible wave of the market. Other concepts related to quantum thinking in physics can help us identify quantum-likeness in nonlocal causation, interference, and so on. The radical reimagining of the market in quantum terms permits a holistic view of global political economy that Newtonian logic cannot abide.

The core proposition is this: a market is a social wavefunction into which all actors are entangled and which is in superposition until localized in interaction. From this, a series of statements can be drawn:

- The invisible social structure of the market is its wave-like nature. It is not directly visible and can only be fully represented when considering all possible outcomes.
- Whenever we interact with "the market" or observe a market interaction, the market-wave "collapses"—just as would any photon being observed. Therefore, when measuring with precise

methodologies there is no "market" to see, only buyer, seller, commodity, et cetera. Markets are constantly collapsing because of the constant intra-activity[70] of actors and structures.

- The market wave function can interfere with other social wave functions—i.e., other social structures like that of a state or a corporation. These effects may be constructive or destructive.
- Actors and other social structures (all understood as their own social wavefunctions) can become entangled with the market. Then a major change in the state of the market can have non-local effects on those actors with which it is entangled.

Using only a few core concepts of quantum physics, we are able to radically reconceptualize the market through a new physical image. While the concept of superposition discussed in the preceding section is mobilized to explain the wavefunction nature of the market—the wavefunction, after all, describes the superposed states—entanglement and interference are productive concepts for thinking about the market. As different linguistic entanglements produce new superposed social wavefunctions, the number of potential social wavefunctions under consideration will remain ever-growing. Now, in place of conclusion, I will briefly offer remarks on how this project of reconceptualizing the market might lead to a broader effort of quantizing global political economy, by returning to the discussion of a micro/macro split in the conceptualization of the market, and how a quantum perspective and improve upon GPE theories of open economy politics and global value chains.

One of the largest research communities in American approaches to global political economy is the school of open economy politics (OEP). This approach, which developed in the 1980s and 1990s, is microfoundational, as "the fundamental building block of OEP is interest, or how an individual or group is affected by a particular policy" (Lake 2009a, 226; see also 2009b). From the individual's interest, then, larger scales of analysis are merely the aggregations of conflicting interest among that collectivity's

[70] While inter-action presupposes the coming-together of separate and separable units, intra-action understands the relations of the network to precede the units ontologically, making all actions into actions *within* the larger whole. For more, see Barad (2007) and Zanotti (2019).

constituency (Lake 2009a, 225-7). OEP was criticized for completely missing the 2008 financial crisis for the limitations the approach places on influence of effects extraneous to aggregations of interest—as Katzenstein and Nelson (2013) argued, OEP may be reading its signals right without reading the right signals—and also for ignoring non-aggregative results of domestic politics (Owen & Walter 2017), policy option limitations emerging from international insecurity (Walter 2016), and the complexity of macroeconomic forces (Oatley 2011; 2017). The issues of including effects of proximate but extraneous actors may be remedied by conceptual deployment of entanglement—where not only constituents but also any actors and structures entangled to constituents are included as effects in the model. Structural considerations of insecurity and macroeconomic forces would seem to act as interference effects in the potential future states of an aggregate system. Given the rigorous econometric basis of OEP, one would assume that the mature mathematical models of quantum mechanics would be welcome additions.

Global value chains, alongside precursors such as global commodity chains (e.g., Gereffi 1996), describe transnational supply chain arrangements in contemporary globalized manufacturing. The concept of the global value chain is sufficiently elastic to encompass free market interactions, modular relationships between lead firms and full-package suppliers, relational agreements between lead firms and suppliers, captive relationships where suppliers are coordinated by a lead firm, and fully integrated firms (Gereffi et al 2005, 89). Given the diversity of possible arrangements, the identification of global value chains—like states in Wendt's example—relies heavily on the ability of the researcher to identify the place of actors within the broader invisible social structure. Indeed, case studies into particular elements of global value chains may include analysis of their relations, but because the social structure is invisible, they cannot ever offer a physical basis for their analysis. Following standard practice in social science, the physical basis for a global value chain is bracketed, instead leading to a more focused analysis of lead firms (e.g., De Marchi et al 2013) or supplier firms (e.g., Kumar 2019). By quantizing the physical basis of global value chains—understood to be constantly collapsing as in the case of the market discussed

above—the social structure becomes logically consistent. As well, given ongoing attention to the interaction between specific issue areas and global value chains—such as the recent special issue of human rights and global value chains in *Competition & Change*—the explanatory power of entanglement and interference seem to offer particularly timely models.

By marking an occasion to reflect on the conceptualization of markets, we underline the importance of understanding how we pay attention to an oft-invoked structural arrangement in global political economy. Though directly invisible, market wavefunctions are constantly collapsing as we interact/intra-act with other constituent parts. The patterns produced through market intra-actions—inflation, recession, inequality, structural power—are clear evidence that the constant collapse of markets has important impacts on everyday life. While the conventional meaning of a 'market collapse' refers to abrupt and visible changes in the stock market, in this quantum understanding of the market *all* intra-actions entail a collapse of the market's social wavefunction. From the new default of cooperation over competition in the quantum market (Hanauske et al 2010) to the ethical implications of radical connectivity (Zanotti 2019), a radical reimagining of the market poses important questions that were previously unthinkable.

The project of quantizing social science does not intend to efface all that has gone before it. Indeed, part of the simplicity of the call to quantize is that it starts with what *mostly* works and seeks to improve it from there onwards. By teasing out the paradoxes that just don't seem to work—like the micro/macro problem in Newtonian conceptualizations of the market—and then deploying the appropriate concept from quantum social theory—like the social wavefunction—the aim is to offer new tools to existing approaches in social science. By exploring a new physical imaginary, the quantum turn invites social scientists to reconceptualize the ways in which tacit Newtonian assumptions limit our ability to understand the social world—who knows how far the quantum leap will take us.

Chapter 7
Concluding Thoughts and Future Directions

"Quantum social science is hard to believe, but when you really think about it, so is the alternative." (Wendt 2022, 121-2)

Introduction

While the recent proliferation of quantum approaches to International Relations theory marks a coming-of-age for the quantum IR community, part of my argument in this dissertation is that this new constellation of researchers drawing on quantum science and quantum theory to inform social inquiry into the international is not merely the latest "camp" (Sylvester 2007), "ism" (Lake 2011), or "turn" (Baele & Bettiza 2021) in a sea of many. The quantum challenge is instead challenges at a foundational philosophical level the relationship between International Relations and physics. Not merely a debate destined for philosophers of social science,[71] quantum challenges dominant assumptions in established and emerging areas of inquiry for International Relations—diplomacy (Der Derian 2011), cooperation (Arfi 2005), statehood (Wendt 2010), ethics (Fierke 2017), international political economy (Murphy 2021a), war (McIntosh 2021), decoloniality (Zanotti 2021), Indigenous sovereignty (Bowman 2021; Salter 2022), language (Wendt 2015), and beyond.

But unlike prior debates around the desirability of "adding" science to the study of world politics (Morgenthau 1946; Kindleberger 1958; Bull 1966), the call of quantum social theory is one for transformation (Barad 2007; Fierke 2022; Murphy 2021c; O'Brien 2021; Zanotti 2018). This is why, in the first chapter, I propose a corrective to our assessment of quantum IR as a philosophical project—I do not deny the cost of learning and employing concepts about which many IR scholars have little to know prior training. But a cost/benefit analysis compounds a neglect of the transformational nature of the quantum

[71] Although this is a large enough group in IR debates (e.g., Kurki 2009; Jackson 2016b)

move with a neglect of the opportunity cost of remaining Newtonian. As with other imaginaries that set the bounds of possibility and impossibility, we have no view from nowhere. In line with prior debates on critical methodologies (Eggeling 2021; Leander 2016; Mutlu 2015; 2019;), my wager is that transparency presents the clearest path to rigour. If IR is to remain Newtonian, then that case must be made; for this dissertation, I have followed a quantum path.

Our world is not one of lawlike regularity, where matter and energy unconsciously interact in patterns limited to local and linear causality, delineated by clear object boundaries and measured by clearer still objective arrangements. We live in a world that is messy, complex, and relational, and we participate in its creation through our actions as humans and scholars. That may very well not be a quantum world, and we may never have an experimental apparatus that convinces all detractors who demand that level of scientistic certainty.

But can we honestly say that our social world is Newtonian? Here I must agree with Wendt's words from this conclusion's epigraph.

Key Findings

The core contribution of this dissertation is at once a clarification of the stakes of IR's quantum leap as well as an uncovering of the scope of quantum's impact for IR theory. These aims are discussed over six chapters that can be broadly sorted into two sections. The first half sets out the framework for the project, in terms of the metatheoretical stakes, physical imaginary, and methodology. In line with these designs, the second half turned to a trio of conceptual case studies, demonstrating the breadth of implications that quantum approaches pose for IR theory across major subfields of security studies, foreign policy and governance, and international political economy.

Chapter 1 takes stock of the assessment of quantum IR from its thoughtful skeptics, separating what falls into the margin of error between cost-logics and what questions remain open for quantum IR to address. While scholars engaged in the quantum IR conversations readily acknowledge the entry cost

into these debates, this chapter articulates why this cost cannot be properly assessed in terms of an additive cost/benefit analysis. Like so many other transformational moves, quantum's call to action is about a shift in imaginary that offers additive benefits as a secondary matter. Recognizing the transformational move of quantum IR and the opportunity cost of remaining Newtonian radically tips the scales in the favour of quantum approaches.

Chapter 2 then turns to the development of quantum mechanics, reviewing the concepts and developments in quantum physics necessary to engage in the debates around quantum IR. While quantum may appear to be unfamiliar due to its specialist vernacular, many of the core concepts of quantum theory express for physicists the relational, uncertain, and complex world that myriad social-theoretic vernaculars endeavour to articulate with their own unique languages. This introduction to quantum theory for social scientists offers a physical framework or a physical imaginary from which a quantum IR can be constructed.

Chapter 3 addresses the methodological design of quantizing through translation employed in the conceptual case study chapters. This is an extended version of the original discussion that I presented in *Quantum Social Theory for Critical International Relations Theorists* (Murphy 2021c), now delving further into the philosophical-methodological influences of Walter Benjamin, actor-network theory, Karen Barad, and Donna Haraway. As I will discuss below, one of the key tasks facing quantum IR in the next phase of its growth is to attend directly to the methodologies of quantization; I hope that the method of translation can serve as one strategy.

The second section of the dissertation moves from stakes to scope, demonstrating the applicability of quantum theory across the field of International Relations through a series of conceptual case studies from across major subfields. Chapter 4 speaks to debates in peace and security studies, and provides a quantized account of violence through a diffractive reading of Johan Galtung's "Violence, Peace, and Peace Research." Concepts of wave/particle duality, entanglement, and interference ground

a reimagination of structural and individual violence. Rather than a binary categorization, a quantum model clarifies how events of individual violence and patterns of social interaction construct violence in a structural form while those structures in turn inform individual acts. Chapter 4 further reflects on how recognizing the relationality embedded in structures of violence is a necessary step for ethical research as well as ethical life.

Chapter 5 addresses foreign policy and strategic studies literatures by arguing that track-two diplomacy abides a quantum-like strategy of social entanglement. While the self-conception of conventional diplomacy as ontologically separate entities interacting to actualize specific agreements abides a Newtonian logic and is dominated by the strategies of classical game theory, I argue that both the definition and evaluation problems acknowledged by scholars of track two diplomacy follow from its quantum physical imaginary. Rather than local and linear causation measured in terms of immediate and actualized outcomes, Track Two draws attention to entanglements building towards the potentiality of future peace. This chapter additionally reflects on the appropriateness of strategies from *quantum* game theory for use in quantum-like social scenarios.

Chapter 6 similarly approaches a definitional problem, this time in the field of international political economy, where "the market" plays a role as foundational—and yet nevertheless underdefined—concept. Drawing on the concept of the social wavefunction, this chapter reimagines the market as a "constantly collapsing" wave, where individual economic entanglements are represented by a system wavefunction that appears concretely in precise moments of intra-action while also producing macroscopic patterns (market forces). This quantization of the market further incorporates a translation of Susan Strange's commentary on globalization and structural power as a proof-of-concept for the quantum imaginary.

Recognizing the stakes and scope of the quantum move in International Relations is crucial for the continued development of the literature, and this dual contribution of the dissertation defends the

position that a careful consideration of quantum is a productive allocation of intellectual resources within IR theory. The pluralism already apparent within quantum IR is not a flash in the pan but an indication of the widespread applicability of quantum insights—and perhaps even the harbinger of the next Great Debate. In an editorial introduction to a special issue of *Security Dialogue*, James Der Derian and Alexander Wendt expressed precisely this sense of optimism:

> The other characteristic of a theory that touches everything is that there are no obvious limits to how it might relate to international relations. We already see in quantum international relations and quantum social science in general remarkable collaborative efforts to respond to diverse questions that range from physical to metaphysical, theoretical to empirical, and explanatory to normative... Although this might lead to a degree of conceptual eclecticism or even philosophical incommensurability, in our view this inchoateness is not surprising nor necessarily detrimental to the early stages of a critical inquiry. (Der Derian & Wendt 2020, 409)

Following Der Derian and Wendt, then, I will by way of conclusion join in the speculation on what a quantum future might hold for the discipline of International Relations, drawing specifically on my own quantum journey that resulted in this dissertation.

Future Directions

In the conclusion to *Quantum Social Theory for Critical International Relations Theorists*, I called attention to five areas where *prima facie* evidence indicated a suitability for further investigation into quantum IR. These were Indigenous thought, postcolonial theory, environmental ethics, Eastern philosophies, and potentiality (Murphy 2021c, 104*ff*). Because—with perhaps the sole exception of potentiality[72]—research into these topics is now well underway in the world of quantum IR, I would in conclusion like to consider three specific future directions of quantum IR that follow from the findings of this dissertation project. First, the need for quantum IR to engage with non-quantum interlocutors; second, the need for continued and further reflection on methodologies of quantization; and third, consideration of the politics of quantum IR.

1. Engagement with non-quantum conversations

[72] But see Prozorov (2022) who discusses potentiality in critique of Wendt (2015).

To dispel the misunderstanding of quantum IR as a niche conversation relevant only to a limited number of topics, a key task for quantum approaches to International Relations will be to engage seriously and in a sustained manner in non-quantum conversations. This task has a serious practical challenge of finding the appropriate balance between doing justice to the complexity of quantum ideas while also leaving sufficient word-space for an article's argument to be meaningful to a larger public. I have previously suggested critical theories of International Relations (Murphy 2021c) as a potential source for engagement, in light of the common ground found in a shared commitment to uncertainty, complexity, and the observer effect. While the growth of quantum-critical literature indicates that there is at least some degree of momentum in this direction, further work can be done to continue exploring points of synergy and complementarity with existing approaches. This can take place through the approach that I call *quantizing critique*, which seeks to enrich existing critical debates from a quantum perspective, as well as through the development of new and *quantized* forms of *critique*, which will infuse quantum debates with sophisticated accounts of criticality. Other avenues for exploration include other approaches that have taken explicit stands against the Newtonian-classical paradigm, whether framed as anti-Newtonian (Bernstein et al 2000) or post-classical (Allan 2018) alternatives. Research programmes calling for greater attention to be paid to complexity may similarly offer fruitful points of departure, whether in terms of complexity in causation (Desrosiers & Vucetic 2018) or complexity theory (Bousquet & Curtis 2011).

2. Reflection on method

Quantum social science approaches employing mathematical modelling have a relatively straightforward explanation of how quantization works; namely, by replacing classical formulas with quantum ones. Not as clear is the quantization of qualitatively-, interpretively-, or theoretically-driven research projects, and that is why a key task for the growth of the quantum IR community is the reflection on methods. This effort may draw inspiration on the recent disciplinary history of critical security studies, where a 'methods turn' made research in the field more accessible to a new generation of scholars (e.g., Salter & Mutlu

2013; Aradau et al 2015). Of particular interest here may be the specific methodologies appropriate to identifying and interrogating significant social entities (class, states, legal systems, etc.) to more precisely explain how some social wavefunctions are able to interfere to a greater degree than others. Strange's explanations of structural power and actor-network theorists' comments on density of connections may provide provocative starting-points, but the methodological question looms large. Here, too, the three relationships to critique can be disentangled; 1) what are the appropriate methods for quantizing as critique, quantizing critique, and quantized critique? and 2) how do these methodological divergences produce important differences in the quantum literature?

3. Consideration of the politics of quantum IR

While some in the quantum community have argued that policy-relevance need not be a criterion for the success of quantum IR (McIntosh, n.d.), I believe that considering the politics of quantum in a broader sense merits serious consideration. Namely, given the centrality of entangled ethics to Baradian quantum social theory in particular (Barad 2007),[73] what implications does quantum theory have for actors across the levels of analysis in world politics? As explored in chapter 5, there are potentially synergistic points for collaboration between the strategies of quantum game theory and diplomatic practice. If this indicates the possibility of a quantum strategy, then how far into foreign policy and governance does a quantum politics extend? These questions remain very much open for debate and discussion, and their potential intersections with existing political movements (e.g., feminism, Marxism, anti-racism) remain undertheorized. Particularly in the form of *quantized critique*, there is an openness to develop new political and ethical questions (e.g., Zanotti 2018; 2021). As I argued in Chapter 1, another consideration of the politics of quantum IR is understanding the significance of socio-political limitations that a quantum imaginary places on human life. It would make sense that freeing political thought from its Newtonian limitations would introduce quantum limitations, but after centuries of Newtonian thought have

[73] We can also consider works in quantum IR drawing on Barad, e.g., Zanotti (2018).

produced insurmountable conceptual challenges—like the problem of consciousness that Wendt (2015) has explored—then perhaps it is time to entertain alternatives. To remain Newtonian despite knowing that its limits are problematic in describing the social world approaches Einstein's definition of insanity.

Final Words

In *You Matter More Than You Think*, Karen O'Brien (2021) makes a strong case for the importance of developing a quantum imaginary because social change demands new ways of thinking. Quantum theory presents a radically different way of conceptualizing the fundamental constituents of matter and mattering, and may seem like a shock to the senses for both the classical social scientist and the quantum-like critic who eschews Newtonian scientism. But if we take seriously the challenge of quantum theory and compare it to our alternative, the costs balance, the benefits abound, and we are left with few options but to agree with Wendt:

> *"Quantum social science is hard to believe, but when you really think about it, so is the alternative." (2022, 121-2)*

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