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Introduction

1. The Goal

Divine action in the context of scientific knowledge is a proposal to establish a link between theology and science—not in the classic sense of a natural theology, which would be an argument for the existence or characteristics of God from nature—but as a *theology of nature*, “a way in which the God in whom we believe on other grounds might be conceived to act in ways consistent with scientific theories.”¹

The aim of this text is to justify belief in a God who can act in the world considering the scientific framework of quantum mechanics. Why quantum mechanics? It is the current theory used by scientists to describe the nature of the matter out of which our universe is composed.² A theory of divine action compatible with contemporary physics is a fundamental requirement for a credible consideration of how God could act in the framework of our contemporary worldview.³ Theories that account for God’s action in the world through quantum indeterminacy have been called theories of *quantum divine action* (hereafter QDA).

The concept of divine action is especially relevant for theology. In *Beyond Liberalism and Fundamentalism* Nancey Murphy has shown that both liberal and conservative theologians have struggled and continue to struggle with the commonly accepted conception of the world as a mechanism describable by scientific laws.⁴ Liberal theologians have accepted the mechanical conception and have developed a view of religious language as expressing feelings and moral convictions. They see religious language as describing the perception of the world in terms of religious vocabulary and theological categories. God is then seen to act through the natural processes and not to violate them. Conservative theologians, on the other hand, have reacted by asserting that religious

¹ Ian Barbour, *When Science Meets Religion: Enemies, Strangers, or Partners?* (New York: HarperCollins, 2000), 88.

² Henry Stapp, *The Mindful Universe* [draft] [online] (Berkeley, California: Lawrence Berkeley National Laboratory, accessed 16 July 2003), p. 2–6, <<http://www-physics.lbl.gov/~stapp/MindfulU.pdf>> discusses how our understanding of reality changed from Newtonian physics to today’s quantum theory.

³ The approach implies that religious language is reflecting an external reality. In certain traditions of theology that idea may be disputed. See Chapter One.

⁴ Nancey Murphy, *Beyond Liberalism & Fundamentalism: How Modern and Postmodern Philosophy Set the Theological Agenda* (Valley Forge, Pennsylvania: Trinity Press, 1996), 62.

language is factual: God can *intervene* and bypass (and therefore violate) the laws that govern the universe.

An understanding of special divine action that is in harmony with scientific knowledge could overcome the problems arising from these two theological approaches. Conservative theologians could affirm special divine acts in the absence of a violation of the laws of nature, whereas liberal theologians could agree that God can perform special divine acts through the natural processes. Special divine action would be possible within the context of our scientific knowledge, and therefore would be *noninterventionistic*.

Murphy saw the need to identify a “causal joint”—a point at which the natural order is affected by God—in order to allow such a noninterventionist understanding. Murphy has evaluated the proposal of recognizing quantum indeterminacy as the causal joint as “promising but as yet inconclusive.”⁵ In this text I attempt to go beyond Murphy to show that quantum mechanics allows for an account of divine action and the identification of a causal joint.

It is widely recognized that the belief systems of historical religious communities are of a contextual nature, depending on the sociological and cultural environment in which they exist.⁶ The contextual environment of the Enlightenment, with its mechanistic and deterministic conception of the world, is fading away and is being replaced with a more open conception. However, contemporary theology is to a significant degree still characterized by the concepts and approaches stemming from the Enlightenment and therefore not in harmony with contemporary science.⁷ The justification of a theory of *divine action* will consequently also involve a reappraisal of philosophical and theological concepts in light of the implications of scientific evidence. A theology of nature implies that “theological doctrines must be consistent with the

⁵ Murphy, *Beyond Liberalism*, 149. See also Nancey Murphy, “Divine Action in the Natural Order” in Robert John Russell, Nancey Murphy and Arthur R. Peacocke eds. *Chaos and Complexity: Scientific Perspectives on Divine Action* (Vatican City State: Vatican Observatory; Berkeley, California: Center for Theology and the Natural Sciences, 1995), 325–358.

⁶ For example, James A. Sanders, *Canon and Community: A Guide to Canonical Criticism* (Philadelphia: Fortress Press, 1984) describes how the text of the Old Testament and its interpretation developed in response to the historical and cultural situations of the religious communities it served.

⁷ Murphy, *Beyond Liberalism*, 152–153; Horst W. Beck, *Biblische Universalität und Wissenschaft: Interdisziplinäre Theologie im Horizont Trinitarischer Schöpfungslehre* (Weilheim-Bierbrunn, Germany: Gustav-Siewert-Akademie, 1994), 363, mentions Carl Friedrich von Weizsäcker expressing surprise at theology ignoring the fundamental changes in the conception of nature in science.

scientific evidence, even if they are not derivable from current scientific theories.”⁸

2. *The Problem in Quantum Divine Action*

The classic mechanical worldview implies a causally closed universe. That worldview has been particularly challenged by the development of quantum mechanics in the twentieth century.⁹ For example, while working on his uncertainty principle, one of the fundamental building blocks of quantum mechanics, Werner Heisenberg concluded that it was necessary to question the classic concept of causality.¹⁰

Naturally, such a radical departure from established concepts evoked a response from the scientific community. In particular, Albert Einstein suggested that uncertainty or indeterminism was a sign of the incompleteness of quantum theory. He argued that quantum theory had not been fully developed and was unable to specify all quantities involved in measurement. Einstein developed a series of thought experiments designed to challenge quantum theory. Niels Bohr successfully responded to each scenario, leading to a more refined understanding of quantum mechanics.¹¹

Questions regarding causality and the very nature of matter resulted in physicists beginning to speculate about metaphysics. Bohr and Heisenberg were later accused of having brought their metaphysical preconceptions (in favor of indeterminism) into quantum theory.¹²

⁸ Ian Barbour, *Nature, Human Nature and God* (Minneapolis: Fortress Press, 2002), 3.

⁹ Robert Russell, Introduction to Robert John Russell, Philip Clayton, Kirk Wegter-McNelly and John Polkinghorne, eds., *Quantum Mechanics: Scientific Perspectives on Divine Action* (Vatican City State: Vatican Observatory; Berkeley, California: Center for Theology and the Natural Sciences, 2001), vi.

¹⁰ See Werner Heisenberg, “The Development of Philosophical Ideas since Descartes in Comparison with the New Situation in Quantum Theory” in *Physics and Philosophy: The Revolution in Modern Science* (New York: Harper & Row, 1958; Reprint, New York: Prometheus, 1999), 76–92.

¹¹ James T. Cushing, *Philosophical Concepts in Physics: The Historical Relation between Philosophy and Scientific Theories* (Cambridge: Cambridge University Press, 1998), 307–315.

¹² Peter Hodgson, “God’s Action in the World: The Relevance of Quantum Mechanics” in *Zygon* 35, no. 3 (September 2000): 506. See also James T. Cushing, *Quantum Mechanics: Historical Contingency and the Copenhagen Hegemony* (Chicago: University of Chicago Press, 1994), xi–xiv, 28–30, for an argument that a possible deterministic interpretation by Louis de Broglie was not accepted due to historical contingencies and the commitments of the people involved in the formation of quantum theory. See also Philip R. Wallace in *Paradox Lost: Images of the Quantum* (New York: Springer Verlag, 1996) who suggested a view of Bohr and Heisenberg that is at variance with our understanding of these authors as discussed in Chapter Two. For example Wallace

Footnotes continued on next page.

Besides making important contributions to the development of quantum theory by advancing its mathematical structures John von Neumann also began to speculate about the relationship between the consciousness of the observer and measurement.¹³ Einstein's famous response "God does not play dice" to Bohr's claim of quantum uncertainty reveals certain metaphysical inclinations in Einstein's thinking about quantum mechanics.¹⁴

Heisenberg's and Bohr's concepts of indeterminacy and complementarity survived the challenges by Einstein, and quantum indeterminacy was accepted by the majority of physicists as a fundamental characteristic of matter. Today, the understanding of quantum mechanics as predicting probabilities—and therefore as indeterministic—is the standard, or *orthodox*, interpretation of quantum theory.¹⁵

In 1952, after quantum theory had been well established, David Bohm developed an alternate interpretation of quantum mechanics¹⁶ attributing quantum indeterminacy to a guiding wave that is dependent on nonlocal, instantaneous influences of the environment.¹⁷ Bohm's approach was rejected on grounds that the symmetry of position and momentum was broken in the same way as in Louis de Broglie's earlier proposal.¹⁸

claimed that Heisenberg denied the objective nature of reality (page 47–49). A more technical work by Wallace is *Physics: Imagination and Reality* (Singapore: World Scientific, 1991) which clarified his views (page 392–393). Wallace claimed that it was Heisenberg position that the observer *creates* reality.

See also Jon Blumenfeld, "Paradox No More" in *The New England Journal of Skepticism* 3, no. 1 (Winter 2000, accessed 18 August 2003),

<<http://www.theness.com/articles/paradoxnomore-nejs0301.html>>.

¹³ John von Neumann, *Mathematische Grundlagen der Quantenmechanik*, (Berlin: Springer Verlag, 1932; Reprint, Berlin: Springer Verlag, 1996), 222–224. The book is available in English as John von Neumann, *Mathematical Foundations of Quantum Mechanics*, trans. Robert T. Beyer (Princeton, New Jersey: Princeton University Press, 1955).

¹⁴ Cushing, *Philosophical Concepts*, 307, traces the source of the famous quote by Einstein. Einstein's German expression was sometimes "Die Natur würfelt nicht," which does not include a reference to God. See also Beck, 361.

¹⁵ Cushing, *Philosophical Concepts*, 290.

¹⁶ David Bohm, "A Suggested Interpretation of the Quantum Theory in Terms of 'Hidden' Variables, I and II," *Physical Review* 84 (1952): 166–193. These articles can also be found in John Archibald Wheeler and Wojciech Hubert Zurek, eds., *Quantum Theory and Measurement* (Princeton, New Jersey: Princeton University Press, 1983).

¹⁷ David Bohm, *Causality and Chance in Modern Physics* (New Jersey: D. van Nostrand, 1957).

¹⁸ Wayne C. Myrvold, "On some early objections to Bohm's theory" in *International Studies in Philosophy of Science* (March 2003) [Page numbers follow online version

Footnotes continued on next page.

However, a minority in the physics community supported Bohm's ideas finding the preservation of determinism an attractive implication of Bohm's work.¹⁹ Like the other founders of quantum theory, Bohm also engaged in metaphysical speculation, emphasizing the interconnectedness and holism of the universe and of quantum systems. In his work *Science, Order and Creativity*, Bohm's search for hidden variables, sub-quantum regularities and realities in quantum mechanics carried over into generalized concepts of order (implicate, explicate, generative, etc.) that he then related to spirituality, human society and the evolution of the world.²⁰ The strongest scientific argument for his view is found in *The Undivided Universe: An Ontological Interpretation of Quantum Theory*. In this book Bohm attempted to go beyond the instrumentalism of the Copenhagen interpretation and proposed a view of reality emerging from his interpretation of quantum theory. Unfortunately, Bohm died in 1992 while putting the last touches on *The Undivided Universe*.²¹

The contemporary discussion about the usefulness of indeterminacy for divine action originated in the writings of Karl Heim and William Pollard.²² In Pollard's book *Chance and Providence: God's Action in a World Governed by Scientific Law*, he reasoned that the world is characterized by chance. He concluded that quantum mechanics demonstrates that the fundamental character of matter is probability-based and therefore *indeterminate*.²³ Pollard understood the causal

available at <<http://publish.uwo.ca/~wmyrvold/BohmFinalv2.doc>>, accessed 16 July 2003]; Cushing, *Philosophical Concepts*, 285–286, 331–353.

¹⁹ David Bohm, *Wholeness and the Implicate Order* (London: Routledge & Kegan Paul, 1981), 68.

²⁰ David Bohm and F. David Peat, *Science, Order and Creativity*, 2nd ed. (London: Routledge, 2000). The second edition was published posthumously and contains additional material by Bohm edited by Peat. A recent development of Bohm's ideas can be found in F. David Peat, *From Certainty to Uncertainty: The Story of Science and Ideas in the Twenty-First Century* (Washington, District of Columbia: Joseph Henry Press, 2002), 61–69.

²¹ Basil J. Hiley, Introduction to David Bohm and Basil J. Hiley, *The Undivided Universe: An Ontological Interpretation of Quantum Theory* (London: Routledge, 1993).

²² For a historical overview see Robert Russell, "Special Providence and Genetic Mutation" in Robert John Russell, William R. Stoeger and Francisco J. Ayala, eds., *Evolutionary and Molecular Biology: Scientific Perspectives on Divine Action* (Vatican City State: Vatican Observatory; Berkeley, California: Center for Theology and the Natural Sciences, 1998), 208–216, is an existing account of the history of QDA by an advocate of QDA.

²³ William G. Pollard, *Chance and Providence: God's Action in a World Governed by Scientific Law* (New York: Charles Scribner's Sons, 1958, 1958; London: Faber and Faber, 1958), 104–105.

structure of the world as *open* and providing “innumerable alternatives” from which God can select a desired outcome.²⁴ Pollard’s key thesis was that divine action is possible through God’s providential action in the probability-based processes of nature. Since this implies that God’s action is not in the form of a natural force, he suggested that a proposal for divine action cannot be pursued as a natural theology. Pollard reasoned that one cannot argue *from* nature to theology, and that belief in divine action is based on theological grounds, but is affirmed in a scientific context.²⁵

Since 1987, the Vatican Observatory and the Center for Theology and the Natural Sciences (VO/CTNS)²⁶ in Berkeley, California, have been sponsoring a series of conferences and books on the subject of divine action, all with the subtitle *Scientific Perspectives on Divine Action*.²⁷ The guiding theme of those volumes, the attempt to establish a two-way interaction between the scientific and theological aspects of the subject without giving priority to either, has led to the accumulation of various perspectives on divine action from contributors in science, philosophy and theology.²⁸

The main proponent of QDA in the VO/CTNS volumes was Robert Russell. Murphy provided important theological backing to Russell with her article “Divine Action in the Natural Order: Buridan’s Ass and Schrödinger’s Cat,”²⁹ linking concepts in theology to quantum indeterminacy and speculating about the integration of quantum mechanical concepts with theological traditions. Russell’s later articles continue to develop Murphy’s theological ideas further.³⁰

²⁴ Pollard, *Chance and Providence*, 114–115.

²⁵ *Ibid.*, 86–88.

²⁶ See <http://www.ctns.org>.

²⁷ The series Robert John Russell et al. eds., *Scientific Perspectives on Divine Action* (Vatican Observatory: Vatican City State; Center for Theology and the Natural Sciences: Berkeley, California, 1993–2001) contains the following titles:
Volume 1: Quantum Cosmology and the Laws of Nature (1993)
Volume 2: Chaos and Complexity (1995)
Volume 3: Neuroscience and the Person (1999)
Volume 4: Evolutionary and Molecular Biology (1998)
Volume 5: Quantum Mechanics (2001)

²⁸ A majority of the publications on quantum divine action either are in these volumes or are other publications by contributors to these volumes.

²⁹ Murphy, “Divine Action,” 325–358.

³⁰ Robert John Russell, “Quantum Physics in Philosophical and Theological Perspective” in Robert Russell, William R. Stoeger and George V. Coyne, eds., *Physics, Philosophy and Theology: A Common Quest for Understanding*, 2nd ed. (Vatican Observatory: Vatican City State; Center for Theology and the Natural Sciences: Berkeley, California, 1995), 343–374; *idem*, “Finite Creation without a Beginning: The Doctrine of Creation in Footnotes continued on next page.

According to Russell and Murphy a means for divine action can be found in *quantum indeterminacy*. Whereas Pollard suggested divine action as generally possible through the chance- and probability-based nature of the world evident in all of our scientific knowledge,³¹ Russell and Murphy specifically insisted that the primary means of divine action is through quantum indeterminacy. Another differentiation from Pollard's approach is Murphy's concept of "under-determination."³² Pollard saw God as simply determining the outcome of all chance events. However, as has been suggested by Murphy and Russell, if that is the case, then that which God has created does not have a degree of independence. God would be the cause of everything, and this leads to theological difficulties with the problem of evil: God would be directly involved in *causing* evil. The concept of *under-determination* implies that God has created matter with innate properties representing actual and potential means of activity. Murphy suggested that the innate properties, which would include the probabilities in quantum theory, factor into the determination of the outcome:³³

This principle of God's respecting the integrity of the entities he has created is an important one. ... I further suggest, on the strength of a similar analogy with the human realm, that we speak of all created entities as having "natural rights," which God respects in his governance. This is the sense in which his governance is cooperation, not domination.³⁴

Murphy here suggested that divine action is mediated by God's cooperation with the natural propensities of the matter that God has

Relation to Big Bang and Quantum Cosmology" in Russell, Murphy and Peacocke, *Chaos and Complexity*, 293–329; idem, "Special Providence and Genetic Mutation: A New Defense of Theistic Evolution" in Russell, Stoeger and Ayala, *Evolution and Biology*, 191–223; idem, "Divine Action and Quantum Mechanics: A Fresh Assessment" in Robert John Russell, Philip Clayton, Kirk Wegter-McNelly and John Polkinghorne, eds., *Quantum Mechanics: Scientific Perspectives on Divine Action* (Vatican Observatory: Vatican City State; Center for Theology and the Natural Sciences: Berkeley, California, 2001), 293–328.

³¹ William G. Pollard, "Creation Through Alternative Histories" in *Transcendence and Providence: Reflections of a Physicist and Priest* (Edinburgh: Scottish Academic Press, 1987), 179.

³² The first use of the term that I found to characterize Murphy's approach in "Divine Action" was in Robert Russell, "Special Providence and Genetic Mutation," 214.

³³ Nancy Murphy, "Divine Action," 340–341. The independence of creation and the kenotic aspects of God's activity are discussed in detail in Nancy Murphy and George F.R. Ellis, *On the Moral Nature of the Universe: Theology, Cosmology, and Ethics* (Minneapolis: Fortress Press, 1996).

³⁴ Murphy, "Divine Action," 342.

created. A God that determines all events, as proposed by Pollard, is another form of determinism and does not allow human freedom.³⁵

Russell's and Murphy's concept of QDA is that of God acting through the indeterminacies of the "smallest constituents."³⁶ A microscopic event that can be influenced by divine action is a quantum event.³⁷ Murphy pointed out that macroscopic events are composed of these "most basic constituents,"³⁸ and consequently "God's capacity to act at the macro-level must include the ability to act upon the most basic constituents."³⁹ Murphy envisioned the replacement of *one key element* of the Enlightenment view of a reductionist-atomist world: The atoms no longer behave in a deterministic fashion. The *atoms* are not to be understood here as the atoms of physics but as the smallest components of the model employed to conceptualize the world: the "most basic constituents." Quantum events are the smallest components at the base of larger-scale macroscopic events, and the QDA approach envisioned by Murphy has therefore similarities with a reductionistic and atomist scheme.⁴⁰ Murphy believes that regularities emerge from the indeterministic quantum events in the form of physical laws and other higher-level laws of nature.⁴¹

Nicholas Saunders has recently raised questions regarding QDA approaches such as the ones proposed by Murphy and Russell.⁴² Saunders's reasoning follows some of the earlier concerns of John Polkinghorne.⁴³ There are three major points presented by Polkinghorne and Saunders:

First, the assertion that quantum theory is intrinsically indeterministic is questioned, given the existence of a number of interpretations of quantum theory. In particular, Saunders pointed out that the causal interpretation by Bohm is consistent with a fully deterministic

³⁵ Robert Russell, "Divine Action and Quantum Mechanics," 315.

³⁶ Murphy, "Divine Action," 342.

³⁷ *Ibid.*, 343.

³⁸ *Ibid.*, 342.

³⁹ *Ibid.*

⁴⁰ Murphy, "Divine Action," 342–343. Higher-level regularities are an emergent property from the "most basic constituents." See Murphy, *Liberalism & Fundamentalism*, 65, for a characterization of reductionism and atomism.

⁴¹ Murphy, "Divine Action," 349. See Murphy and Ellis, 19–38, for a discussion of hierarchies and emergence that is less focused on quantum indeterminacy at the basis.

⁴² Nicholas Saunders, *Divine Action and Modern Science* (Cambridge: Cambridge University Press, 2002); Nicholas Saunders, "Does God Cheat at Dice? Divine Action and Quantum Possibilities" in *Zygon* 35, no. 3 (September 2000).

⁴³ John Polkinghorne, "The Metaphysics of Divine Action" in Russell, Murphy and Peacocke, *Chaos and Complexity*, 147–156.

interpretation of quantum mechanics.⁴⁴ It follows that a deterministic account of quantum mechanics does not allow for any QDA proposal since there is nothing for God to determine. God could then only act by *intervention*—by temporarily suspending the laws of nature—and therefore divine action could only be conceived of as *interventionistic*.⁴⁵

Second, Saunders and Polkinghorne pointed out that the evolution of the wave function characterizing quantum systems is deterministic. The standard mathematical formulation of quantum mechanics is the Schrödinger equation, an ordinary second order partial differential equation. The evolution over time of the solutions to the Schrödinger equation are mathematically well-behaved and unambiguous.⁴⁶ Indeterministic characteristics surface only when a *measurement* is performed.⁴⁷ If measurements are rare then God would only have a limited number of opportunities for divine action. Therefore, Saunders and Polkinghorne concluded that QDA proposals would only allow for sporadic and infrequent divine action even if quantum mechanics is assumed to have an indeterministic nature.⁴⁸

Third, Saunders viewed the potential indeterminacies resulting from measurements as minuscule.⁴⁹ In general they could not result in the large-scale macroscopic effects envisioned by QDA advocates. Saunders cited a humor column (“Daedalus”) by David Jones in the journal *Nature*. Jones claimed that it would take God about 100-million years to change the trajectory of an asteroid in a significant way, given the small effects of quantum indeterminacies.⁵⁰

Polkinghorne initially suggested the alternative use of chaos theory for use in divine action theories,⁵¹ but that approach has encountered difficulties regarding his notion of “active information” communicated through “zero energy differences.”⁵² Polkinghorne sees no proposal that

⁴⁴ Saunders, “Does God Cheat at Dice?,” 527.

⁴⁵ Saunders, “Does God Cheat at Dice?,” 521; Polkinghorne, “Metaphysics,” 153.

⁴⁶ John Polkinghorne, *Quantum Theory: A Very Short Introduction* (Oxford: Oxford University Press, 2002), 90–91.

⁴⁷ Saunders, “Does God Cheat at Dice?,” 525; Polkinghorne, “Metaphysics,” 152.

⁴⁸ Saunders, “Does God Cheat at Dice?,” 532; John Polkinghorne, “Physical Process, Quantum Events, and Divine Agency” in Russell, Clayton, Wegter-McNelly and Polkinghorne, *Quantum Mechanics*, 188–189.

⁴⁹ Saunders, “Does God Cheat at Dice?,” 522.

⁵⁰ Saunders, “Does God Cheat at Dice?,” 540; Saunders, *Divine Action*, 171–172; David E. H. Jones, *The Further Inventions of Daedalus: A Compendium of Plausible Schemes* (Oxford: Oxford University Press, 1999), 152–153.

⁵¹ Polkinghorne, “Metaphysics,” 152–154.

⁵² John Polkinghorne, “Physical Process, Quantum Events, and Divine Agency” in Russell, Clayton, Wegter-McNelly and Polkinghorne, 189, footnote 9, mentions Saunders Footnotes continued on next page.

would take concepts of divine action beyond a “crude starting point” and hopes that progress in the area of quantum chaology will provide opportunities for the further development of divine action concepts.⁵³

Russell has responded to Saunders and Polkinghorne in the following ways:

First, he pointed out that quantum mechanics should be interpreted in the sense of leading to an *ontological indeterminism*. He saw the *Copenhagen interpretation* providing such an interpretation.⁵⁴ Russell argued against alternatives such as Bohm’s deterministic formulation⁵⁵ and claimed that Bohm’s version of quantum theory does not result in a return to determinism because of the nonlocal aspects of the pilot-wave. He then compared Bohmian quantum mechanics and the Copenhagen interpretation,⁵⁶ suggesting that Bohm’s theory embodies quantum features known through the Copenhagen interpretation such as superposition, entanglement, etc.⁵⁷ Russell wanted to reevaluate the way Bohmian quantum mechanics is understood in the discussion of divine action—and, in particular, the nature of determinism in Bohm’s formulation.⁵⁸

Second, Russell defined a *quantum event* in order to reply to the objection that there are not a large number of *measurement events* that would allow God to act:

The wavefunction ψ , which had evolved deterministically in time under the influence of the classical potential V and according to the Schrödinger equation, changes discontinuously from a superposition of states to a specific state. This is also a convenient place to offer a more precise definition of the term ‘quantum event’ than one customarily finds in the literature. I propose that we restrict our usage of the term to what we are calling “measurements,” that is, those interactions that are irreversible regardless of whether they are micro-macro, micro-meso, or micro-micro interactions.⁵⁹

Polkinghorne and others also saw the possibility of extending the meaning of “measurement” beyond the association with a laboratory

as providing the key argument that led Polkinghorne to conclude that the use of classic chaos theory is problematic.

⁵³ Ibid., 190.

⁵⁴ Russell, “Divine Action,” 293.

⁵⁵ Ibid., 304.

⁵⁶ See Russell, “Divine Action,” 325–328.

⁵⁷ Appendix to Russell, “Divine Action,” 324–328.

⁵⁸ Ibid., 327.

⁵⁹ Ibid., 307. However, Russell never cites any literature in physics that would establish what a “quantum event” is.

situation. Polkinghorne reasoned that measurement is what occurs during interactions between the micro- and macrolevel. Measurement is an “irreversible macroscopic registration of a property.”⁶⁰ Russell likewise reasoned that measurements are simply *irreversible* interactions. Then he suggested some possibilities of irreversible interactions in quantum mechanics. Irreversible interactions could be envisioned to occur on the microlevel or between the microlevel and other levels. Russell described an additional “meso” level for interaction with “sub-microscopic objects with enough degrees of freedom to make the interaction irreversible (at least in practice).”⁶¹ Russell argued that a large number of opportunities exist for divine action.⁶²

Third, in response to the claim that quantum indeterminacies could not have large macroscopic effects, Russell mentioned known macroscopic quantum phenomena like superfluidity and superconductivity. He also pointed out examples of single microscopic events resulting in a macroscopic effect. For instance, the evolution of life on earth might progress due to genetic mutations caused by quantum effects.⁶³

The last response by Russell to Saunders’s and Polkinghorne’s questioning of QDA is the strongest. We have evidence of quantum effects at the macrolevel, and consequently quantum behavior can be seen as affecting macroevents.

Russell’s first point, regarding interpretative implications of quantum mechanics, comes down to a metaphysical choice, since both Bohmian quantum mechanics and the Copenhagen interpretation are identical in their predictions for experiments.⁶⁴ Russell’s evaluation that the notion of determinism as seen to be implied by Bohmian quantum mechanics in the contemporary discussion needs to be reevaluated is certainly correct because of Bohm’s own assessment of his causal interpretation that “although the interpretation is termed *causal*, this should not be taken as implying a form of complete determinism.”⁶⁵ Bohm’s theory is

⁶⁰ Polkinghorne, “Physical Process,” 186.

⁶¹ Russell, “Divine Action,” 306.

⁶² *Ibid.*, 310.

⁶³ *Ibid.*, 299.

⁶⁴ James Cushing, “Determinism versus Indeterminacy in Quantum Mechanics: A ‘Free’ Choice” in Russell, Clayton, Wegter-McNelly and Polkinghorne, *Quantum Mechanics*, 103.

⁶⁵ Bohm and Peat, 88. A similar statement is made on page 97 and in Bohm and Hiley, 3. See also David Bohm, “Reasons for the Inadequacy of Laplacian Determinism” in *Causality & Chance*, 158–160, and Philip D. Clayton, *God and Contemporary Science* (Grand Rapids, Michigan: Eerdmans, 1997), 145–147, interpreting Bohm.

inconsistent in some ways, as will be discussed in Chapter Four. However, the holism and the nonlocality of Bohm's quantum mechanics hint at phenomena difficult to accommodate within the concept of quantum events in the existing QDA concept.⁶⁶

The second objection by Saunders and Polkinghorne was that quantum events only show indeterminate effects during measurements in the laboratory when the wave function is seen to collapse. This then limits the number of events available for QDA. Russell's approach was to first reason that the concept of quantum measurement is applicable to physical events in general and then to claim that such measurements (essentially irreversible interactions) occur frequently.

It is important to note the following in the current discussion about measurement, wave function collapse and the nature of quantum events:

Indeterminacy. Richard Feynman pointed out that wave functions describe possible states of quantum systems and wave functions are therefore not to be understood as regular descriptions of classic realities. It is true that the wave function develops in a deterministic fashion, but the wave function does not describe a scenario in terms of classic physical concepts.⁶⁷ It could be said that the wave function describes a situation as containing a number of possible outcomes, and then measurement or collapse causes one of the potential outcomes to be realized. Both components are necessary for indeterminacy to have its effects. In this sense indeterminacy is present even before the collapse of the wave function. It is not necessary to immediately perform a measurement because it is possible for an indeterminate effect to become evident much later. Erwin Schrödinger described the wave function as an *expectation-catalog* in his famous article on the cat paradox.⁶⁸

Measurement and interactions. Interactions in quantum mechanics can always be described by a wave function.⁶⁹ The wave function typically is in the form of a superposition in the case of an interaction.⁷⁰

⁶⁶ Bohm and Peat, 90–103.

⁶⁷ Richard P. Feynman, Robert B. Leighton and Matthew Sands, *The Feynman Lectures on Physics* (Reading, Massachusetts: Addison-Wesley, 1965), 16–5 – 16–6.

⁶⁸ Erwin Schrödinger, “The Present Situation in Quantum Mechanics” in Wheeler and Zurek, 158.

⁶⁹ Polkinghorne, *Quantum Theory*, 49–50.

⁷⁰ George Greenstein and Arthur G. Zajonc, *The Quantum Challenge* (Sudbury, Massachusetts: Jones and Bartlett, 1997), 186–187, 131; P. J. E. Peebles, “Measurement Theory” in *Quantum Mechanics* (Princeton, New Jersey: Princeton University Press, 1992), 248–251; Michael E. Peskin and Daniel V. Schroeder, *An Introduction to Quantum Field Theory*, (Westview Press, 1995), 276.

Such interactions are reversible. Complex multiple interactions can result in complex wave functions describing *entanglement*.⁷¹

The problematic use of the concept of irreversibility: The notion of irreversibility is tied to wave function collapse in quantum theory. The use of macroscopic characteristics to define what constitutes wave function collapse can be questioned because wave function collapse in turn defines how the macroscopic world emerges from the quantum theoretical description.⁷² This seems to be nothing more than a circular definition.

Localization of measurement and collapse. Currently many physicists conclude that the question of the localization of wave function collapse has not been satisfactorily solved yet and may even be unsolvable. Polkinghorne discusses a variety of possible approaches for locating collapse, each in turn depending on the choice of a given interpretation of quantum theory.⁷³ He understands wave function collapse to be the macroscopic registration of a microproperty: However, such a definition is not very helpful since no unambiguous way exists to delineate the boundary between microscopic and macroscopic systems.⁷⁴ Russell's definition of a quantum event as an irreversible interaction of a quantum system with another system could be acceptable as a possible solution to this problem if one would be able to establish that boundary without in turn invoking the notion of measurement. However, there are other effects caused by measurement that also need to be considered.⁷⁵

Measurement and "classic" states known as eigenstates. A measurement forces the measured quantum system into an eigenstate.⁷⁶ Measurement suppresses superposition, but a superposition is necessary

⁷¹ Ibid., 188.

⁷² Asher Peres, "Can we undo Quantum Measurements?" in *Physical Review*, D22 (1980): 879–883; Reprinted in Zurek and Wheeler, 692–694; David Bohm, *Quantum Theory* (New York: Dover Publications, 1951), 608–609; Bohm, *Causality & Chance*, 160.

⁷³ Greenstein and Zajonc, 190; Thomas Tracy, "Creation, Providence, and Quantum Chance" in Russell, Clayton, Wegter-McNelly and Polkinghorne, *Quantum Mechanics*, 254; Polkinghorne, *Quantum Theory*, 44–53; Bohm, *Quantum Theory*, 586–588; Chris Clarke, "Quantum Histories and Human/Divine Action" in Russell, Clayton, Wegter-McNelly and Polkinghorne, *Quantum Mechanics*, 160–162; Polkinghorne, "Physical Process," 181–190.

⁷⁴ von Neumann, *Quantenmechanik*, 224–236.

⁷⁵ John Polkinghorne, *The Quantum World* (Princeton, New Jersey: Princeton University Press, 1984), 62. See also von Neumann, *Quantenmechanik*, 187.

⁷⁶ An eigenstate is a quantum state that represents a definite quantity for an observable and provides a connection to the quantities in classical physics. See Greenstein and Zajonc, 32, 159, or Peebles, "Measurement Theory" in *Quantum Mechanics*, 231–258.

for wave phenomena such as interference to surface.⁷⁷ If measurements were continuously performed on very small scales as envisioned, then phenomena such as interference and superconductivity would be limited, and the macroscopic quantum effects, including those mentioned by Russell, would be suppressed since they depend on holistic quantum effects of the entire system.⁷⁸

Large-scale quantum systems. The suggestion that indeterminacy applies in general to small-scale quantum events raises questions about the possibility of macroscopic quantum effects mentioned before. Raymond Chiao has suggested a thought experiment involving a quantum entanglement over a distance of a couple of billion light years.⁷⁹ Recent experiments to investigate the feasibility of quantum cryptography are based on the establishment of nonlocal effects over long distances.⁸⁰ In order to account for those experiments as quantum events, the entanglements over cosmic distances would need to be understood as involving single systems.⁸¹ Moreover, according to Schrödinger entanglement is an ubiquitous phenomenon which might lead to the need to consider the universe as *one* quantum system and therefore a quantum event would need to have a *global character* and could not be understood in a reductionistic fashion.⁸²

In summary the QDA approach as proposed by Murphy and Russell has difficulties accommodating characteristic phenomena of quantum theory such as measurement and nonlocal effects. The concept of quantum events is difficult to defend given quantum theory. In particular worrying is the limited reflection of the authors on the measurement

⁷⁷ Greenstein and Zajonc, 160.

⁷⁸ Zeh, "The Program of Decoherence: Ideas and Concepts" in Domenico Giulini, Erich Joos, Claus Kiefer, Joachim Kupsch, Ion-Olimiu Stamatescu and H. Dieter Zeh. *Decoherence and the Appearance of a Classical World in Quantum Theory* (Berlin: Springer Verlag, 1996), 22.

⁷⁹ Raymond Chiao, "Quantum Nonlocalities" in Russell, Clayton, Wegter-McNelly, *Quantum Mechanics*, 36. A similar experiment is described by John Archibald Wheeler, *Geons, Black Holes & Quantum Foam: A Life in Physics* (New York: W. W. Horton, 1998), 334–337.

⁸⁰ One recent experiment by Mitsubishi was able to prove this effect over a distance of 67 kilometers using fiber optics. See Wolfgang Stielor, "Neuer Weltrekord bei Quantenkryptographie" in *c't: magazin für computer technik* (Hanover, Germany: Heise-Verlag, December 2002).

⁸¹ For references to actual experiments see for example Wheeler, *Geons*, 337, or Henry Stapp, *Von Neumann's Formulation of Quantum Theory and the Role of Mind in Nature* [online] (Berkeley: Lawrence Berkeley National Laboratory, 2001, accessed 16 July 2003), <<http://www.categoricalanalysis.com>>.

⁸² Erwin Schrödinger in *Proceedings of the Cambridge Philosophical Society* 31 (1935): 555 cited in Aczel, 70.

problem. Consequently, Arthur Peacocke, who has also written on divine action, now supports Saunders's views of the minimal macroscopic effect of quantum indeterminacy.⁸³ This falls in line with Polkinghorne's assessment that currently no viable proposal for divine action through quantum indeterminacy exists. Polkinghorne suggested that "bold metaphysical speculation, which takes science into account but is relatively uninhibited in pressing on to grander designs" will be a necessary step in developing new approaches.⁸⁴

3. *The Proposed Solution*

In this text we follow Polkinghorne's advice and to redesign QDA as it emerges from an understanding of quantum theory without regard to metaphysical commitments to a classic Enlightenment view of the world. Murphy has argued that the shift from modernity to postmodernity in Anglo-American philosophy is characterized by the rejection of reductionism:

I argue that there has been a similar revision of view of the relation of parts and wholes reflected in science and other branches of philosophy and thus that a metaphysical shift has occurred—the rejection of modern atomism-reductionism in all of its forms.⁸⁵

However, the QDA approach presented by Russell and Murphy still represents a reductionist approach and is therefore inconsistent with what Murphy saw as the direction of philosophy. We propose to follow through on Murphy's insight by giving a holistic account of divine action, and by revising the understanding of what constitutes a quantum event.

The problematic nature of wave function collapse and the corresponding difficulty in defining the relation between the micro- (quantum) and the macro (classic) level are the reasons for the difficulties encountered by a reductionist approach to QDA. Indeterminacy is a phenomenon associated with wave function collapse, but collapse is only specified in the Copenhagen interpretation as occurring during measurement and involves a classically understood measurement device. What is needed is a proper scientific understanding of wave function collapse in the world, and consequently a proper

⁸³ Arthur Peacocke, *Paths from Science towards God: The End of All our Exploring* (Oxford: Oneworld Publications, 2001), 104–108.

⁸⁴ Polkinghorne, "Physical Process," 190.

⁸⁵ Nancy Murphy, *Anglo-American Postmodernity: Philosophical Perspectives on Science, Religion and Ethics* (Boulder, Colorado: Westview Press, 1997), 2.

understanding of the physical nature of the world. This has never been accomplished in the contemporary discussion.

Quantum mechanics is useful for the description of both micro- and macro-level entities. Quantum mechanics is currently the most fundamental physical theory, allowing us to describe how matter works. Any object can be described using a wave function, from the smallest known entities to the whole universe.⁸⁶ Consequently, we would expect one fundamental component of a QDA theory to be quantum mechanics and the wave function. The problem with the wave function is that it does not describe the measurement process. Collapse (and therefore measurement) is “imposed upon the formalism from the outside.”⁸⁷ Describing a scenario using the wave function results in a large set of potentialities but no selection of a specific outcome.

The classic level does not have a sense of potentialities; the outcome of an experiment is a definite quantity. We might not have total clarity on how this comes about, but we know that instruments in a laboratory always show a definite value and not a set of possibilities as suggested by the wave function. Nonlocal effects and other quantum phenomena are expressed in terms of wave functions and not by a description using laws of classical physics. Since there are known quantum effects resulting in observable effects at the macroscopic scale (such as superconductivity and superfluidity) *the acceptable domain for the use of the wave function must extend into the macrorealm.* It follows from the first point that the measurement instrument, which is described using the classic laws of physics, can also be represented by a wave function. If this is done, then the measurement apparatus and the measured entity must be considered as properly represented by one huge entangled wave function. The decision to use a classic description for the measurement instrument is arbitrary since no scientific criteria exist to distinguish micro-level entities from macro-level entities.

Our minds only recognize classic quantities and never recognize something like a superposition. By the time wave functions reach our consciousness, they must have already collapsed; otherwise, we would observe multiple possible outcomes, such as multiple positions of a pointer on a dial, rather than just one outcome.

⁸⁶ Eugene P. Wigner, *Symmetries and Reflections: Scientific Essays* (Woodbridge, Connecticut: Ox Bow Press, 1979), 173–174; Anton Zeilinger, “On the Interpretation and Philosophical Foundations of Quantum Mechanics” in U. Ketvel et al., *Vastokohtien todellisuus: Festschrift for K.V. Laurikainen* (Helsinki: Helsinki University Press, 1996), 3.

⁸⁷ Polkinghorne, “Physical Process,” 181.

John von Neumann proved that the validity of quantum theory does not depend on where collapse and measurement are envisioned to take place. Given that only classic outcomes are recognized by our consciousness, von Neumann speculated that measurement takes place through the consciousness of an observer.⁸⁸ Following von Neumann, Eugene P. Wigner⁸⁹ and John Archibald Wheeler⁹⁰ came to similar conclusions about the role of consciousness. Wigner commented: “It was not possible to formulate the laws of quantum mechanics in a fully consistent way without reference to the consciousness.”⁹¹

QDA approaches can be made workable by accepting consciousness as the *natural* location where measurement, and therefore wave function collapse, occurs. Wigner claimed:

The measurement is not completed until its result enters our consciousness. This last step occurs when a correlation is established between the state of the last measuring apparatus and something which directly affects our consciousness. This last step is, at the present state of our knowledge, shrouded in mystery and no explanation has been given for it so far in terms of quantum mechanics, or in terms of any other theory.⁹²

Such an interpretation of quantum mechanics gives the observer a role in measurement and wave function collapse. However, the role of the observer cannot be reflected in a QDA proposal, in which it is assumed (in harmony with a classic conception of the universe) that reality has an observer-independent nature, an assumption widely accepted in the context of the VO/CTNS work on QDA.

The idea of consciousness as the cause for *collapse* would obviously have significant consequences for our conceptualization of the world. No longer could we assume a classic world with definite physical characteristics, because the indefiniteness of the microrealm also becomes valid for the macrorealm. The world would become a *quantum world* in a *quantum state*, which is naturally describable by a wave function. As James Butterfield put it: “Quantum theory apparently implies that such indefiniteness should also be endemic in the familiar

⁸⁸ John von Neumann, “Der Meßprozeß” in *Quantenmechanik*, 222–237.

⁸⁹ Eugene P. Wigner, “Remarks on the Mind-Body Question” in *Symmetries and Reflections*, 171–184.

⁹⁰ John Archibald Wheeler, “Genesis and Observership” in *At Home in the Universe* (New York: Springer Verlag, 1996), 23–46.

⁹¹ Wigner, “Mind-Body Question,” 172.

⁹² *Ibid.*, 187.

macrorealm of tables and chairs.”⁹³ Wave functions can also be used to express classic states, and therefore classic definite elements in the world are also describable by a quantum state.

Russell claimed that quantum theory needs to be interpreted in terms of “ontological indeterminism.”⁹⁴ However, in Russell’s worldview indeterminism, as a desirable feature of quantum theory for divine action, has been grafted into a classic picture of the world. Henry Stapp⁹⁵ pointed out in *Quantum Ontology and Mind-Matter Synthesis*⁹⁶ that the evident nonlocal features show that “the profound deficiencies [of] the classical conception [or better concepts] of nature are not confinable to the micro-level.”⁹⁷ Some physicists have drawn a sharp distinction between the real classic world and the quantum world with its potentialities,⁹⁸ but Stapp proposed that we instead *ontologize* the orthodox interpretation of quantum mechanics and abandon the classic view of the world by accepting quantum theory as an adequate representation for the entire world.⁹⁹ According to Stapp, the ordinary substantive matter postulated by classical mechanics simply does not exist. The quantum state of the universe is a wave function (the *universal wave function*¹⁰⁰) containing a collection of potentialities with complete physical information about the universe. The conscious recognition of events by an observer then reduces potentialities in the quantum state to a definite classic state.¹⁰¹

Others have come to the same conclusions as Stapp. Recently Menas Kafatos and Robert Nadeau wrote two books on the nature of reality,¹⁰² and considered Bohr’s instrumentalist understanding of quantum

⁹³ Butterfield, “Some Worlds of Quantum Theory” in Russell, Clayton, Wegter-McNelly and Polkinghorne, *Quantum Mechanics*, 114.

⁹⁴ Russell, “Divine Action,” 293.

⁹⁵ His main publication on the subject is Henry Stapp, *Mind, Matter and Quantum Mechanics* (New York: Springer Verlag, 1993). Recent presentations, articles and other publications are available from <<http://www.categoricalanalysis.com>> (accessed 16 July 2003).

⁹⁶ Henry Stapp, *Quantum Ontology and Mind-Matter Synthesis* [online] X-th Max Born Symposium (1998), <<http://www.categoricalanalysis.com>>; accessed 16 July 2003.

⁹⁷ *Ibid.*, 8.

⁹⁸ *Ibid.*, 10.

⁹⁹ *Ibid.*, 18.

¹⁰⁰ The term was coined by Hugh Everett, See Chapter Four for details.

¹⁰¹ *Ibid.*, 28.

¹⁰² Menas Kafatos and Robert Nadeau, *The Conscious Universe: Parts and Wholes in Physical Reality* (New York: Springer Verlag, 2000); Robert Nadeau and Menas Kafatos, *The Non-Local Universe: The New Physics and Matters of Mind* (Oxford: Oxford University, 1999).

mechanics as the “complete description” of reality.¹⁰³ They stated that classic physics is an approximation that only works because the relatively high speed of light and the relatively small scale of quantum action typically only cause negligible effects at the macrolevel.¹⁰⁴ Based on an ontologization of quantum mechanics in the manner of Stapp, Kafatos and Nadeau contended that the universe is a conscious, self-organizing system.¹⁰⁵

Evan Harris Walker has also concluded that an ontological interpretation of quantum mechanics is necessary and reached this conclusion independent of Stapp’s work.¹⁰⁶ Walker proposed an understanding of reality in harmony with concepts found in Zen Buddhism. He contended that the determination of reality by quantum mechanics is “underconstrained” in a way similar to that of Murphy,¹⁰⁷ but he goes one step further: Walker suggested that the human will can actually influence the selection of the outcome,¹⁰⁸ and that God is the collective power of all our consciousnesses connected to one another, “the power that creates miracles.”¹⁰⁹

The authors who support such interpretations also contend that the human brain has a special capability to enable the collapse of the wave function. These arguments have tried to avoid giving the brain (or consciousness) a special metaphysical status by seeking out physical processes in the brain that impose classicality and therefore cause wave function collapse. Stapp suggested that the brain develops a series of action plans that are then processed through feedback loops that employ the quantum Zeno effect in order to reduce the number of potentialities. These feedback loops evaluate the compatibility of the mental state to the physical event. Human will or attention then causes a rapid rerouting of the potential action plans through these loops so that, finally, only one plan of action is executed.¹¹⁰

¹⁰³ Kafatos and Nadeau, *Conscious Universe*, 73.

¹⁰⁴ *Ibid.*, 75.

¹⁰⁵ *Ibid.*, 6.

¹⁰⁶ Evan Harris Walker, *The Physics of Consciousness: The Quantum Mind and the Meaning of Life* (Cambridge, Massachusetts: Perseus Books, 2000). The book is a unique interwoven artwork of a tragic love story, the history of quantum mechanics and an argument on the nature of reality.

¹⁰⁷ *Ibid.*, 259.

¹⁰⁸ *Ibid.*, 301–302.

¹⁰⁹ *Ibid.*, 329.

¹¹⁰ Stapp, “Psycho-Physical Theory and Will” in *Mindful Universe*, 67–68, 39–48; Stapp, “A Quantum Theory of the Mind-Brain Interface” in *Mind, Matter, and Quantum Mechanics*, 145–172.

Roger Penrose recently suggested that a future theory of quantum gravity could solve the problem of wave function collapse in quantum theory and that a special quantum mechanical effect in the brain could be the basis for consciousness.¹¹¹ Kafatos and Nadeau considered Roger Penrose's ideas, but concluded that neither his nor Stapp's suggestion can be verified. They contended that consciousness might not be analyzable and might need to be taken as a metaphysical *a priori* for physics.¹¹² On the other hand, Walker considered consciousness and brain to be separate. The consciousness "observes" (in the sense of monitoring) the brain and the potentialities it develops, and then brings about one state through observation (in the sense of causing collapse).¹¹³

Approaches to divine action can be made workable by adopting a *quantum view of the world* with wave function collapse caused by consciousness. The wave functions that consciousness processes are huge entanglements of quantum systems, and they are tied to the abilities of the consciousness to recognize elements of the physical world. These are typically of a macroscopic nature and not small quantum events.

In such a scenario the third objection by Polkinghorne and Saunders to QDA approaches—that indeterminacy can only have minimal effects—would no longer be valid. Only *observation* causes indeterminacy to become effective, and indeterminacy is dependent on the recognition of macroscopic entities by the cognitive processes in the human brain. The potential effect is so evident at the macroscopic level that Bernard d'Espagnat rejected this approach because "it seems impossible to confine such effects within acceptable limits." To exemplify the questionable nature of this approach, d'Espagnat pointed out that a person looking at the moon could make the moon have a definite location that it did not have before.¹¹⁴ However, d'Espagnat's rejection of this approach is based on effects that would be desirable in a theory of divine action. Divine action would need to be able to account

¹¹¹ Roger Penrose, "Quantum Theory and Spacetime" in Stephen Hawking and Roger Penrose, *The Nature of Space and Time* (Princeton, New Jersey: Princeton University Press, 1996), 62; Roger Penrose, *The Large, the Small and the Human Mind* (Cambridge: Cambridge University Press, 1999), 92, 133–135; also Roger Penrose, *Shadows of the Mind: A Search for the Missing Science of Consciousness* (Oxford: Oxford University Press, 1994), 335.

¹¹² Kafatos and Nadeau, *Conscious Universe*, 138–139.

¹¹³ Walker, 258.

¹¹⁴ Bernard d'Espagnat, *Reality and the Physicist: Knowledge, Duration and the Quantum World*, J. C. Whitehouse trans. (Cambridge: Cambridge University, 1989), 213. The chapter "The Dilemma of Modern Physics: Reality or Meaning" discusses Wheeler's proposal of a quantum world.

for significant macroscopic effects, and d'Espagnat's objection supports the conclusion that this approach indeed fulfills that requirement.

The second objection by Polkinghorne and Saunders to QDA—that there are only infrequent and sporadic measurement events that would allow divine action—can also be given a satisfactory response. All cognitive processes cause wave function collapse and therefore also cause indeterminate processes that allow for divine action to abound, as long as the conscious observer is observing.

There are two options to envision divine action in a quantum world. One can take Murphy's concept of under-determination of quantum events and extend this to the events recognized by consciousness. Divine action would work directly at the interface between consciousness and the universe. This approach might have advantages when it comes to arguing for divine communication, but it has the defect that God might be seen as influencing our perception. Another option is to follow Chiao's suggestion to understand God as a sporadic conscious observer.¹¹⁵ In order to be able to allow for divine action in this case, one must hold that the divine observer has abilities that go beyond the human observer. The human observer has only a limited ability to select one outcome among the potential outcomes. The divine observer can arbitrarily choose *which* of the possible outcomes becomes definite, and this capability provides the means for divine action.¹¹⁶

4. Differentiation from the Work of Others

It is proposed here to accept wave function collapse caused by *consciousness* (whether it be divine or human) as it interfaces with the *quantum world* as the *causal joint* for divine action. As discussed above, such an approach enables a response to the objections regarding the existing QDA proposals. Although there are extensive publications by physicists supporting the view of the universe as a quantum world, there exists no a recent work by a theologian that takes a holistic quantum view of the world and relates it to divine action.

Some of the contributors to the VO/CTNS volumes have evaluated and discussed the proposals by Stapp and Wigner and thereby have provided responses to the proposed use of conscious collapse models in a theory of QDA:

James Butterfield discussed the common implications of such an understanding of collapse in his article "Some Worlds of Quantum

¹¹⁵ Chiao, 38–39.

¹¹⁶ Pollard, *Chance and Providence*, 114.

Theory”¹¹⁷ where he referred to Wigner and Stapp. Butterfield investigated the consequences of an approach to collapse caused by the observer through consciousness and found that what we commonly call the macrorealm would then be governed by wave function potentials. The macrorealm would not be in a classic defined state; it would only *appear* classic to us because our consciousness collapses the indefinite superposition into an eigenstate correlated to the result that we perceive when we “see” or in other ways become aware of the state of our environment. Once a part of the macrorealm is perceived by consciousness, that which was perceived is no longer indefinite. The unperceived states of the superposition vanish. If the perception of a certain area of the macrorealm ceases, then the usual indefiniteness slowly sets in again. Butterfield gave this approach “very little credence” without providing any further commentary or discussion.¹¹⁸

Ian Barbour did not find Wigner’s concept of observer-caused collapse convincing, since results of measurements might be recorded, for example, on computer tape or on the dial of an instrument instead of being recognized directly by an observer. Barbour reasoned that an observer, given Wigner’s ideas, looking at the recorded result much later would only then cause the past to become definite by merely looking at the computer tape. However, this is exactly what is advocated by John Archibald Wheeler: Not only is the macrorealm indefinite right now, but the past is also indefinite until someone observes it and causes one potential event out of many to become definite.¹¹⁹ Barbour found such an approach difficult to accept because Wigner’s concept could imply that the observers of the big bang have caused the big bang to occur 13 billion years ago in a certain way. Barbour considered the flow of information, and not the fact of observation, to be necessary for wave function collapse to occur.¹²⁰

Robert Russell referred to the work of Stapp, Wigner and von Neumann as an interpretation of quantum mechanics promoting the idea that “consciousness creates reality.”¹²¹ Reality is the classic state after wave function collapse. If consciousness causes collapse, then—according to Russell—it “creates reality.”

¹¹⁷ James Butterfield, “Some Worlds of Quantum Theory” in Russell, Clayton, Wegter-McNelly and Polkinghorne, *Quantum Mechanics*, 111–140.

¹¹⁸ Butterfield, 121–122.

¹¹⁹ John Archibald Wheeler, “Genesis and Observership” in *At Home in the Universe*, 23–46.

¹²⁰ Barbour, *Science Meets Religion*, 79–80.

¹²¹ Russell, “Divine Action,” 303.

Philip Clayton discussed the ideas of Stapp, Wheeler and Wigner and found the major problem to be the “counterintuitive features,” like the collapse of undetermined events in the past. However, Clayton also noted that quantum mechanics has always challenged our intuitions.¹²²

John Polkinghorne saw the move to use consciousness as the cause of wave function collapse as one of a number of possible metaphysical choices. According to Polkinghorne, such a choice gives consciousness a privileged position for which there is no warrant in science. Polkinghorne saw many open questions: Whose consciousness can affect collapse? How does collapse and measurement happen during times and locations in the universe where no consciousness is present?¹²³

In summary, the contributors to the VO/CTNS volumes are mostly silent on the observer-causes-collapse concept, although there are explanatory advantages for the consciousness-based approach as pointed out by Chiao,¹²⁴ who was also a contributor to the VO/CTNS volumes. Observer-caused collapse does give a privileged position to consciousness, as noted by Barbour and Polkinghorne. However, the privileged nature of consciousness is our everyday experience. The conscious collapse models have so far not been investigated for their usefulness in divine action proposals. These models represent a possible and even a promising area for research.

The consciousness-based approach also leads to a unified view of the universe as described by quantum theory. The authors of the VO/CTNS volumes have wrestled with the dichotomy of a classic deterministic worldview versus the quantum mechanical nature evident at the microlevel. It is because of that struggle between a classic deterministic worldview and the quantum view that a significant portion of the discussions in the VO/CTNS volumes have been concerned with the basic nature of quantum mechanics: Is it deterministic or not? That question has clearly not been resolved by the investigation in the VO/CTNS volumes. Sadly the investigations in the VO/CTNS volumes have not taken the challenge that quantum theory poses to our notion of reality seriously and no detailed investigation of the measurement problem which is crucial for any quantum divine action proposal was completed.

In *Chaos and Complexity* Murphy discussed the problem of top-down causation, in contrast to the typical view of bottom-up causation by

¹²² Philip Clayton, “Tracing the Lines” in Russell, Clayton, Wegter-McNelly and Polkinghorne, *Quantum Mechanics*, 218–220.

¹²³ Polkinghorne, “Physical Process,” 185.

¹²⁴ Chiao, 38.

quantum events.¹²⁵ QDA as proposed in this text is a form of top-down causation¹²⁶ since wave functions are used to describe entities of any size. Consequently, there is no need for a bottom-up approach in which indeterminacy from small components causes macroscopic phenomena to emerge. Nadeau and Kafatos have pointed out that nonlocal effects cause the manifestations of physical regularities and even the properties of biological systems.¹²⁷ If the causal nexus for divine action is the interface between consciousness and the potentialities embodied in the wave functions, then divine action can have a top-down influence over phenomena in the hierarchies of sciences. QDA so conceived is a holistic approach.¹²⁸

George Ellis has shown that macroscopic quantum effects establish the holistic character of quantum mechanics. A macrosystem, such as a Bose-Einstein condensate, exhibits quantum effects that cannot be analyzed in a reductionist way.¹²⁹ Ellis discussed the measurement process in terms of a holistic top-down view. Given these effects, Ellis was looking for a mechanism in nature that would cause collapse for macroscopic entities without an observer present. But he concluded, “We do not know when [the] collapse of the wave function will take place.”¹³⁰ However, we *know* that collapse has taken place when *our consciousness* recognizes an event. A possible solution to this problem is to remove the requirement that collapse be observer independent.¹³¹

5. Summary

Through the years, the understanding of divine action has been shaped to a significant degree by the theological traditions and the philosophy of the times in which explanations for divine action were offered. In particular, the term *interventionism* arose in the context of two competing approaches, each attempting to justify the concept of divine action in the Enlightenment. Liberal theologians chose experience (focusing mostly on *Gefühl*, Schleiermacher’s *God consciousness*) as

¹²⁵ Murphy, “Divine Action,” 357.

¹²⁶ Chiao, 38.

¹²⁷ Nadeau and Kafatos, *Non-Local Universe*, 113.

¹²⁸ Chiao, 38, suggests such a top-down approach through measurement but understands God’s consciousness effecting wave function collapse.

¹²⁹ George Ellis, “Quantum Theory and the Macroscopic World” in Russell, Clayton, Wegter-McNelly and Polkinghorne, *Quantum Mechanics*, 262.

¹³⁰ Ellis, “Quantum Theory,” 266–267.

¹³¹ A private talk with Robert Russell (21 August 2003) seems to indicate that the notion of an observer-independent universe might have been a requirement for QDA theories in the context of VO/CTNS.

their foundation whereas conservative theologians chose Scripture for a foundation. Parts of the conservative tradition have affirmed the priority of Scripture when Scripture appeared to be in conflict with science, leading to an interventionist account of divine action. The first chapter following this summary contains an investigation of the development of the main theological bifurcation as a reaction to the rise of modern science and the Enlightenment worldview of a deterministic universe. The scientific developments in the twentieth century have challenged the Enlightenment worldview, but Enlightenment thought still has an overwhelming influence on our understanding of nature. This has hindered the acceptance of quantum theory, and has also affected the formulation of divine action theories. Chapter One concludes with an investigation of *interventionism* and *noninterventionist divine action* in light of the developments in the twentieth century.

Chapter Two contains a description of the first interpretations of quantum theory that emerged during the pioneering phase of quantum mechanics, mainly in the first half of the twentieth century (see Figure 1). Included is Einstein's view of quantum theory as of a statistical nature, Bohr's insistence on an epistemological description, Schrödinger's search for a deterministic wave interpretation, von Neumann's formalization of quantum theory (and his suggestion that an observer or consciousness is necessary for wave function collapse because measurement can not be localized in the physical world) and Heisenberg's understanding of the wave function as representing an ontological reality.

In Chapter Three pioneers of QDA are investigated. William James developed an argument for an indeterminist universe even before quantum theory emerged. Arthur Compton, one of the founders of quantum theory, attempted to use quantum indeterminacy to understand why one is able to lift his hand if one so desires without violating determinism. Two versions of QDA were developed by Karl Heim and William Pollard after the Second World War. Heim's QDA was based on a challenge to the Enlightenment concepts of objectivity, space and causality. He envisioned the world as a communication medium between agents. Pollard investigated the interpretation of chance and proposed the divine determination of chance outcomes to be the means for divine agency. Eric Mascall integrated quantum indeterminacy into his Thomist understanding of events. Finally Frederik Belinfante gave an argument for the existence of God from quantum theory, and established scientific parameters that must be satisfied by future theories of QDA. Contemporary authors on divine action have only represented the views

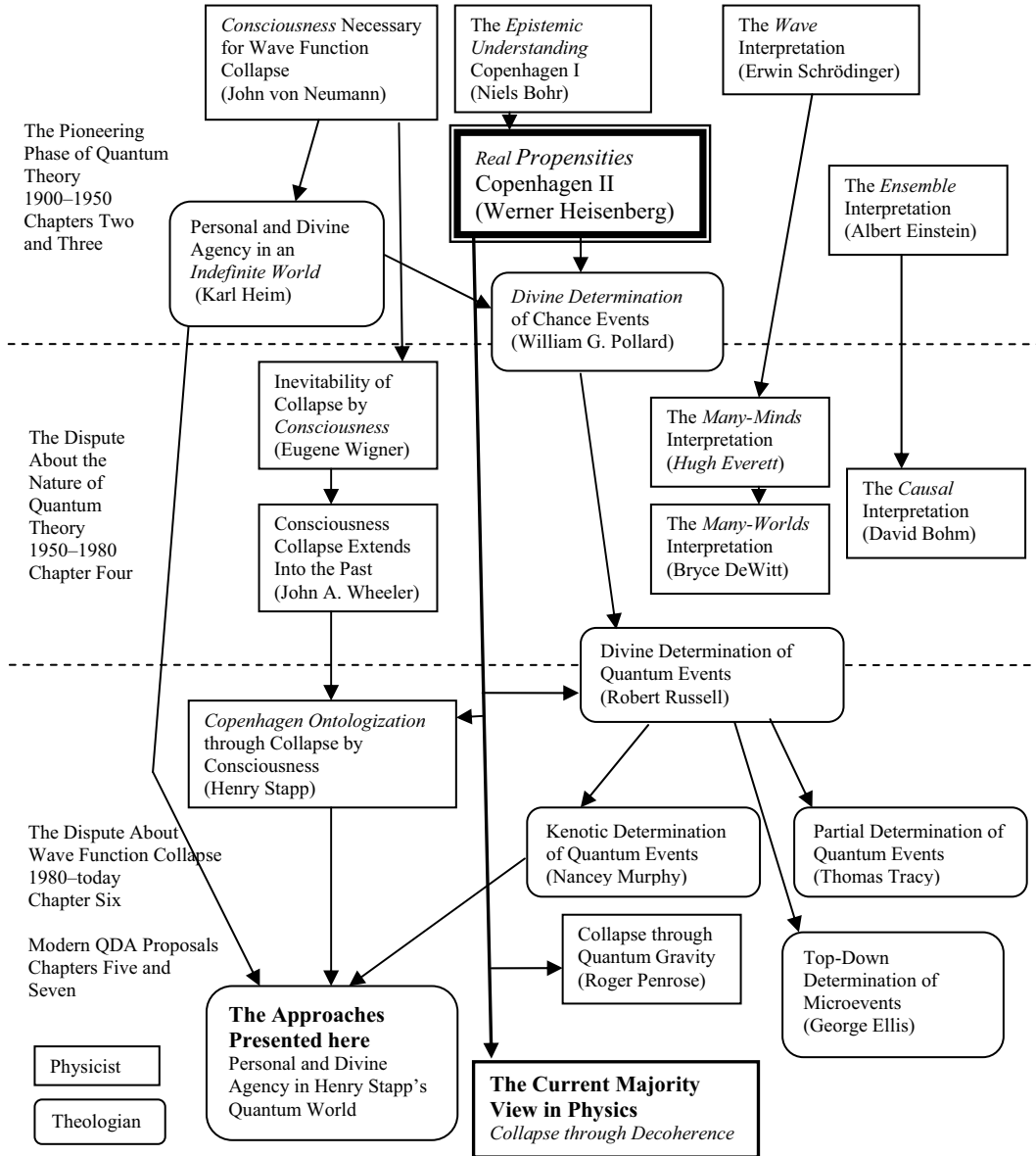
of the pioneers of QDA in a limited—and in many cases inaccurate—way.

Chapter Four covers the dispute about the nature of quantum theory that arose in the 1950s and lasted through the 1970s. During that period the basic nature of quantum theory was challenged by attempts to reestablish determinism through hidden-variables theories. Hugh Everett and Bryce DeWitt proposed the many-worlds interpretation, and Bohm developed a causal interpretation based on the nonlocal influences on particles that always have a definite position. None of these approaches has been accepted by a majority of physicists as an improvement of the standard theory. The approach to wave function collapse through consciousness was further developed by Wigner and Wheeler, resulting in the paradox of Wigner's friend and the insight that quantum theory could be seen as implying the determination of the past.

Chapter Five covers the QDA approach as developed by Russell, Murphy, Tracy and Ellis at the end of the twentieth century. We will also investigate the views of their opponents: Polkinghorne, Saunders, Peacocke and Hodgson. We find a limited investigation of quantum theory and numerous inaccurate representations of issues in quantum theory, so that we have to conclude that the literature on the field is basically scientifically suspect. Polkinghorne has correctly pointed out that the QDA approaches can be questioned because the measurement problem has not been adequately addressed, and therefore the implicit assumption of a partially classic understanding of the nature of the universe—commonly referred to as the *macrolevel*—is not adequately justified.

In Chapter Six contemporary attempts to solve the measurement problem in the context of the Copenhagen interpretation are investigated. These include *spontaneous collapse*, mainly represented by the approach of Giancarlo Ghirardi, Emanuele Rimini and Tullio Weber; *collapse by quantum gravity* as proposed by Penrose (we will also consider his approach to consciousness through special quantum effects in the brain); the majority view in physics today—the contention that the influence from the environment (*decoherence*) causes quantum collapse; Stapp's suggestion to ontologize the Copenhagen interpretation based on von Neumann's understanding of *collapse through consciousness*; and Stephen Hawking's highly popularized view. The conclusion is that Stapp's view is the most consistent approach, one having explanatory power that goes far beyond quantum theory.

Figure 1: Quantum Theory and Divine Action Proposals



Chapter Seven contains a proposal of a theory of divine action emerging from James's indeterministic universe, Heim's concept of the world as a communication medium and Stapp's interpretation of quantum theory. This results in a universe that is governed by potentialities and propensities rather than *classic definiteness*. Agents that have free will (such as persons or God) restrict these potentialities through wave function collapse and thereby cause parts of the universe to become definite. Two modes of divine action could be envisioned:

First, following the proposal by Chiao, God is conceived of as another agent in the universe, the *divine observer*, causing wave function collapse.

Or *second*, drawing on Murphy's concept of under-determination, divine action is conceived of as occurring in each of the wave function collapses caused by any agent in this universe.

The conclusion contains reviews of important points made earlier and an exploration of one implication of the proposed divine action concept for the future of the world.

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