Contraria sunt Complementa:

Global Entanglement and the Constitution of Difference

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The physicist Niels Bohr identified a parallel between quantum physics and Daoism and Buddhism. The parallel maps onto two debates regarding Global IR, on the one hand, and the implications of quantum physics for the social sciences, on the other, highlighting the potential for a conversation between them. The quantum arguments unsettle the hierarchy between 'positivists' and 'reflectivists,' raising a question of which science, while Daoism and Buddhism, as traditions that have for millennia explored questions of language, agency and ethics, provide a point of departure for thinking about the human and social implications of more recent discoveries in quantum physics. Starting with Bohr's concept of complementarity, the argument moves to an analysis of Karen Barad and Alexander Wendt's work on quantum physics and the social sciences, and then explores Bohr's parallel to Daoism and Buddhism. The structuring of the article around a series of oppositions, including particle/wave, ontology/epistemology, materiality/consciousness, egoism/relationality, East/West, highlights the relationship between global entanglement and the constitution of difference with it.

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In 1947, Niels Bohr, the father of the Copenhagen interpretation of quantum physics, [1] was awarded the Order of the Elephant by the Danish government.[2] It was customary for those receiving the Order to carve the family coat of arms into a family wall of fame. As the Bohr family did not have a coat of arms, he was allowed to design one for himself (Harrison 2000-2002). The ancient Chinese symbol of the Dao, which is formed around the ying and yang symbol, [3] is at the centre of the coat of arms. The inscription reads *contraria sunt complementa* (opposites are complements). In bringing the Daoist symbol to his coat of arms, Bohr juxtaposes complementarity, which is one of the principle concepts for which he is known, with the Daoist symbol of 'yin' and 'yang, thereby illustrating a parallel between quantum physics and this ancient system of thought.

Insert Image A

Bohr's parallel between quantum science and Daoism may seem counter-intuitive. Science is a form of inquiry that seeks to discover 'truth' about 'reality.' Daoism is more likely to be viewed as a philosophy or religion, belonging to another time and place, and thus of lesser importance in the context of modernity. The parallel establishes a more level playing field for raising questions about what the two might have in common. At the heart of this parallel is the shared idea that opposites are complementary rather than logical contradictions, as they are often understood in European philosophy (Wang 2012: 8).[4] His parallel maps on

[1] The Copenhagen Interpretation is the most widely accepted by physicists and considered the 'standard' interpretation.

[2] He was the only person to be awarded this honour who was not either royalty or a famous general.

[3] In Daoist philosophy everything arises from pairs of opposites referred to as 'yang' and 'yin. In addition to the traditional oppositions of yin and yang in the Daoist classification, including sunny/shady, masculine/feminine, active/passive, rational/intuitive, heavy/light, one might add particle and wave (Harrison 2000-2002).

[4] See Ling (2013) for a discussion of Daoism as it relates to IR. While her focus is on extrapolating the theoretical dimensions of Daoism and their significance for rethinking global politics, this piece is more concerned with the parallel to quantum physics.

to two important debates within International Relations, raising questions about the potential benefits of a conversation between them.

Scholars of post-colonial or global IR have questioned the ethnocentrism of the discipline and its concepts, which originate primarily in 'the West' (e.g. Acharya 2014; Jabri 2012; Seth 2013; Epstein 2017), and the U.S. in particular. This thriving debate has explored the meaning of the 'international' (Jabri 2007, 2013; Bilgin 2008, 2010; Tickner 2013), 'worlding' (Tickner and Waever 2009; Bilgin 2016) and the nature of difference (Inayatullah and Blaney 2003; Bilgin 2016). Numerous studies also point to the hybridity of actual practice (Datta Ray 2015; Wang 2017), or analyse how insights from these traditions originating outside the West might contribute to a rethinking of the field (Ling 2013a, 2013b; Bleiker, Mandaville, and Chan 2001), not to mention debates in China, among others, that raise questions about the potential contribution of more ancient systems of thought, such as Confucianism, for rethinking international relation's theory (Zhao 2009; Zang and Chang 2016; Callahan and Barantbatseva 2012). There has, however, been a tendency to become stuck in a West/non-West binary (Hutching 2011), thereby reifying cultural positions in a hierarchical pattern, such that 'the West' becomes the point of reference for thinking 'beyond.' Indeed, a survey of how IR is studied around the world revealed that the differences are far less stark than one might expect (Tickner and Waever 2009; Tickner and Blaney 2012), not least because the main categories of the discipline have percolated out from the U.S. core to the periphery.

In so far as the challenge to create a more level playing field arises from more critical scholars, who, among others, also question the epistemological assumptions of IR, the West/non-West hierarchy overlaps with that between 'positivists' or 'rationalists and 'interpretivists' or 'reflectivists,'[5] from which science claims the high ground and any form of inquiry that does not conform to this unitary model (e.g. King, Keohane and Verba 1994) is considered non-science. These hierarchies point to the difficulty of thinking about difference as anything other than mutually exclusive. More critical conceptions of difference begin with greater attention to the underlying inequalities or forms of inclusion and exclusion (Walker 2002), which, within the former framework are largely unacknowledged, under-analysed and 'derived from various *a priori* Euro-centric hierarchical conceptions of the 'standard of Civilization' (Hobson 2014: 559). Connolly (1991) articulated the paradox that identity

[5] The rationalist/reflectivist distinction was framed by Keohane (1988).

establishes itself in relation to a set of differences, and operates under powerful pressures to fix, regulate, or exclude some of these differences as otherness.[6] While potentially reinforcing the primacy of the identity/difference relationship, complementarity highlights the constant flux of oppositions within a framework that emphasises relationships of difference within a whole rather than the independence of parts.

The emerging debate about the implications of a quantum turn in the social sciences, as represented by two significant works by Karen Barad (2007) and Alexander Wendt (2015), would seem to occupy a different space.[7] While identifying with feminist theory, or constructivism and critical realism, respectively, both authors engage primarily with debates in science and, while claiming that quantum effects are macroscopic as well as microscopic (i.e. at the sub-atomic level), perhaps do not go far enough in elaborating the significance of these arguments for what we do as social scientists (Lamb-Brook 2016). On the positive side, the 'quantum turn' has the potential to shift the debate about science away from the hierarchical construction of 'positivists' and 'others,' to a question of *which* science, and the relationship between them. Wendt (2015) argues that most social science, including constructivism, rests on assumptions that originate with classical physics, including atomism, materiality, determinism and localism. Both Barad and Wendt shift emphasis from the stability and determinacy of the material world toward a greater focus on the particle-wave relationship, non-locality, non-linearity and indeterminism. In so far as quantum entanglement refers to a physical 'reality,' and is not merely metaphor, the debate has potential implications not only for how the relationship between 'positivists' and 'interpretivists' is understood, but also for rethinking the subordination of the social sciences to the natural.

[6] Starting with Campbell's ([1993]1998), this type of argument has had a significant impact on the discussion of identity and difference in IR.

[7] Non-Newtonian or post-classical approaches to social theory, drawing on, among others, Foucault or Butler, Latour or Deleuze and Guttari, have informed the way that more critical scholars of international relations engage in analysis. They have not, however, been explicit in exploring the quantum underpinning. Barad's (2007) and Wendt (2015) are exceptions. Wendt (2015: 147) distinguishes Barad's work from, for instance, the New Materialists, by her explicit engagement with quantum theory. It should also be noted that Wendt is not the only scholar of IR who has ventured into quantum physics. Both Jenny Edkins (2003) and James DerDerian (2013**)** made earlier interventions, although not in book length form.

Placed at the intersection between these two debates, Bohr's parallel is important for two reasons, respectively. First, the grounding of concepts in a scientific metaphysics is important, not because of science envy, but rather to counter the prevailing certainty that because the world works in a particular way, we must necessarily act in a particular way, which in IR has usually rested on assumptions of materialism and egoism. If 'reality' is instead both 'relational' and 'entangled,' and not only at the microscopic level, then our assumptions about both theory and practice also need to be rethought.[8] Second, Bohr's parallel to Daoism, as well as Buddhism (see Bohr 1958: 20), points to traditions that have for millennia, explored the relevance of insights more recently discovered by quantum physicists, which provides a backdrop for thinking more explicitly about the implications of a quantum turn for macroscopic relations, from human social relations to global politics.[9] Finally, both Bohr's concept of complementarity and these ancient traditions shift away from a focus on the material properties of ontologically separate objects or individuals to a relational ontology of entanglement, within which oppositions are mutually implicated, and from which difference emerges from a dynamic process of mutual constitution.

In what follows, I develop Bohr's concept of complementarity and start to unpack its significance through a close analysis of the arguments of Barad and Wendt, after which I return to Bohr's (1958: 20) *parallel* with Daoism as well as Buddhism. In the first section, I explore Bohr's complementarity, as it relates to particle and wave, highlighting the tension at its heart. I then look at the concept of entanglement through a close reading of both Barad and Wendt.[10] Rather than asking which argument is the better depiction of a quantum world, I

[8] This requires less a paradigm shift, than an understanding of the relationship between the assumptions of classical and quantum physics, and how the two co-exist.

[9] It is important to emphasise that many of these themes are also evident in indigenous forms of thought from other areas of the world. Ling (2013), for instance, engages Daoism with the Pachamama tradition in Latin America. See also Mitchell (2015) on the latter.

[10] Bringing the two arguments into conversation with each other serves two purposes. The first is to give the reader some insight into what is at stake in this quantum turn, which, given that it is new and so contrary to conventional wisdom, may seem strange and inaccessible to many. The second is to show how Barad and Wendt, when read together, illustrate Bohr's point about the difficulty of capturing 'reality' in its totality precisely because oppositions are complementary. While both particle and wave are important in quantum physics, each author foregrounds one side of the equation, which is particularly evident in their respective discussions of entanglement.

argue that their respective emphases on materiality and consciousness are an expression of complementary. In the third section, I look more closely at Bohr's parallel to not only Daoism but Buddhism, as two systems of thought that have for millennia explored a metaphysics of both complementarity and entanglement. The structuring of the article around a series of oppositions, including particle/wave, ontology/epistemology, materiality/consciousness, egoism/relationality, and East/West, reinforces the point that difference is constituted out of an entangled whole.

Complementarity

In classical physics a particle can only be a particle and thus an independent entity, which gives rise to assumptions of materialism, locality and determinism. One of the central discoveries of quantum physics, as demonstrated in the famous two-slit experiment, is that a particle can become a wave and a wave can become a particle in certain circumstances. In the experiment, an apparatus placed at one of end of the room, shoots out quantum or elementary particles toward a barrier with two small holes to the end of measuring the way that they are detected after coming through the openings. [11] One would expect that particles would end as they began, that is, as particles. Instead, between the beginning and the finish something strange happens. If there is a single opening in the barrier the particle passes through it as a particle, as one might expect. If there are two slits the same electron does the impossible, which is to pass through both slits at the same time, as only a wave of energy can do. Stated somewhat differently, when there are two openings, the particle acts like a wave, passing through both at the same time, while arriving at its destination as a particle. The question is how the electron perceives that the second opening exists and is available. Since the electron can't really 'know' anything, it was concluded that the only source of this awareness is the person watching the experiment. Thus knowledge that the electron has two possible paths to move through is in the mind of the observer. The experiment further illustrates that elementary particles are not objective material objects, with characteristics that can be determined. Rather phenomena arise from an interaction of some kind, or indeed can be seen

[11] The simple form of the experiment was first conducted in 1801, long before quantum physics, by Thomas Young, and has been reproduced numerous times in the centuries since with identical results. For a more in-depth discussion of this experiment by the authors, see Barad (2007: 81-84) and Wendt (2015: 43-49).

as the interaction itself. The latter contrasts with classical assumptions that a particle has a path, position and velocity that exists independently. Instead, as the American quantum physicist, Henry Stapp (1971: 1303) stated, it is 'in essence a set of relationships that reach toward other things.'

The constant fluctuation between particle and wave expresses a relationship of complementarity, which suggests that oppositions are at one and the same time mutually implicated and mutually exclusive, meaning that we cannot see both at the same time. The principle of complementarity was put forward by Bohr as the first principle of interpretation (Omnes 1999: 153). Others have said that his principle 'provoked the equivalent of an epistemological earthquake, a true reversal in the order of knowledge' (Omnes 1999, xxi). Bohr's 'epistemological earthquake' concerns the role of the observer, and indeed the apparatus of observation, in what is measured and thus known. While classical physics assumes an observer who is independent of the world to be measured, Bohr's discovery highlights the interaction between ourselves and the external world, stressing that humans intervene at every stage of science and not least in determining the very language in which laws of nature are formulated.[12] The observer is entangled in language and the scientist, in talking about phenomena that do not follow the laws of classical physics, is, nonetheless, dependent on more classical concepts. As Aage Petersen (1985: 302) noted:

> When one said to [Bohr] that it cannot be language which is fundamental, but that it must be reality which, so to speak, lies beneath language and of which language is a picture, he would reply 'We are suspended in language in such a way that we cannot say what is up and what is down. The word 'reality is a word, a word which we must learn to use correctly.'

Bohr did not accept the idea that 'things' are ontologically basic units with inherently determinate boundaries or properties; nor that words have inherently determinate meanings. He introduced the concept of 'phenomenon,' which includes the observed object, the unambiguous result of the observation, and the full description of the conditions that validate the result (Stenholm 2011: 51), or the 'apparatus' as I discuss below in relation to Barad. His

[12] Bohr's shift does not require abandoning the rationality and objectivity which is central to scientific practice, but rather suggests the possibility of providing an account of phenomena that will convey 'equivalent information to all observers,' or statements that are intelligible to all human beings (Rosenfeld 1961: 384).

epistemological framework rejects both the transparency of language and of measurement, as well as the idea that they perform mediating functions. Language does not represent states of affairs, and measurements do not represent measurements of independent states of being; both, as well as the observer, are part of the same whole, which is a radical shift from the assumptions of Newtonian physics and Cartesian epistemology.

Epistemology and Ontology

Bohr (2010) emphasises the inseparability of ontology and epistemology; however, consistent with the concept of complementarity, he foregrounded only one of them. As Stenholm (2011: 60), notes, his theory 'offers epistemological recipes only, and carries no (necessary) ontological implications.' Others, and not least Einstein (Einstein, Polodsky and Rosen 1935**)**, argued that Bohr's focus on epistemology leaves the theory incomplete. While Karen Barad (2007: 122) and Alexander Wendt (2015: 75) embrace Bohr's point about the ultimate inseparability of epistemology and ontology, they both, in contrast to Bohr, emphasize ontology.

Barad (2007: 46) finds much in Bohr's philosophy-physics to admire and seeks to elaborate its significance. She argues, however, that his philosophy-physics contains far reaching ontological implications which he does not develop. Her attempt to 'complete' Bohr's theory starts with a critique of the claim that individuals have inherent attributes, prior to their representation, which is the point of departure for representationalism (Barad 2007: 46). Representationalism, she argues, constitutes the represented as independent from the practices of representing rather than accounting for the practices through which representations are produced. Barad examines the relationship between discursive practices and material phenomena, in order to account for 'nonhuman' as well as 'human' forms of agency, which leads to the heart of quantum physics, that is, that 'we are a part of that nature that we seek to understand' (Barad 2007: 67).

Like Barad, Wendt (2015: 74) points to Bohr's refusal to engage in ontological questions and concludes that the Copenhagen interpretation is 'essentially incomplete,' in so far as it offers no answer to a crucial epistemological question: '*why* is our knowledge of the quantum domain so unlike our knowledge of the macro world?...The answers cannot be found solely in epistemology, but only by engagement with ontology' (2015: 75). While noting the powerful grip of materialism on the scientific imagination, for Wendt (2015: 81) the problem is that, from a purely materialist position, one can't get to consciousness, which

he defines as the experiential aspect of mind (2015: 15); quantum physics also raises a question of whether the 'ultimate constituents of reality are indeed wholly material,' given that physicality, in a quantum world, is not equivalent to materiality. The 'collapse of wave functions,' he argues, provides a physical, but non-material space for consciousness at the quantum level (2015: 109). In this respect, 'mind is neither reducible to matter nor emergent from it. Mind is in matter all the way down, which makes mind and matter continuous (2015: 112).

Both Barad and Wendt argue that Bohr's focus on epistemology is incomplete, and seek to explore the ontological significance of quantum theory. The effort to 'complete' what Bohr has left incomplete, by making an ontological turn, might be understood to be *contrary* to the indeterminism and complementarity at the heart of the Copenhagen interpretation. From this perspective it would seem more consistent to eschew the search for completeness and to instead examine the implications of the inseparability of ontology and epistemology, [13] a claim that has received very little attention. However, the point of complementarity is that opposites are entangled but cannot be viewed at the same time. In this respect, while ultimately representing two sides of the same coin, it is difficult to explore both simultaneously, just as it is impossible to see particle and wave at the same time. Bohr, like Barad or Wendt, failed to do so. Next to Bohr, the two arguments express one side of the ontology/epistemology opposition. However, when read in conversation with each other, they express a different relationship of complementarity vis-à-vis one another,[14] given the central contrast between them. Barad highlights the entanglement of matter, while Wendt's focus is the physicality of consciousness and entanglement in language. The two quantum arguments might be compared to see how, for instance, they relate to other existing social theory debates, such as feminism, constructivism or critical realism, which the authors have, respectively, been a part of. I instead engage with them, less as a form of critique than as an *illustration* of oppositions as complementary. This highlights Barad's (2007: 93) point that knowledge production is a boundary marking process, an 'intra-action' and conversation by which difference is produced. Both authors express the central point of entanglement, i.e.

[13] Ludwig Wittgenstein (1958) also makes this claim. See Stenholm (2011) for a discussion of the similarities between the arguments of Bohr and Wittgenstein.

[14] As they too are observers, their social positioning is of interest, given that Barad started as a physicist and moved toward social theory, while Wendt is a social scientist who has moved toward physics.

they move from an individualist to a relational ontology, while bringing different sides of the particle/wave dialectic to the fore.

Quantum Entanglement

Classical physics rests on an assumption of the separability of matter, that is, that objects exist independently of one another. The separability of objects and their local positioning in space is the point of departure for measurement by a scientist who stands outside of this relationship. This assumption stands in stark contrast to the notion of entanglement, which is said to be 'the very essence of quantum physics' (Barad 2007: 386), and has fundamental implications for how phenomena are understood and what it means to measure them. From a grounding in the materialism of classical physics, quantum entanglement is difficult to grasp.[15] At its core, entanglement arises from the question of whether A and B exist as independent entities, separate from one another, or whether they are correlated, such that, for instance, when A moves up, B moves down. In explaining quantum entanglement to members of the U.S. Congress, a National Science Foundation officer presented it as follows:

> Two particles can have linked spins even though they are at a distance (and appear to be completely separate entities). Manipulating one particle and then reading the spin of the other, linked, particle is the basis of quantum information teleportation.[16]

In other words, no matter how far apart, the two entangled particles are not separate at all and thus the interconnection of the spin is instantaneous even if they are separated by great

[15] In ordinary English usage, entanglement often suggests an undesirable relationship or situation, given involvement with people or things that may be difficult to understand, deal with or escape (Cambridge 1995: 460), and thus carries a pejorative connotation. The meaning in German, the native language of the physicist Erwin Schrodinger (1935), who used the term *Verschrankung*, is more neutral, connoting an unfolding or crossing over in an orderly manner rather than being caught up in an entangled mess. The contrast regards the difference between a piece of string that is knotted and thus entangled as opposed to a carefully woven tapestry that has *Verschrankung* (Clegg 2006: 3).

[16] As quoted in Barad (2007: 385). Barad presents this testimony to show that quantum entanglement is a subject of research by a range of U.S. institutions, from the National Security Agency (NSA) to the Army, Navy and Air Force or the Department of Energy (DOE) among others.

distances, which means that something happening in one part of the universe can have 'non-local' consequence in other parts, regardless of the distance (Smetham 2010: 80).[17] The idea that entanglements can be non-local stands in stark contrast to the classical assumption that objects occupy a point in local space at a given moment in time,[18] and, due to their separation, have no connection with objects at a distance. Bohr argued that A and B can't be considered to be fully separable particles by virtue of their entangled relationship, which is, however, complementary, in so far as it is only possible to measure the position and momentum of one at a time (Wendt 2015: 51).[19] When two or more quantum systems are entangled, the parts of the combined system are not fully separable and their properties depend on the relationship to a whole. The *relational* properties of entangled systems conflict with the principle of atomism, by which the nature of the whole arises from the sum of its parts. Entanglement has no equivalent in classical physics.

A first step in thinking about the significance of entanglement is to abandon the deeply engrained habit of thinking in terms of individual subjects or objects with an intrinsic nature and to instead begin to imagine the web-like entanglements within which phenomena are constituted, interconnected or constrained. The temptation is to treat entanglement as metaphor, but both Barad (2007: 110) and Wendt (2015: 40, 63) argue that it has a material or physical basis, respectively, in quantum physics, and that quantum effects are not confined to the microscopic level but reverberate through more macroscopic processes as well. [20]

[17] As Wendt (2015: 52-4) notes, quantum physics has shown that reality is fundamentally non-local. The Bell Experiment's proved that local reality was *not* a basic feature of the universe. They demonstrate that instantaneous correlations can occur between events that are widely separated in space. However, in quantum mechanics, non-locality can also be temporal, with corrections occurring between events separated in time.

[18] Locality means that no causal influence can be faster than light, which implies a temporal separation of cause and affect which rules out any instantaneous causation or action at a distance (Wendt 2015: 64).

[19] In the debate between Einstein and Bohr regarding two different criterion for reality, Einstein assumed it would be possible to predict the value of a physical quantity through measurement, without in any way disturbing it because it existed as an independent object. It should be mentioned that Bohr won this debate.

[20] Barad (2007: 279) states that quantum mechanics is the most successful theory in the history of physics, 'accounting for phenomena over a range of 25 orders' magnitude from the smallest particle

However, they provide very different takes on the significance of the quantum turn for the analysis of social/natural phenomena. This difference is most evident in their approach to entanglement.

While it is impossible to do justice to these two very rich and complex arguments in such a short space, I bring the two into conversation around a specific concept to highlight the boundary that separates them. I have already pointed to their common acknowledgement of the ultimate inseparability of ontology and epistemology, combined with a justification for focusing on the former, as well as their shared view that the subject matter of the natural and social sciences is not completely different, not least because quantum effects can be experienced in all layers of life. In looking more closely at their difference, I show how the two arguments about entanglement are complementary. I have kept the discussion of the science to a minimum, assuming the reader who wants to engage with the scientific arguments can read their books.

Differing Matter

Realism, as commonly understood, assumes the existence of individual entities with nonrelational properties (Barad 2007: 55). From a realist perspective, 'things' have an independent existence and the language of science mirrors or reflects these discrete objects. Barad develops a framework of 'agential realism,' which rests on very different assumptions. Drawing on Bohr, she begins with a notion of 'phenomena' as entangled material agencies. She states that 'experimenting and theorizing are dynamic practices that play a constitutive role in the production of objects and subjects and matter and meaning' (2007: 56). 'Intra-actions' are both a part of and constitutive of the phenomena that are produced. The intra-action arises from within, preceded by and producing practices that are entangled. Different

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of matter to large scale objects.' In this respect quantum mechanics not only supplements Newtonian physics but supercedes it. She states emphatically that Bohr's analysis of the nature of measurement interactions and the epistemological implications are *not* limited to the microscopic domain. The key issue is that quantum effects are less obvious in the realm of everyday experience; we don't notice them because they are very small, they are difficult to observe and one needs to know how to identify an entanglement.

intra-actions produce different phenomena (2007: 58) and it matters who or what is excluded through these entangled practices.

Barad (2007: 150) argues that entanglement is the very nature of *matter*. Entanglement does not refer to just any connection, interweaving or enmeshment. The 'cut' that marks difference, and thereby creates separability, is a part of the entanglement. She draws on a metaphor of diffraction to discuss her methodology for analysing the production of difference.[21] Diffraction, in general terms, arises from the interference or disturbance that occurs when two waves meet, and here the example of waves of water in the sea provides a useful image. As they meet, one wave is superpositioned against the other, which creates a different pattern of movement. While classical physics would recognize this activity in relation to waves, the crucial insight of quantum physics is that particles too can in certain conditions exhibit wave-like behaviour, just as waves can become particles (2007: 83). It is this superpositioning, and defraction that distinguishes an 'intra-action' from an 'inter-action.' While interaction arises from the engagement of ontologically separate entities with one another, intra-action assumes that phenomena arise from the engagement itself, and are part of a dynamic and entangled whole, from which parts are constituted and defined through their difference.

Diffraction experiments, such as the two-slit experiment, provide a point of departure for 'a new way of thinking about the nature of difference, and of space, time, matter, causality and agency,' among others (2007: 83). Barad hopes to show that 'entanglements' are very specific configurations. However, it is difficult to build apparatuses for their study, because the apparatus changes with each intra-action (2007: 74), and because space, time and matter 'do not exist prior to the intra-actions that reconstitute entanglements.' The apparatus and the observed phenomenon change alongside one other. In classical physics, objects have pre-existing properties and boundaries that make the measurement of determinate interactions possible, and there is an assumed intrinsic separation between the knower and the known, as well as the apparatus of measurement itself (2007: 107). By contrast, in quantum physics the object of measurement is not fixed; the boundary that separates the object from the 'agencies of observation' (2007: 107) will be indeterminate in the absence of the specific physical

[21] The metaphor of diffraction emerged in critical cultural analysis with Donna Haraway's (1992), 'The Promises of Monsters,' as a feminist tool for rethinking difference/s beyond binary oppositions. On diffraction, see also Barad (2014), and Kaiser and Thiele (2014).

arrangement of the apparatus (2007: 114). She discusses, for instance, the difference between measuring 'position' and 'momentum', which are not simultaneously determinate and require mutually exclusive experimental conditions. The measurement of position is defined by reference to a fixed platform, while the measurement of momentum requires a moveable platform. In this respect, every measurement involves a particular choice of apparatus which provides the condition 'to give meaning to a particular set of variables at the exclusion of other essential variables' (2007: 113-115). The two are entangled, and thus not entirely separable, and the measuring apparatus itself enacts a 'cut.' The interaction between object and apparatus forms an inseparable part of the phenomenon, which means that measurement practices are also an indispensable part of the results and thus must be considered part of scientific theorizing and situated within theory (2007: 121).

While Bohr's writings focus on the inherent *semantic* indeterminancy and the profound epistemological implications of the lack of inherent separation between knower and known, Barad wants to claim that it is not too far a stretch to understand the indeterminacies to be at once semantic *and* ontic (not merely epistemic) (2007: 127) as well as ethical. Making knowledge is about making specific world configurations rather than making facts, of materially engaging as part of the world in giving it specific material form. Her methodology requires attention to the fine details (2007: 92), with the potential to place the understandings generated from different (inter)disciplinary practices in conversation with one another, in a dynamic relationality to the other,

> being attentive to the iterative production of boundaries, the material-discursive nature of boundary-drawing practices, the constitutive exclusions that are enacted and questions of accountability and responsibility for the reconfigurings of which we are a part' (Barad 2007: 93).

The latter entails an ethics of responsibility which flows from the fact that 'we' are a part of the world's differential becoming, and practices involve specific material engagements that participate in reconfiguring the world (2007: 91).

A *relational* ontology is at the heart of agential realism. The material-discursive boundary-making practices that produce 'objects' and 'subjects' and other differences emerge out of and in terms of a changing relationality. In developing her 'agential realist' account of how material-discursive practices matter, Barad presents performativity, in her critique of Butler, as a challenge to the excessive power granted to language in determining what is real,

providing a point of departure to contest unexamined habits of mind that grant language and other forms of representation more power in determining ontologies than they deserve (2007: 133). This opens the way to a post-humanism that takes issue with human exceptionalism while accounting for the differential constitution and positioning of the human vis a vis other creatures, both living and non-living (2007: 136).

Collapsing Wave Functions

While Barad's argument highlights the entanglement of matter, Wendt is more concerned with the entanglement of *consciousness*. Like Barad, he (2015: 131) positions the human in a larger context of 'life,' arguing that, from a quantum perspective, 'human life is essentially continuous with rather than qualitatively different from other organisms.' It is quantum coherence that is said to distinguish life from non-life. Quantum coherence creates a unity of 'self,' and the retention of this unity in memory. It is physical but not material, and the essence of subjectivity, which he understands as experience (Wendt 2015: 139). Consciousness arises at the interface (or boundary) between the inside, which at the human level we associate with a sense of 'I,' and the outside, for instance, the external environment which is a necessary source of nutrients and energy. Consciousness, far from being a purely human attribute, goes all the way down – 'experience is inherent in the deep structure of matter' (2015: 111) - and is the crucial means by which the 'self' is able to respond to its environment. Wendt's 'flat consciousness,' is present in all life, from plants to non-human animals and humans, and is fundamental to the ability of any living subject to negotiate its environment, including to feed itself or survive in the face of threats.

While Barad analyses how separability emerges from matter, Wendt highlights the *experience* of separability and subjectivity. In the classical vision, humans or other forms of life are completely material and mental states are simply brain states. People may have consciousness but it is epiphenomenal (2007: 151) or secondary. Separability means that nothing about 'us', whether body or mind, depends 'constitutively on other people' (2015: 152). Humans are independent beings, confined to their own skin, from which the mind responds to local causal forces that arise from an outside environment, while inside, the various stimuli give rise to reasons and behaviour. This means that humans are just complicated machines, lacking in subjectivity, such that free will and 'life' do not exist (2015: 153). Wendt, in developing the quantum alternative, states that 'what looks like separate organisms are just local decoherence effects of quantum fields. From a quantum

perspective, everything really is related to everything else' (2015: 149), and humans are 'literally walking wave functions' (2015: 154).

The shift toward a quantum model has further implications, which may help to resolve certain long-standing anomalies, such as the lack of fit between the assumptions of rational choice and human behaviour under uncertainty (2015: 155). The classical model of rational choice places constraints on how actors calculate probabilities and organize preferences, which further assumes that success or failure in achieving goals is a matter of correspondence between what is going on in the mind and the material environment (2015: 165). Quantum decision theory challenges these assumptions, shifting from a correspondence between mind and environment to the entanglement between the brain of the agent and a context (2015: 166). In this view, the entire brain, including the emotions and sub-conscious, and not only reason, are involved in decisionmaking.[22] The potential to exploit non-local connections to the environment, (2015: 167) means that the strategies of different agents may be entangled (2015: 170). Entanglement is not limited to what is going on inside any one mind but extends to a relationship with others. Far from literally the same, or fully separable, agents share an entangled state within which their strategy sets are correlated, much as the measurement of the spin of one particle in an entangled pair induces a state of change in the other (2015: 171).

Wendt, drawing on Barad, makes the distinction between inter-action, which assumes the separability of agents, and intra-action, which assumes that humans are entangled with the social world and not fully separable from each other (2015: 172). However, in contrast to her focus on the material 'cut,' human beings only become who they are through the collapse of wave functions into well-defined states, which happens through continuous measurements on and by our environments. Decisions are made on the basis of Will, which involves the reduction of indeterminate reasons to determinate choices, such that the actual reason why an agent does X only emerges with its enactment (2015: 181). Through repeated acts of will based on a conscious intention, agents 'enforce correlations backwards on their behaviour over time, which provides a sense of coherence not only in terms of its consistency with the past, but also teleologically in so far as the future gives meaning to and completes the past (2015: 182). The production of meaning is wilful in the sense that it requires ongoing decisions to collapse the potential meanings of words into actual ones; it is only in the

[22] As Rene Jeffries (2014) notes, neuroscience is a largely materialist science but recent discoveries, such as those of Damascio, have demonstrated the inseparability of reason and emotion.

experience of language that meanings are realized (20015: 221). Linguistic meaning presupposes consciousness and in so far as consciousness originates in wave functions that are inherently non-local, i.e. shared, it is through experiences of language that we gain access to other minds (2015: 221).

A central question is how, given a range of potentials and probabilities, a single potential, at any one point in time, is isolated such that, as a result of wave function collapse, one possibility rather than another materialises. The *sedimentation* of certain practices over time increases the probability of collapse around some potentials rather than others (for instance, fear, as opposed to compassion, in relations between states). Further, wave function collapse is inherently *contextual*. Wendt (2015: 217) states that 'in language what brings about a concept's collapse from potential meanings into an actual one is a speech act, which may be seen as a measurement that puts it into a context, with other words and particular listeners.'[23] It is only with the introduction of context – the way that associations are measured – that words take on specific identities as a result of the network's 'collapse' (2015: 220). The key point is perhaps that language use arises from a form of *entanglement*, which highlights the superpositioning of social structures and individual subjectivity, that is, that which can be meaningfully said in any one context will build on shared intersubjective understandings, even while there is an element of subjectivity by which these constraints cannot be considered to be absolute.[24] He states that 'Consciousness originates in wave-functions that are inherently non-local, in so far as they are shared – as they must be for language to be social - through experience of language we might gain access to other minds (2015: 221). These shared understandings constitute the stream of thoughts and potentials

[23] This starts with communicative intent (the decision to communicate one meaning rather than another) which depends also on the listener, whose understanding will depend on how what is said interacts with a memory of words and their association. As such 'memory structures relate to concepts in the same way that measurement devices in physics relate to particles', which suggests that quantum entanglement and interference are manifested in actual language use (2015: 217). In so far as memories are stored not as isolated entities but as networks of related words, their entanglement is evident in how they are activated (2015: 219).

[24] Wendt's quantum shift involves an acknowledgement of the role of language that was missing in his earlier work on constructivism (see, for instance, Zehfuss: 2002).

that circulate through the consciousness of the human or social subject, which are shaped but not determined by context.

Opposition and Complementarity

Wendt and Barad both move from a classical world of separate objects that exist in local space to quantum entanglement and non-local relationality. From this common point of departure, each argument develops a distinct and complementary focus. Wendt begins with quantum coherence and the experience of separability, as well as the constitutive importance of the interface between inside and outside for life and consciousness. Barad is more concerned with the process of boundary marking at the level of matter, and the ontological significance of the 'cut' that constitutes separability. While the discursive and material cut are of equal importance, she seeks to demonstrate how the cutting and marking of the body or matter more generally, provides a different approach to difference. While both Barad and Wendt seek to de-centre the human, and reposition language users within nature rather than outside of it, Barad avoids any distinction between language using humans and other forms of life. She discusses the inseparability of the dynamic relationship between discursive and material practices all the way down, although it is difficult to grasp what precisely she means by discursive when one steps beyond human language. While Wendt also claims that life goes 'all the way down,' he focuses more on the human and social dimensions of entanglement through language, than on matter per se. Barad spotlights the particle, and Wendt, the wave.

Insert Table B

The 'intra-action' of these two, in many respects, very different interpretations of quantum physics for social life, highlights their complementarity. Both accept the basic quantum point about the complementarity of particle and wave, which is the necessary condition for the more relational ontology of entanglement. However, they begin with different concerns and emphasise different aspects of the dynamic relationship between particle and wave. Barad starts with a critique of representationalism, which rests on an assumption that language mirrors or reflects a world of discrete objects. Wendt begins with a critique of the materialist assumptions of classical physics or contemporary social science,

arguing that we cannot get to a notion of consciousness from a purely materialist perspective. Each provides a physical basis for mutual constitution, one of which is material and the other non-material. Wendt argues that mutual constitution is untenable within classical physics (2015: 260), while Barad highlights the difference between interaction and intra-action (2007: 33). What makes mutual constitution untenable, from a purely materialist perspective, is the atomism of classical physics. Two discrete subjects or objects may engage in an exchange but the result is not mutual constitution in so far as their separateness is apriori, absolute and thus remains unchanged. Mutual constitution and intra-action both suggest a more dynamic process by which the entangled boundary that emerges from the encounter will be transformed, thereby potentially changing ontological status, the context and the possibilities available within it.

One might, in light of this conversation, ask which is the *correct* interpretation of the 'reality' of quantum physics at the interface between the natural and social sciences. In so far as the two areas of scientific inquiry are – at least at present - distinct, and involve different kinds of expertise, it is difficult as a more social analyst to answer this question. If we, however, accept, that both point to a very different set of assumptions about this reality than that of conventional social science, the central question becomes less one of which is correct than what difference the shift from a classical framework to the quantum makes. Both arguments provide a material or physical basis, respectively, for a *relational ontology*, raising significant questions about classical assumptions that we are separate in an absolute sense and possess an intrinsic identity. The complementarity of the two arguments also reinforces the point that a 'complete' depiction of the 'reality' of an indeterminate world is impossible.

It may be tempting to see this complementarity as little more than one author distinguishing their argument from the earlier work of the other. Or, their respective arguments could be viewed through the lens of their different intellectual histories, placing Barad in the context of feminist arguments about the body and embodiment, or Wendt in the development of constructivism or critical realism. However, while we would expect the two arguments to be different, it is how they are different that is key. While the discursive has a role in Barad's argument, entanglement itself is defined in material terms; while the physical - if not the material - is important to Wendt's argument, his focus is entanglement in language and consciousness. While there is room for critique of both, my point is that they each highlight a different aspect of a mutually implicated relationship and the boundary that

distinguishes them. Both particle and wave are constitutive and both are important, but it is difficult to observe them both at the same time.

The inseparability of the observer and the apparatus - however the latter is defined - means that we as analysts are always part of the context of analysis, which has ethical implications. Thus the 'real' vs. 'normative' distinction that is so central to classical social science, collapses. As part of a context, our actions are entangled with and impact on the reality that emerges. As Wendt (2015: 287) states, social-scientific research is responsible, at the micro-level, for helping to "create, sustain and/or transform . . . reality (2015: 287). Any perception that we are getting closer to "truth" is more a reflection of the role of repeated measurements in stabilizing a certain reality than of their role in capturing an independently existing one. Or, according to Barad (2007: 203) we are responsible for the world we live in, 'not because it is an arbitrary construction of our choosing but because it is sedimented out of particular practices that we have a role in shaping.' In this respect, as the physicist John Wheeler (Folger 2002) claimed, we are 'participants' in making the universe. In the next section, I build on these claims but shift to the 'parallel' to quantum physics noted by Bohr.

The Parallel

Both Barad and Wendt explore a relational ontology that is grounded in scientific discovery and practice. In her final chapter, Barad articulates an 'ethics of responsibility' which grows out of her attempt to think difference differently. But thinking difference differently looks somewhat different from the perspective of Bohr's complementarity than Barad's ontological cut. Wendt mentions ethics in passing but doesn't explore the implications in any depth. In this section I return to Bohr's parallel as a way to explore the potential macro-level implications of a quantum metaphysics, for human social and political life. Consistent with his coat of arms, in a 1937 lecture in Italy, Bohr (2010: 20) stated,

> 'For a parallel to the lesson of atomic theory…we must in fact turn to…that kind of epistemological problems with which already thinkers like Buddha and Lao Tse have been confronted, when trying to harmonize our position as spectators and actors in the great drama of existence.'

Popular representations of quantum physics have alternatively embraced or created distance from this parallel. Barad (2007: 67-68) criticizes those who 'often position [quantum physics] as the scientific path leading the West to the metaphysical Edenic garden of Eastern

mysticism…' She further states that 'those who naively embrace quantum physics as some exotic other that will save our weary Western souls forget too quickly that quantum physics underlies the workings of the A-Bomb….' In this comment, she fails to acknowledge that the parallel originates with Bohr, who had a role in developing the A-Bomb, even while the Copenhagen interpretation is the point of departure for her own argument. Further, as Bohr (2010: 20) quite rightly notes, mysticism is not the point of the parallel. He states, that it does not imply the acceptance of any 'mysticism foreign to the true spirit of science' (2010: 20). It instead provides a point of departure for examining whether 'the straightforward solution of the unexpected paradoxes met with in the application of our simplest concepts to atomic phenomena might not help us to clarify conceptual difficulties in other domains of experience' (Bohr 2010: 20).

The 'domain of experience' of particular concern here is social life and ethics, and indeed, these traditions of thought, going back millennia, have been concerned with precisely this, including the relationship between language and materiality. I approach Daoism and Buddhism, not by association with religion or mysticism, but rather as a metaphysics that shares a family resemblance with that of quantum physics.[25] Bohr is one of the fathers of atomic theory. He was involved in the Manhattan project. The Copenhagen interpretation is widely accepted by quantum scientists. There is thus every reason to take his parallel seriously, and to assume that it does NOT rest on 'naïve romantization' (Barad 2007: 68). His articulation poses the question of why he made this connection and what it might tell us about the nature of complementarity and difference beyond the sub-atomic level. The Eastern traditions, which are millennia old, demonstrate the significance of complementarity and entanglement for human social and political practice, including ethics, while the science provides a grounding in 'reality,' thereby magnifying the importance of both at the macro-scopic level.

[25] In doing so, I also question the tendency to dismiss traditions of thought outside of Western science, without examining them in their own right. The dismissiveness would seem to be part of the boundary making between culture and nature which Barad otherwise calls to account. As stated in the beginning, a growing chorus of scholars have highlighted the failure to engage with modes of thought that originate in other parts of the world.

Yin and Yang

L.H.M. Ling (2013a, 2013b), who has explored the significance of Daoism for theorizing global politics, states that 'In Daoist dialectics, complementarities (yin) prevail despite the contradictions (yang) between and within polarities. Nothing remains stable or the same.' From this perspective, ethics, rather than hinging on universalised concepts, such as happiness for the greatest number, in the utilitarian ethics of Bentham, or duty to universal principles, in the deontological tradition of Kant, views choices through the reversal of positive chains of opposites. In Verse 2, of the *Dao de Ching*, the seminal text of Daoism, Lao Tzu states that 'under heaven all can see beauty as beauty, only because there is ugliness. All can know good as good, only because there is evil.' *Yinyang* suggests that good and evil, for instance, while often understood to be two ends of an either/or spectrum, are always already implicated in each other.[26] By way of looking at what this means in practice, it is useful to start closer to home with an ethical dilemma that arises from the creation of nuclear weapons, which are a product of quantum theory. On the one hand, these weapons are the ultimate bad, as expressed in Oppenheimer's reference at the time of the first atomic explosion to the line from the *Bhagadvad Gita,* 'Now I have become death, the destroyer of worlds' (Eastwaren 1985). Nuclear weapons could bring an end to life on the planet and are thus difficult to defend on ethical grounds. However, nuclear weapons have been valued by many as a good in ending World War II or providing the stability of nuclear deterrence.

Michael Frayn's (1998) play,[27] *Copenhagen*, provides an interesting account of the ethical dilemma as it relates to the human actors who formed part of the experimental context of nuclear development. The play revolves around the visit of the German physicist Werner Heisenberg to Niels Bohr, who is half Jewish, in occupied Denmark in 1941. The central question throughout the play regards Heisenberg's intention in visiting Bohr.[28] Why did he

[26] The concept of 'actionless action (*wu-wei*) refers to an action that does not force but arises in conformity with the Dao or the natural pattern of things, rather than imposing 'will. See Wang Chen (1999).

[27] I have relied on a film depiction of the play in this analysis (Frayn BBC 2016). See also Edkins (2003) for a very insightful analysis of this play.

[28] Barad (2007: 22) begins with a critique of Frayn's play, claiming that it is based more on Heisenberg's concept of uncertainty than Bohr's complementarity, which is evident in the focus on the former's 'intention' in visiting Bohr. She states that this contrasts with Bohr's point that an

come to Copenhagen at that point in time? In a normal context it would be straightforward enough for a former student, Heisenberg, to visit his former mentor, Bohr. But in the context of Nazi-occupied Germany, Heisenberg's position as physicist in Germany, and Bohr's status as a half Jewish quantum physicist, complicates the question. Heisenberg's intention and the difference this intention makes to his intra-action with Bohr, ultimately boils down to a question of whether their encounter in Copenhagen could have resulted in Germany developing an atomic weapon first. While the play is full of insights, here I want to highlight the relationship between good and evil expressed by their intra-action. Heisenberg, the potential villain as a Germany physicist, who was suspected of wanting to mine information from Bohr to the end of constructing a German atomic weapon, in the end potentially saved lives, including Bohr's. He was not in any case responsible for the death of a single person. Bohr, who later had a role in developing U.S. atomic weapons, was, in the end, potentially implicated in the deaths resulting from the explosions over Japan, and therefore for inflicting more harm than his former student, which again highlights the principle of complementarity and the idea that everything contains its opposite. The particle contains wave and the wave, the particle, just as the good contains the bad and the bad, the good, and this relationship is in continuous flux.

As Robin Wang (2012) notes, yin and yang are not 'things' or 'objects' but express a relationship, which always applies in particular and relative contexts. While there is a dependence on context for understanding this relationality, the fact that anything can be simultaneously yin or yang mirrors the fact that 'things are always implicated in multiple relations at once' and it is the intentions and priorities of the observer that determine which relation is in view (Wang 2012: 7),[29] which resonates with the conclusion of the famous two-slit experiment in quantum physics. The idea that oppositions are logical contradictions is central to European philosophy, while Chinese thinkers are more inclined, not only to see oppositions existing through interaction with and in dependence on each other but also, as the context changes, the same thing can reveal opposite qualities (Wang 2012: 8). Wang's (2012: 9-11) 'six forms' of yin/yang, regarding different types of opposition, and thus the

intentional state of mind can only be spoken of within a meaningful context. She again weighs heavily on the material conditions, without attention to the complementary role of consciousness. While taking her point about context, I try to show the interplay of the two within the play.

[29] For a further elaboration of the significance of Daoism for IR, see Ling (2013).

multiplicity and complexity of relationships, provides further insight into the interaction between Bohr and Heisenberg.[30]

Frayn's play, on the surface, communicates the *opposition* of Bohr as good to Heisenberg's evil. Bohr is a potential victim of the Nazi regime, and thus harmless, while Heisenberg occupies a position of power in Hitler's machine and thus is himself a potential perpetrator of evil. But as the play progresses, it becomes clear that the qualities of good and evil arise less from any intrinsic identity or intention of either individual than from the context of World War II and the race to acquire nuclear weapons. The context also constitutes the *interdependence* of the question regarding Heisenberg's 'intention' and how Bohr responds, i.e. their relationality, as illustrated in a series of thought experiments within which their intra-action unfolds in very different ways. The thought experiments revolve around a moment during a walk in the dark when Heisenberg asks Bohr whether a physicist has a moral right to work on a practical application of fission. The further unfolding, which extends into a larger future of different world/s, depends on whether Bohr engages in a further conversation with him, or storms back to the house in anger.[31]

While Bohr and Heisenberg would appear to be opposites, each was in varying respects implicated in the other (*mutual inclusion)*, which means that their relationship and the context of their interaction continuously changes. The relationship is in one moment characterised by outrage, and moments later, intellectual synergy or an unusual sympathy. It continuously vascillates against the backdrop of a changing emotional landscape, where a movement in one produces a change in the other, as the emotions rise and fall (*interaction and resonance).* In other respects, the one provides what the other lacks, for instance, if Heisenberg is continuously calculating sums and figures, Bohr is the philosopher who raises the larger questions. They are *complementary.* In the final thought experiment, Bohr recognizes that Heisenberg failed to do the sums, when he would have been expected to do

[30] The forms include 1) contradiction and opposition; 2) interdependence; 3) mutual inclusion; 4) interaction or resonance; 5) complementarity or mutual support; and 6) change and transformation.

[31] Wang (2012: 9) draws on a classic text from the *Zonghen* (School of Strategy) during the Warring States period (451-221 B.C.) to illustrate interdependence, using an opening and closing door metaphor, stating that a door needs to open and close as two interrelated modes as it would otherwise be a wall or an open space. It is the opening and closing, or the change and movement that transforms things.

so, and thereby resituates the context of Heisenberg's visit and with it the future potentials that could arise from it. If Heisenberg failed to do the sums, it was because he hadn't thought to do so – and thus at that point in time probably did not have the necessary calculations to construct an atomic weapon. However, in pointing out this absence, Bohr risked planting the idea in Heisenberg's head, thereby creating the potential for him to calculate the formula necessary to develop a German bomb. The relationship between them, like that of wave and particle, is one of *change and transformation*, that is fundamentally dynamic, in continuous fluctuation and indeterminate.

Through the play's representation of the relationship between Bohr and Heisenberg, Frayn shows the relevance of complementarity in the context of a human, social, cultural and ultimately political relationship. Given the involvement of both in the development of quantum physics and atomic weapons, this relevance extends beyond them as individuals to the larger world, including the past and future. Their intra-action demonstrates the dependence of observation on one's position in social space, and a particular context in which the 'intentions' of either participant arise from the meaning attributed to that context by either and at any one point it time. It also reveals the difference that a small response or the utterance of just a few words could make to the further unfolding of events and thus the future shape of the world. Finally, the fluctuation of identity and difference, both in relation to Bohr or Heisenberg as individuals, or in their intra-action with each other, suggests the absence of any intrinsic nature that belongs to either in separation. They are entangled, or constituted in relation to one another, against a dynamic backdrop of contextual change. Their identities were neither fixed nor do they exist in an absolute position or hierarchy in relation to each other. While Heisenberg was originally the student to his mentor Bohr, the latter, as the half-Jew in Nazi-occupied Denmark became the potential subordinate to Heisenberg. Upon Bohr's eventual escape and involvement in the Manhattan project, and with the eventual defeat of Germany, the hierarchy shifts once again, along with the moral culpability attached to the use of atomic weapons. As one moved up, the other moved down. The two characters are entangled and in an indeterminate and continuously fluctuating relationship of complementarity, from which the differences between them emerge.

Emptiness and Dependent Origination

Yinyang highlights the complementarity of oppositions, while Buddhism provides insight into the ethical implications of a relational ontology for the negotiation of an ethics of

complementarity. The two have co-existed in the Chinese context since Buddhism was introduced from India along the Silk Road (see Frankopan 2015), which also suggests the complementarity of two the traditions. Buddhism is consistent with many cutting-edge assumptions in the philosophy of science (Garfield 2001: 507). Both Buddhism and Western science seek to know reality objectively, and are committed to inquiry and investigation, which involves probing beneath surface appearances with the use of special techniques of investigation (Harrington in Davidson and Harrington 2002: 19). Both traditions have also sought to address human suffering. A major difference regards the focus of science on the manipulation of the material world as opposed to the Buddhist emphasis on transforming the world. The assumption of the latter that the transformation of human suffering is possible goes hand in hand with an ethical imperative to bring about change. Change begins with self-transformation, the liberation of practitioners and an underlying assumption that all life within the universe is connected.

The quantum notion of entanglement by which phenomena constitute, and are constituted out of a relational ontology has a parallel in the Buddhist concepts of 'emptiness' and 'dependent origination.' The physicist Laurent Nottale (1998: 111) noted that:

> Some philosophers have..concluded that nothing including matter and mind, intrinsically exists. If we trace the history of this line of thought back, it seems to have been first formulated in Oriental thought by Siddharta Gautama [Buddha] over two thousand five hundred years ago. There is no nihilism in this concept, no denial of reality or existence, but rather a profound view of the very nature of existence. If things do not exist in absolute terms, but do nevertheless exist, then their nature must be sought in the relationships that bring them together. Only these relationships between objects exist and not the objects themselves. Objects are relationships…Will the physics of the future succeed in making an equation of what is now a purely philosophical vision?

The second century philosopher Nagarjuna (see e.g. Garfield 1995), founder of the Madhyamaka (Middle Way) School of Mahayana Buddhism, set up a dialectic, based on his theory of two truths, one of which is absolute and the other provisional. The absolute truth is that all things are empty and the provisional truth is that they exist, even though this existence

is impermanent and fleeting (Soeng 2004: 32).[32] Emptiness, which is the centrepiece, is a reference to the absence of intrinsic nature, not in the sense of nihilism, as is often assumed, but because everything is fundamentally relational (Priest 2009: 467). Things arise in dependence on other things and thus have no being of their own, or are 'empty' of own being. Nagarjuna's concept of 'dependent origination' highlights the extent to which all things and events arise in dependence on a complex web of interrelated causes and conditions, and that nothing exists by itself. There can be no whole without parts and without a whole there can be no concept of parts and all phenomena lack an independent identity (Dalai Lama 2000: 2004: 37-38). Because any thing is a compound entity, it has no core independent of the conditioning factors that are responsible for its creation. It is instead made up of a web of relationships that are dynamic in character (Soeng 2004: 192).

A simple material object, such as a pot, for instance, cannot be said to exist in and of it itself; it is a product of the intention of the potter, the circumstances that gave rise the intention, the subsequent action, the combination of clay and water, the coming together of molecules, the atoms and other minute particles that form these constituents, which are themselves dependent on numerous other factors (Dalai Lama 2000: 37).[33] Likewise, the identity of any one person, such as Bohr or Heisenberg, is defined by having been born of certain parents at a certain time, having a certain DNA, going to a certain school, with certain friends, and being affected by the things she did and saw (Priest 2009: 469).[34]According to Nagarjuna, 'emptiness' is a condition of interdependence, that is, that all things are empty

[32] The two realities are, ultimately, two aspects of the same, despite the fact that they are apprehended by different epistemic instruments, appropriate to each (Garfield 2010: 347). Philosophers in the Madhyamaka tradition recognized a distinction between a non-conceptual ultimate truth and a level of truth that lies with concepts and words.

[33] Ricard and Thuan (2001: 90) draw on a further 'tent' example in Buddhist analysis. If a tent is dismantled by separating its cloth, poles and roles, then the tent no longer exists, although the parts do. If the cloth is torn up, there are threads that can be reduced to fibres and further to molecules, and then atoms and finally to particles whose mass is equivalent to intangible energy. The change from tent to particles, or the other way around, from particles to tent, contains, they argue, no discontinuity that would justify the distinction between microcosm and macrocosm.

[34] One further dimension that arises from Frayn's play, is the cultural origination of Bohr and Heisenberg, which in the case the latter, gave rise to conflicting emotions regarding his 'homeland' and moral questions regarding his role as a physicist in Hitler's regime.

means that all things are mutually dependent (Barnhart 1994: 649). In this respect, dependent origination and emptiness are ultimately two words for the same thing (Poromaa 2009: 135). There is no absolute, non-relational, independent 'presence' that is unconditional (Barnhart 1994: 652). Things are both separate and entangled, real and unreal.

The problem of human suffering and the avoidance of suffering is at the heart of Buddhism, which is a further extension of this dialectic. The Buddha understood the cause of suffering to be the self-centredness of the ego, as well as its disconnection from the dynamic, contingent and fluid processes of life. The assumption of the egoistic self leads to self-grasping, or seeking happiness in attachment to things, people, a career, etc., which often leads to action on behalf of the egoistic self and at the expense of others. Paradoxically, it is the aversion to suffering that attracts suffering (Rinpoche 2002: 194). This tendency to egoism does not represent human nature, as suggested by mainstream science.[35] Instead, the relational ontology of dependent origination suggests that compassion is basic to human nature. Ignorance may keep us from recognizing this nature but the objective is to peel away the layers of ignorance in order to uncover the compassion that constitutes our core (Davidson in Davidson and Harrington 2002: 85). Freedom from suffering requires 'letting go' of this egoistic self, and embracing the emptiness (Poromaa 2009: 30). The egoistic self that clings, and refuses to accept its impermanence is the problem. Letting go of the egoistic self arises in part from an awareness of entanglement with others, a position from which one's own interests cannot be separated from the interests of others. As the Dalai Lama (2000, 48) notes: 'Due to the fundamental interconnectedness which lies at the heart of reality, your interest is also my interest. From this, it becomes clear that "my" interest and "your" interest are intimately connected. In a deep sense they converge.'

If 'we' are not entirely separable, but deeply entangled in a relationality with others, a rethinking of what is possible, desirable and ethical is needed, not least because harm to the other is then ultimately harm to the self as well. The emphasis on compassion does not pave a

[35] Within the context of a dialogue between Buddhists and Western scientists, the Dalai Lama raised a question about whether the assumptions of mainstream science and, in particular, of human nature as aggressive, selfish and heartless, are the final word. As he (in Davidson and Harrington 2002: 82) states: 'Maybe it's too early to say. Has science stopped evolving? [Western science] is a particular viewpoint based on a certain stage of history and evolution in human knowledge...In particular, I feel that science has not yet paid enough attention to the internal world [of consciousness] compared to the external. So maybe there is still a lot of ground to cover.'

path to a utopian future, but it does displace selfishness from the core of human nature, making it instead a conscious choice of conscious human beings (Ponomaa 2009: 85). The choice arises from a continuous dialectic between awareness of the 'self' and consciousness of entanglement with others The point has relevance in relation to Wendt's discussion of quantum coherence, in which the boundary that distinguishes the 'I' inside from its environment is also a necessary condition for life. A relational ontology of compassion, when taken to its extreme, would eliminate this boundary entirely and thus life along with it.[36] While compassion arises from a consciousness of entanglement with others, it necessarily preserves the boundary between self and other. The separation is not, however, complete and relies on some kind of balance, as well a continuous dialectic fluctuation between self and other, or the egoism of 'self' and consciousness of entanglement with others.

The ethical choice then rests in small acts rather than grand gestures. Within Barad's argument, the dynamic intra-action of matter requires attention to the fine detail and the difference each 'cut' makes. For Wendt, each use of language within a context instantiates a reality. Buddhism highlights the consequences of the smallest act, in thought, spoken word, or deed, for redefining a complex reality. The concept of *karma* (literally "action") suggests that whatever we "think, say, do, desire and omit" creates new circumstances and causes some other event (Dalai Lama 2000: 141). The point is thus not that we can simply through our acts change the world in one fell swoop, but rather that each small act contributes to a change of context, a change in the relationship of parts to the whole, and in the framework of intra-action with others. Every act, every karma, is also the consequence of some previous karma and thus every event is both a cause and an effect, which means that whatever you do will come back to you (Easwaren 1985: 17).

[36] Take, for example, an act of political self-sacrifice, which ends in the death of the agent, such as Thich Quang Duc's self-immolation by fire in 1963, which was framed as an action of compassion for the Vietnamese people. The act destroyed the body, the home of the egoistic 'I'. While the same would be true of any suicide, the self-immolation did so in the most painful way possible, thereby communicating that far from the act of a desperate individual on behalf of the self, this was an act on behalf a people and life giving rather than destroying. If this kind of compassionate performance were to become the political norm, it would constitute a threat to life, and indeed Buddhism condemns suicide, while allowing self-immolation under certain conditions with right intent. See (Fierke 2012, 2017) for a more indepth discussion of this case.

What is crucial is the cumulative effect of any one potential over time. To take an example, when one person hits another, out of anger, the effects will be experienced physically and emotionally by the other, but also, having indulged his hot temper, the consciousness of the agent may also be effected, making him an angrier person, who potentially becomes more belligerent over the years. According to the Buddhas, as Easwaren (1985: 18) notes, 'we are not punished for our anger but by our anger.' Anger becomes its own consequences. A similar karma may inflict societies at war. Here we might consider the conclusions of the Chilcot Inquiry (2016) regarding the multiplication and magnification of problems that have unfolded from the decision to invade Iraq in 2003. Actions can be compared to a very tiny seed that potentially grows into a huge and deeply rooted tree, which may be very difficult to dislodge. In Buddhism, intention is crucial to ethical choice, which is an emphasis that is closer to Wendt than Barad. Good intention and compassionate choice require non-attachment and benevolence, and actions that do not harm others. Much as the potter moulds clay into a finished shape, particular patterns of behaviour lead to particular results that reverberate across time and space, and in this respect individuals and societies create themselves through their moral choices while also creating their futures. Rather than a Cartesian dualism, which fixes a particular relationship in place, both Daoism and Buddhism assume a dynamic dialectic of complementary oppositions from which choice and action arise.

Conclusions

Beginning with Bohr's concept of complementarity, this article has explored several oppositions, from that of Bohr's emphasis on epistemology to Barad and Wendt on ontology, from Barad's focus on material entanglement to Wendt's on entanglement in language, from Bohr's identification of a 'parallel' between quantum physics and Eastern wisdom, to the ethical implications of Daoist *yinyang* and the relational ontology of Buddhism. The structure of the paper itself reveals a seamless web of oppositions and complementarity that extends in several directions, from the natural and social sciences to the relationship between West and East. The parallel reveals some of the implications of complementarity at the macroscopic

level, and not least that of human, social and political intra-actions within a holographic global space.[37]

Eastern wisdom does not provide an anecdote to Western problems or point towards a mystical Shangrai Lai; it does, however, highlight the indeterminacy and continuously fluctuating relationships of complementarity, which are both contextually specific and non-local, arising from the shifting boundaries between self and other. Wendt's argument about the importance of quantum coherence may lead to the dual conclusion that boundaries are crucial to the protection of life at all levels, as expressed for instance, in arguments that nuclear deterrence is necessary to prevent nuclear war; but that compassion and awareness of our entanglement with as others is no less crucial, even while realizing that either can, when taken to the extreme, be dangerous to 'life.' Barad's argument, while eschewing any notion of consciousness, highlights the importance of ethical 'responsibility' in relation to the commitments 'we' are willing to take on, including commitments to 'ourselves' and who 'we' may become (2007: 382). Barad's 'thinking difference differently,' when placed more explicitly in the context of Bohr's complementarity and parallel, challenges some of her assumptions, while also giving them more depth.

The framing of the two arguments against the backdrop of complementarity highlights the incompleteness of any attempt to capture reality, thereby presenting a challenge to rethink the nature of oppositions, seeing them less in terms of fixed hierarchies, than multiple and shifting potentials, from which the smallest choice has consequences that ripple through time and space. Both Barad and Wendt challenge the hierarchy between the natural and the social sciences, opening a space for greater engagement between them, just as the dialogue between Western scientists and Buddhists contributes to new insights that begin to dissolve the assumed superiority of Western science vis a vis an historically orientalised East. Quantum physics re-positions humans in relation to a larger world and universe, and in so doing raises questions about ethical assumptions that justify control or dominion over the environment, as we too are a part of nature and 'life' that goes all the way down (Mitchell 2015).

From a quantum perspective, the elevation of the egoistic rational actor to a positive value plays a constitutive role. The ontology of separation taken to its extreme, and divorced

[37] In a hologram, information that generates the whole is encoded in each pixel, such that the whole is present in each (Wendt 2015: 271). In a holographic universe, wholes are constituted from parts, which are themselves wholes which are constituted of parts, and so on and so on.

from context, is thus less a description of human nature than a normative statement about how we should act, that is, first and foremost with our own preferences in mind with little thought for the impact on others. For instance, when President Trump says 'America first' or Brexit voters say 'Britain first,' it means that their actions will be determined first and foremost by what is good for these political entities, ignoring their entanglement with the larger world. Both votes arose from a small act by millions of people of ticking a ballot. The aftermath saw a dramatic increase in small acts of hate toward those defined as different, which in the U.S. context was directly correlated in the press with the enabling influence of Trump's words and his election (see, e.g. Yan et.al. 2016, Timmons 2016). A further expression of the debilitating impact of an ethics of individual utility maximization, when taken to its extreme, is the accumulation of global wealth in the hands of a small number of people, and the collapse of social responsibility both within and more globally without. The imbalance arising from the latter, has reinforced the domestic politics of the former, which is ultimately threatening to the cohesion of Western societies. The emphasis of quantum coherence on survival of the 'I', which is equally dependent on entanglement with an external environment, suggests the importance of balance. Bringing the Buddhist emphasis on compassion to the discussion provides a bridge between Wendt's discussion of quantum coherence, and a notion of ethical responsibility in Barad, by which we are both separate from and connected with others. This suggests the importance of mutual care in our common constitution, at the level of human, social and political intra-actions and in the relation to non-human life and the environment, a theme that resonates with and provides a physical basis for what feminists have referred to as a 'global ethic of care' (see, e.g. Robinson 2006, 2011; Sjoberg 2006; Fierke 2014)

Finally, both Barad and Wendt observe the dynamics of quantum physics from a different angle, and provide an interpretation articulated in language, which raises a question of whether Bohr was perhaps right that the problem is ultimately one of epistemology and language. Meaning is always attributed to the world from different positions in social, academic or global space and there is no privileged vantage point from which to articulate what is 'real,' other than the potentials that 'we' enact. To prioritize either matter or consciousness over the other would seem, from my position as lay observer, to defy the basic principle of quantum physics regarding the intra-action and inseparability of particle and wave, the difficulty of observing both at the same time, and the importance of the apparatus for any measurement of this relationship. The quantum argument about measurement presents a fundamental challenge to the dominant understanding of what it means to measure social

phenomena. The attempt to fix meaning and compare our words with the world assumes that the objects of measurement possess an intrinsic identity, locally positioned in time and space. If the act of measurement instead changes the object of observation, or if language use is itself a form of measurement that transforms and constitutes reality, this has dramatic implications for the position of the analyst. Measurement then must be understood to play a role in constituting the world it seeks to explain.

Complementarity and *yinyang* provide a different approach to difference. Both highlight indeterminacy and the continuous fluctuation of opposites that is the dynamic force of life. A more fluid notion of oppositions that accepts the dynamic movement, and multiplicity, when paired with an awareness of entanglement, suggests the need for alternative models of global engagement, more akin to a conversation than a monologue of threat and force. For instance, in place of the assumed timeless superiority of a small portion of the global population and orientalization of the rest, the door is opened to a greater understanding of the complementarity of East and West or North and South, but one in which these are not fixed positions in a global hierarchy.[38] A more fluid and global conversation suggests the importance of greater attentiveness to our participation in constituting 'reality,' in which the differences are neither absolute nor fixed, but open to contingency and change. Global entanglement alerts us to the extent to which, not only the world, but difference within it, is of our making.

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[38] A view that is facilitated by a broader view of history, which does not begin in 1648 but recognizes the extent to which, as Hobson (2004) has argued, the development of Western Europe was dependent on knowledge and technology imported from the East, or places this short period of history within a much longer time frame, going back, for instance to the proto-globalization of the ancient Silk Roads (see, for instance, Frankopan 2015).

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Image A

Harrison 2000-2002

Table B

Barad	**Wendt**
Matter	Consciousness
mattering difference	wave function collapse
intra-action	mutual constitution
agential realism	will, intention
measurement apparatus	language use as measurement