Does the Trinity Play Dice?

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The interpretation of quantum theory and its implications continue to be controversial. In this paper, we survey some issues raised in debates in order to pursue the belief that the God who is involved with the world in quantum phenomena is the Holy Trinity. Interpretations which emphasize participatory aspects of quantum theory are especially congenial to an understanding of divine action which centers on the Incarnation. In this light, we examine questions about reality, knowledge of the world, the role of chance, complementarity, material identity, and the entanglement of systems.

Creation as a Work of the Trinity

Questions about the meaning of quantum mechanics usually are not posed as in the title of this paper. Statements about the theory are, following Einstein, sometimes put in terms of "God" playing dice with the universe. The difference is important, and must be dealt with if we are to make significant progress toward a theological appreciation of quantum mechanics

A statement that God does something means little unless we know what concept of deity stands behind it. Einstein expressed his own belief in God as "a superior mind that reveals itself in the world of experience," a belief which he identified with Spinoza's pantheism.[1] Some New Age writers have tried to use ideas from quantum theory itself to develop a concept of the divine.[2] For process thinkers, God is necessarily involved with the world, while it seems obvious to many other people that "God" must be the transcendent Supreme Being of traditional philosophical theism.

The latter is the working view of most Christians. Western theologians, in spite of their Christological and Trinitarian beliefs, often revert to philosophical unitarianism when they discuss creation and providence. Barth pointed out that classical Reformed and Lutheran ideas of providence were vitiated by the fact that the deity who preserved, accompanied, and governed creatures in those theologies did not have the distinctive features of the God who is revealed in Jesus Christ.[3] This tendency to be content with a general theism, rather than a distinctively Christian belief, poses dangers for dialogue between science and Christian theology, including theological assessment of quantum theory, because such dialogue must consider creation and providence.

Unfortunately, Barth's own treatment of these doctrines was weakened by the fact that he saw no need to discuss questions raised by the natural sciences.[4] That attitude will not suffice today. Science should not dictate our theology, but theology must be engaged with science if it is to support the proclamation of the Gospel to people in a scientific world. God's revelation in Christ must illumine scientific discoveries, which in turn will help us to understand God's actions in the world.[5]

How might we try to see quantum phenomena in a Trinitarian manner? One approach would be to search for "vestiges of the Trinity" in subatomic phenomena. For example, Augustine thought that the Trinity was imaged by such triads as human memory, understanding, and will.[6] But even if one accepts the underlying idea of an "analogy of being" between God and the world, the fact that there is much disagreement about both the interpretation of quantum theory and Trinitarian theology today means that such a search would likely result only in some speculative and transient parallels.[7]

We will stay closer to the foundations of Trinitarian thought by attempting to relate our understanding of quantum theory to God's self-revelation in Jesus Christ. It is, after all, the belief that God is definitively revealed in Jesus which requires a Trinitarian conception of God. Our theological focus, then, will be on the economic Trinity: God revealed in interaction with the physical universe. We will try to gain a better understanding of this interaction by considering what quantum physics can teach us about the world and what our role is in it.

It is not my intention here to attempt a thorough discussion of quantum theory and the proposals which have been made for its interpretation. Our concern with quantum physics is primarily theological, not philosophical (even though philosophy cannot be avoided). We will concentrate on issues and ideas which seem promising in the science-theology dialogue and suggest some possibilities for engagement. Interpretations which emphasize *participatory* aspects of quantum theory are of particular interest for a theology which places Incarnational and Trinitarian concepts at the forefront.

The Quantum Revolution

Modern quantum theory is now over seventy years old, and many authors have considered its religious implications.[8] Quantum physics, however, has not played a major role in serious theological reflection, and has not provoked anything like the religious debates which have surrounded biological evolution, the big bang, or genetic engineering.

The scope of quantum theory is not always appreciated. It involved first simply the idea of a discrete or "quantized" character for some phenomena. To deal with the thermodynamics of radiation, Planck in 1900 introduced the idea that electromagnetic radiation of frequency f could be emitted or absorbed only in "quanta" of energy hf, where Planck's constant h is very small on the scale of everyday phenomena. (h has dimensions of energy multiplied by time, or action.) Then Einstein suggested that light actually existed as such quanta or photons, though many well-known observations indicated that light was a wave phenomenon. Bohr applied Planck's constant to explain why atoms could exist only in certain states. And de Broglie's proposal, that wave-particle duality extended to all matter, was confirmed.

Heisenberg, Schrödinger, and Dirac developed the basic structure of modern quantum mechanics in the mid 1920s. The theory was quickly found to explain and unify whole areas of physics and chemistry. It also explained many new phenomena. Quantum theory today is not just the theory of a limited regime, like a theory of optical systems. It is a theory about how *any* physical system must be described, and has been applied successfully to phenomena as diverse as superconductivity and elementary particle reactions. Many systems can be treated adequately by classical physics, but such descriptions are approximations. While we should beware of simplistic reductionism, quantum theory does seem to be foundational for all physical phenomena, even where explicit reference to it is not made.

There is little debate about the *correctness* of quantum theoretical descriptions of phenomena which have been subjected to experimental test. The equations of the theory agree with observation. But when we seek a philosophical interpretation of the theory, arguments arise.[9]

Most working scientists use the machinery of the theory and ignore the philosophical questions. However, as soon as we do start to think about the meaning of our equations and experiments, fundamental problems surface. Quantum theory changes not only our understanding of the world but our understanding of what it means to understand it. One unnamed theologian has been quoted to the effect that quantum theory is "the greatest contemporary threat to Christianity," and compares its challenge to the one which confronted the western church with the rediscovery of Aristotle.[10] It is unfortunate for quantum physics to be regarded simply as a "threat," but it does demand some new theological thinking.

Reality?

We begin by exploring some fundamental aspects of quantum theory which seem to challenge traditional views. The role of *chance* has to be considered, but we must ask even more basic questions about *reality* and *knowledge*. Classical physics assumed that there is an objective, real world independent of the human mind. The role of observers in quantum theory questions this assumption.

An "observer" could be a piece of physical apparatus, such as a photographic plate. The need to consider such an observer might be attributed to its physical interaction with what is observed--an interaction which cannot be made negligibly small because of the quantum of action. (For example, a particle can be seen only if it interacts with a photon which will transfer momentum to it.) Measurements are often discussed in that way in elementary texts, but it is an oversimplification. We must also consider decisions to make one observation rather than another and, more profoundly, the possible role of *consciousness* in observation.

Questions about observers and consciousness are introduced when we apply the basic Schrödinger equation of quantum theory to physical systems. This equation describes the spreading in space and time of a wave function psi, whose absolute value squared at any point is proportional to the probability of finding a particle there. Where $|psi|^2$ is large, a particle is likely to be found, and where it vanishes, one will not be found. But speaking of a particle being "found" implies that someone looks for it, and it is here that questions arise.

Suppose a particle is projected toward a device which will, with equal (1/2) probabilities, scatter particles in two directions, A and B. After the scattering but before observation, psi will be made up of two parts, psi_A in direction A and psi_B in direction B. Each has an amplitude $1/2^{½}$, representing probabilities of 1/2 of a particle being found in either direction. As time passes, the waves move apart, corresponding to possible motions of a particle away from the scatterer. This evolution of the wave is described by the Schrödinger equation.

When an observation is made to determine where the particle is, something different happens which is *not* described by that equation, a "collapse" of the wave function. If a detector along A registers a particle, psi collapses to a wave of unit amplitude along A, that along B being reduced to zero. This collapse *cannot* simply be attributed to an interaction between the detector and the particle, for the same collapse will also take place if we look for a particle along B and do not see anything there![11]

The fact that the wave collapses even if there is no physical interaction suggests that it is not a purely objective entity. Some have argued that it is misleading to speak of the collapse as a physical occurrence. psi, they say, is a mathematical artifact containing our statistical knowledge, and the collapse is a change in that knowledge. We do not speak of a "collapse" of data in an actuarial table when someone dies! But the situations are not the same. There are physical factors, perhaps unknown to us, which cause one seventy-year-old to die while another survives, but attempts to construct corresponding "hidden variable" versions of quantum theory, while interesting, have not been very helpful. In standard quantum theory, psi gives as complete a description of a system as we can get.

Given that the collapse is significant, at what point in the measurement process does it happen? Is it when an atom in the detector is excited, when that excitation is amplified to a certain level, or when a conscious agent becomes aware of the signal? Bohr thought that collapse took place when information reached a classical level, but he did not clearly explain why a particular size and/or momentum of the detector would be critical in this regard.[12]

One recent approach makes use of the idea of decoherence.[13] When the measuring apparatus consists of many particles and dissipative effects are taken into account, any quantum interference between macroscopically different states of the apparatus (such as the "live cat" and "dead cat" states of Schrödinger's notorious thought experiment) is quickly destroyed. This explains that the wave function will appear to collapse without explaining in a deterministic manner why there is collapse to a particular state.

Wigner argued that it is not just observation but the *consciousness* of observation which causes the collapse. Thus, the collapse takes place when information from a detector enters a mind.[14] Wheeler has emphasized the *participatory* character of the world which such a view suggests.[15] This leads to a "Participatory Anthropic Principle," in which the suitableness of our universe for intelligent life is related to the need for the existence of intelligent observers to make the universe real.[16]

This is not solipsism, when each person's reality exists only in his or her mind, nor does the mind simply create its own reality, as in simplistic versions of New Age thought. (To make anything happen we have to observe systems, not just think about them!) But this idea--that human decisions about what to observe and consciousness of observation play a role in what happens with physical systems--is still disturbing to many scientists and theologians who would like to maintain some concept of an objective, real world. This idea is rejected sometimes because of its "anthropocentrism."[17] The doctrine of the Incarnation, however, suggests that in our attempts to understand the world, we could have a nuanced emphasis on the place of humanity.

One response to questions about reality, somewhat like Bishop Berkeley's idealism, is that things exist ultimately because they are in God's mind. If quantum theory requires an ultimate conscious observer, it has been claimed, then it proves the existence of God.[18] Such an argument stands within the tradition of independent natural theology: God's existence is derived from our experience of the world. The conclusion, that an Ultimate Observer exists, is similar to that of other arguments which claim to show the existence of a Prime Mover or an Intelligent Designer. Philosophers may argue about whether the existence of such beings really has been demonstrated. Christian theologians need to ask if they have anything to do with the biblical God.

The Christian doctrine of creation says that the God who has revealed himself in Jesus Christ is the Creator, Sustainer, and Goal of the cosmos. In the Incarnation, the Word of God has become a creaturely participant in the universe (John 1:14), and this participation is the *purpose* of the universe (Col. 1:15-20). The doctrine of the Incarnation can be regarded as a *The*anthropic Principle, paralleling Wheeler's Participatory Anthropic Principle.[19] It is not simply humanity, but humanity indwelt by the divine Logos, which is crucial for the existence of the universe. The theological task is then to explore the idea that God endows the world with reality, not simply by a decision imposed from outside the cosmos but through participation in it. The Incarnation, in other words, would be seen as *necessary* for creation.

Wigner's idea is subject to the criticism that the universe existed before conscious life evolved.[20] We certainly do not want to argue that the world first came into being when the baby Jesus first opened his eyes! In a later section, we will see that the "entanglement" of systems in quantum theory involves time as well as space, so that we must be wary of common-sense ideas of temporal ordering.

The "many worlds" interpretation of quantum theory, in which measurement causes a *split* in the universe itself, avoids the problem of collapse, but at considerable cost.[21] *Two* worlds would arise in our example, one with a particle on path A and an observer who sees it there, and another with it on B and a corresponding observer. The real world in this interpretation is a "multiverse," a multi-branched array of universes continually splitting as observations are made. Each of us has multiple copies, with variations, in many worlds. This is a serious proposal, though there is an air of science fiction about it. But contrary to the claims of some proponents, there is no compelling reason to adopt it unless we feel that no interpretation of wave function collapse is viable.[22]

A many-worlds interpretation would raise serious theological questions. We would need to consider, for example, Barth's concept of evil as the "nothingness" which God has not chosen.[23] Such a concept is meaningful for a single universe, but its significance in a many-worlds picture is unclear. For instance, there would be some branches in which Hitler won, and others, such as ours, in which he did not. Which branch represents the will of God? Which expresses the nothingness which God does *not* choose?

Much of modern theology suggests that such questions must be answered eschatologically. That means more than saying that everything will finally be all right. Eschatology must be Christological, for the universe has its fulfillment in Christ. And it must be *axiological*, involving evaluation and judgment of what has taken place. Good is to be vindicated and evil condemned.[24] We would have to picture, in a sense broader than that envisioned by Teilhard, convergence of the *multiverse* upon Christ-Omega in which finally "the sea was no more" (Rev. 21:1).

Knowledge?

If there is some reasonable sense in which we can speak of a real world, what can we know about it? This topic can be approached via Heisenberg's uncertainty principle, which says that it is not possible to know precisely and simultaneously the values of two conjugate variables such as position and momentum. The product of their uncertainties must be at least h/4pi

We cannot have knowledge more precise than that, but can God? We may be tempted to answer, "Yes, God knows everything." But in the strongest interpretation of quantum theory, a pair of precise simultaneous values for position and momentum is not a real "thing." If so, then asserting that God has this knowledge may be like claiming that God knows the color of truth. Aquinas said that God's omnipotence does not extend to an ability to do things which are self-contradictory,[25] and the same argument can be extended to divine omniscience.

Christians, however, should not be excessively concerned to remove every hint of weakness from their concept of God. The focus of the divine self-revelation is Christ crucified, and God's "power is made perfect in weakness" (2 Cor. 12:9).

Chance?

These considerations can help us to deal with the question of our title. Does the Trinity uniquely determine everything that takes place, or is there an element of chance at the most basic level of reality? In most Christian traditions, any fundamental role of chance was seen as inimical to God's omnipotence, and rejected as "Epicurean" and verging on atheism. Must we respond in the same way to the notion of probability in quantum theory?

It would be anachronistic to look for references to quantum phenomena in the Bible, but chance is encountered there in the casting of lots (e.g., Josh. 14:2, Acts 1:26) and answers by oracles. God's will is made known by means not humanly predictable. In the Bible, that kind of unpredictable behavior is associated especially with the Third Person of the Trinity, the Holy Spirit.[26] The fourth Gospel compares the Spirit's activity in conversion with the unpredictability of the wind (John 3:8).

It is possible to develop hidden variable theories which reproduce the results of quantum theory. The role of probability would then be like that in classical statistical mechanics, where use of statistics is convenient in dealing with huge numbers of particles, but not essential. Even if it is not possible for us ever to know the values of the hidden variables, God might. As Prov. 16:33 suggests, phenomena which seem random to us today might be known and controlled by God.

But God can be almighty without hidden variables! God need not control the precise trajectories of particles if, as standard quantum mechanics holds, such trajectories do not exist. To say that God does everything that happens does not mean that God does everything we can imagine. God knows the outcomes of events as fully as they can be known, but quantum theory says that that is not as fully as classical physics held. The limits on divine knowledge suggested here are not like the idea attributed to the Epicureans, that God simply does not bother to be involved with the world.[27]

We may think of the divine operations (Greek *energeia*), in the technical sense of classical theology, as being in close connection with the scientific concept of energy which has developed from the same root.[28] God's "cooperation" with natural processes in classical doctrines of providence means that divine and created energies concur in bringing about whatever happens in the world, just as the divine and human operations in Christ concur perfectly.[29] The Schrödinger equation of quantum theory is the statement that the change in time of a system's wave function is produced by the energy (Hamiltonian operator) of that system. We can, therefore, believe that the divine operations concur with physical processes to the full extent described by the Schrödinger equation, while recalling that what this equation determines in any given situation is not one definite outcome but a spectrum of probabilities.

If God does not control the precise outcome of every atomic scattering event, divine omnipotence must be eschatological. Despite uncertainties about what may happen on the way, the universe will finally be brought to its fulfillment in Christ. One basic rule of practical probability is that, in the end, the house always wins.

Complementarity in Physics and Theology

Quantum physics seems to require two types of description of one world, exemplified by wave-particle duality. Bohr saw in this a fundamental theme of quantum physics which he called *complementarity*. In any given experimental arrangement, an electron will manifest itself either as a wave or as a particle, and not as some hybrid. For some arrangements, it will be a wave and for others it will be a particle. *Both* descriptions are necessary if we are to account for all the observations which we can make. Wave and particle descriptions would be *contradictory* if we applied them simultaneously. However, if we are careful to use the appropriate one in each situation, they are *complementary*.

The uncertainty principle can be seen as a quantitative expression of wave-particle complementarity: The more precisely we can describe something as a wave, the less precisely we can describe it as a particle, and vice versa. Bohr also suggested qualitative applications of the complementarity concept, such as space-time or causality, and even descriptions of a biological system as living or as machine. (To observe a system precisely enough to describe it mechanically, we have to kill it.) What is common to all such pairs of descriptions is that the use of one in a given situation precludes simultaneous use of the other.

While attempts have been made to view science and theology as complementary,[30] it is more relevant to our present topic to consider the possibility of using the concept of complementarity within theology itself. Two pairs of concepts which one might think of as candidates for complementarity are the Trinity and Unity of God and the humanity and divinity of Christ.

Perhaps it is best simply to point out the need for some care. First, it is risky to divorce complementarity from the *observability* of properties in quantum mechanics and apply it simply to abstract concepts or doctrines. We do not "observe" God's inner life, but only know of God through God's action in the world. If we can be said to "observe" anything, it is the *economic* Trinity shown to us by God's works which extend "outside God." While the persons of the Trinity act in different ways, all that God does in the world involves the united activity of Father, Son, and Holy Spirit. Thus it is not clear how triune and unitary aspects of God are to be regarded as complementary.

Secondly, the ways we attempt to apply complementarity will depend on our underlying theological assumptions. The possibility of regarding the divinity and humanity of Christ as complementary has been discussed by some authors.[31] This seems plausible within the Reformed tradition, in which the properties of the divine nature are not thought to be communicated to the human nature. In the Lutheran tradition, in which this communication (which implies the omnipresence of Christ's humanity) is accepted, the idea of complementarity does not seem well suited for Christological description.[32]

Identity

We have noted the belief that quantum theory poses a threat to Christian views of reality, and have seen that some traditional ideas about reality, knowledge, and chance do require reconsideration. In the next two sections, we will point out some concepts of quantum physics which seem to support traditional theological arguments.

The ground of the ongoing importance of the Incarnation as God's revelation is the resurrection of Jesus. Belief in the resurrection of the body, however, has been challenged since the earliest days of Christianity. One type of criticism has been based on the supposed impossibility for the same material to be part of two different bodies in the resurrection. Thus a person eaten by cannibals or whose organs were donated for transplant would provide a *reductio ad absurdum* argument against bodily resurrection. These situations become a nonproblem in light of quantum theory's requirement that identical particles be absolutely indistinguishable. We cannot, in the last analysis, speak of "the same atoms," but only of the same *pattern* of atoms[33]

Entanglement

In 1935, Einstein and co-workers Podolsky and Rosen presented a thought experiment which was supposed to show that quantum theory was incomplete.[34] Two particles, A and B, with net momentum **0** were to be allowed to move apart, as might happen in a decay process. The position of A and the momentum of B could simultaneously be measured with complete precision. But then conservation of momentum would also give the momentum of A, so that A's position and momentum would be precisely known. Since the uncertainty principle does not allow this, they argued that the quantum theoretical description of nature is incomplete.

Basic to this argument is the assumption that, in accord with relativity, systems separated from one another by some distance cannot communicate with one another instantaneously. There is no "spooky action at a distance" in Einstein's phrase. Thus a measurement on A cannot have an immediate effect on B. This assumption of *locality* means that we can consider the universe to be made up of separate parts.

Yet when it became possible to do experiments equivalent to that in the above argument, the assumption of locality was challenged. The work of Aspect, et al. and related experiments show that individual parts of a system remain "entangled" even when separated by space-like intervals.[35] This indicates that the world has a strongly holistic character. *Theologically*, it suggests a way of understanding omnipresence of the humanity indwelt by the Word in the Incarnation (Matt. 28:20), a concept for which Luther ("the right hand of God is everywhere") and the Lutheran tradition have argued.[36] We can see the Incarnation as the beginning of God's "dwelling" in the universe (John 1:14) without thinking of it restricted to the interior of a sphere which expands at the speed of light from Nazareth!

Quantum entanglement is not only spatial but *temporal*, as Wheeler has pointed out in his discussion of "delayed choice" experiments.[37] Wheeler's example, observing light from a quasar which passes through the "gravitational lens" of an intervening galaxy, dramatically illustrates this. In such a case, there may be two images of the quasar. A present day terrestrial observer can decide what experimental setup to use to observe individual photons from the quasar in order to determine whether a photon has traveled along both paths around the galaxy or along only one. That choice today, in some sense, determines what was the case billions of years ago.

Such considerations indicate that it may be possible to hold with Wigner that it is consciousness which endows quantum potentialities with reality, and still believe that there was a universe before consciousness evolved. In connection with the Theanthropic Principle, which we have discussed, this suggests that the "scandal of particularity" of an Incarnation in the middle of cosmic history is compatible with the belief that the Incarnation is necessary for the existence of the universe.

The arguments in the last three paragraphs are attempts to apply the quantum entanglement of systems to the presence of God Incarnate in our space-time reality. Thus they deal with possible implications of quantum physics for our understanding of the economic Trinity. It also would be possible, in a more venturesome way, to seek parallels between quantum entanglement and the concept of *perichoresis*, or mutual indwelling, of the persons of the Trinity in one another. This might be seen simply as an analogy or illustration for Trinitarian thought, but those who seek "vestiges of the Trinity" may pursue the idea that this feature of quantum reality is part of the divine imprint on creation.

Quantum Theory as a Stimulus to Dialogue

In closing, we may note a matter of general interest in addition to the specific topics which we have discussed. The fact that concerns about the interpretation of quantum theory are being posed in terms of "God" is significant[38] As we have argued, the idea of "God" underlying such statements may be quite different from Christianity's Christological and Trinitarian concepts. But the use of theistic terms shows that developments in science have provided new opportunities for correlating the Christian message with current questions.

Notes

1Albert Einstein, "On Scientific Truth," *Essays in Science* (New York: Philosophical Library, 1934), 11.

[2]E.g., Michael Talbot, *Beyond the Quantum* (New York: Bantam, 1988).

[3]Karl Barth, *Church Dogmatics*, vol. III, 3 (Edinburgh: T. & T. Clark, 1936-1962), 30-3.

[3]Barth, *Church Dogmatics*, vol. III, 1, ix-x.

[5]George L. Murphy, "Chiasmic Cosmology: An Approach to the Science-Theology Dialogue," *Trinity Seminary Review* 13 (Fall 1991): 83.

[6]Augustine of Hippo, "On the Holy Trinity," in *The Nicene and Post-Nicene Fathers*, First Series, vol. III (Grand Rapids MI: Wm. B. Eerdmans, 1978 reprint), especially Book X, 134-43.

[7]For a survey of modern Trinitarian issues and options, see Ted Peters, *God as Trinity* (Louisville, KY: Westminster/John Knox, 1993).

[8]Ian G. Barbour, *Religion in an Age of Science* (San Francisco: HarperCollins, 1990), 95-124, surveys issues. Two recent essays worthy of note are those by John Polkinghorne, "The Quantum World" (pp.333-42), and Robert John Russell, "Quantum Physics in Philosophical and Theological Perspective" (pp.343-74), in *Physics, Philosophy, and Theology: A Common Quest for Understanding*, ed. Robert J. Russell, et al. (Vatican City: Vatican Observatory, 1995).

[9]Jim Baggott, *The Meaning of Quantum Theory* (New York: Oxford, 1992) introduces the theory and interpretations. An older but more detailed treatment is Max Jammer, *The Philosophy of Quantum Mechanics* (New York: John Wiley, 1974).

[10]Allen Emerson, "A Disorienting View of God's Creation," *Christianity Today* 29, no. 2 (1985): 18.

[11]M. Renninger, "Messung ohne Stöering des Messobjekts," *Zeitschrift für Physik* 158 (1960): 417.

[12]Classical phenomena are those for which the action integral, roughly distance traveled multiplied by momentum, is much larger than h/2p. In such a case the Schrödinger equation is equivalent to an equation for conservation of probability together with the classical Hamilton-Jacobi equation.

[13]Roland Omnès, *The Interpretation of Quantum Mechanics* (Princeton, NJ: Princeton University, 1994), especially Chapter 7. The concept of "consistent histories" is also important here. See Robert B. Griffiths, "Consistent Histories and the Intepretation of Quantum Mechanics," *Journal of Statistical Physics* 36 (1984): 219.

[14]Eugene Wigner in I. J. Good, ed., "Remarks on the Mind-Body Question," *The Scientist Speculates: An Anthology of Partly-baked Ideas* (London: Heinemann, 1961).

[15]John A. Wheeler in O. Gingerich, ed., *The Nature of Scientific Discovery* (Washington, DC: Smithsonian, 1975), 261-96; 575-87.

[16]John D. Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle* (New York: Oxford, 1986).

[17]E.g., Omnès, *The Interpretation of Quantum Mechanics*, 81.

[18]F. J. Belinfante, *Measurements and Time Reversal in Objective Quantum Theory* (Oxford: Pergamon, 1975), 98-9.

[19]George L. Murphy, "The Incarnation as a Theanthropic Principle," *Word & World* XIII (1993): 256; and "Cosmology and Christology," *Science and Christian Belief* 6 (1994): 101.

[20]E.g., John Polkinghorne, *Serious Talk* (Valley Forge, PA: Trinity Press, 1995), 28-9.

[21]Jammer, *The Philosophy of Quantum Mechanics*, Chap. 11. George L. Murphy, "Parallel Worlds, Quantum Theory, and Divine Sovereignty," presented at the 1987 Annual Meeting of the American Scientific Affiliation.

[22]E.g., Frank J. Tipler, *The Physics of Immortality* (New York: Doubleday, 1994), 167-73.

[23]Barth, *Church Dogmatics*, vol. III, 3, 289-368.

[24]Willem B. Drees, *Beyond the Big Bang* (La Salle, IL: Open Court, 1990), Chap. 4.

[25]Thomas Aquinas, *Summa Theologicae*, vol. 2 (Garden City, NY: Doubleday, 1969), 198.

[26]George L. Murphy, "The Third Article in the Science-Theology Dialogue," *Perspectives on Science and Christian Faith* 45 (1993): 162.

[27]E.g., the comments of Chemnitz in Heinrich Schmid, ed., *The Doctrinal Theology of the Evangelical Lutheran Church,* 3rd ed. (Minneapolis, MN: Augsburg, 1961), 188.

[28]George L. Murphy, "Energy and the Generation of the World," *Zygon* 29 (1994): 259.

[29]Ibid.

[30]E.g., John W. Haas, Jr., "Complementarity and Christian Thought - An Assessment," *Journal of the American Scientific Affiliation* 35 (1983): 145, 203; and K. Helmut Reich, "The Relation Between Science and Theology: The Case for Complementarity Revisited," *Zygon* 25 (1990): 369.

[31]E.g., William Austin, "Waves, Particles and Paradoxes," *Rice University Studies* 53 (1967): 85; Ian G. Barbour, *Myths, Models, and Paradigms* (New York: Harper & Row, 1974), 151-5; and Christopher B. Kaiser, "Some Recent Developments in the Sciences and Their Relevance for Christian Theology," *Reformed Review* 29 (Spring 1976): 148.

[32]For the differing views of Reformed and Lutheran dogmaticians compare Heinrich Heppe, *Reformed Dogmatics* (Grand Rapids, MI: Baker, 1978), 439-45, and Schmid, *The Doctrinal Theology of the Evangelical Lutheran Church*, 314-5; 327-34.

[33]George L. Murphy, "Quantum Theory and Resurrection Reality," *CTNS Bulletin* 11 (1991): 25.

[34]A. Einstein, B. Podolsky, and N. Rosen, "Can quantummechanical description of reality be considered complete?" *Physical Review* 47, (1935): 777.

[35]A. Aspect, et al., "Experimental Tests of realistic Local Theories via Bell's Theorem," *Physical Review Letters* 47 (1981): 460. A helpful survey is R. >A. Bertlmann, "Bell's Theorem and the Nature of Reality," *Foundations of Physics* 20 (1990): 1191.

[36]In addition to the discussion in Schmid (Reference 32), see Martin Chemnitz, *The Two Natures in Christ* (St. Louis, MO: Concordia, 1971). This is a translation by J. A. O. Preus of the original edition of 1578.

[37]John A. Wheeler, "Beyond the Black Hole" in *Some Strangeness in the Proportion*, ed. Harry Woolf (Cambridge, MA: MIT, 1980). See also Nick Herbert, *Quantum Reality* (Garden City, NY: Doubleday, 1985), 164-8.

[38]E.g., Baggot, *The Meaning of Quantum Theory*, Section 5.5.

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