CHAPTER TWELVE

DIALOGUE ON CERTAINTY

WHEN ONE CONSIDERS THE SCIENCE OF THE QUANTUM WORLD, THERE are several issues that cause consonance and dissonance with religion. Before we examine the intersection of science and faith in regard to the quantum world, a word of caution. The quantum world is invisible. Quantum theory is a series of mathematical equations. The calculated results can be checked against experimental results. The predictions of these calculations can be experimentally investigated. By this process, scientists gain confidence that mathematical equations model the quantum world. Yet, one has not really gained "a picture" of the quantum world. The mathematical equations may tell us the energy levels that an electron is in, but the equations are not giving us a mental picture of an electron like we have a mental picture of a ball. Thus, a scientist has to interpret the calculated results. Since the only things we have ever seen are macroscopic objects, then our interpretations of the calculated results are in terms of macroscopic objects or contrasted to the behavior of macroscopic objects.

As one reads about quantum theory, one quickly realizes that it is sometimes difficult to separate in the narrative what is a calculated result and what is an interpretation. Thus, one is always trying to determine if an interpretation or an observation is being presented. For example, when one reads that a quantum jump is discontinuous or the electron disappears from one energy level and reappears at another energy level, is this an interpretation or a calculated result?

Since the quantum world is invisible and strange, it lends itself to mystic or spiritual speculation. Thus, probably more so than any other area of science, it is very important to know the philosophical viewpoint of the scientist writing on quantum mechanics. If the writings emphasize nonmaterialism or a holistic view of the subatomic world, do these statements come from the mathematics or the philosophy? As we shall see below, one can read two opposite "spins" on the same quantum event.

Some of the scientific-faith issues that come from quantum mechanics include: Can the same object express contradictory properties? Is the universe deterministic? Is the physical world really there? Each issue is discussed below.

Is the "Physical" World Really There?

Quantum theory has raised an intriguing question about the ontology (essential nature) of the universe. In observing the "quantum leap" of an electron from an inner orbit around a nucleus to an outer orbit or vice versa, the electron disappears. Its positional probability changes, but it does not travel. It ceases to exist in one orbit and begins to exist in another orbit without appearing to have a trajectory from one orbit to the other. This phenomenon raises the question: Is the "physical" world really there?

Scientific View

Heisenberg wrote, "[T]he idea of an objective real world whose smallest parts exist objectively in the same sense as atoms or trees exist, independently of whether or not we observe them . . . is impossible."[1] Why does Heisenberg say that there is no objective reality at the quantum level? A reason has to do with what is called the collapse of the wave function or the quantum jump. Let us consider a single atom in a sample of radioactive iodine. As we discussed previously, one-half of the sample will decay within eight days. Our atom under consideration has many possible states: it will not decay in the next eight days; it will decay after eight days; it will decay after seven days; it will decay in the next second; and so on. The wave function for this atom is a superposition of all these states with each state having a probability of being observed. Upon observation, the wave function collapses uncontrollably in a quantum jump to one of the possible states. There is no way to predict which state gets transformed from the possible states to an actual state. As Heisenberg further observed:

> The probability wave means a tendency for something. It is a quantitative version of the old concept of "potentia" in Aristotelian philosophy. It introduces something standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality.

> The indivisible elementary particle of modern physics possesses the quality of taking up space in no higher measure than other properties, say color and strength of material. In its essence it is not a material particle in space and time but, in a way, only a symbol.[2]

So to Heisenberg, an electron is no more physical than color is. (Of course, this is a circular example since color in most cases is produced by the movement of electrons.) Schrödinger was not happy with Heisenberg's interpretation and said to Bohr, "If one has to stick to . . . quantum jumping, then I regret having ever been involved in this thing."[3] And to show how ridiculous this interpretation was to him, Schrödinger introduced in 1935 what is called Schrödinger's Cat Paradox.[4] Take the previous radioactive atom and place it in a box along with a detector, a bottle of poisonous gas, and a cat. Close the box. If the radioactive atom decays, the detector will cause the bottle to release the poison and kill the cat. When one opens the box after one day, will the cat be alive or dead? When the experiment begins, the wave function for the whole system (cat + atom) corresponds to a live cat. As time passes, the probability that the atom has decayed increases with the cat dying. The wave function becomes a mixture of cat-alive and cat-dead. Upon observation, the wave function uncontrollably collapses (quantum jump) to one of these outcomes. In this paradox, a macro-object, the cat, has been placed in quantum states of not-alive/not-dead until the observation is made. Schrödinger did not believe that this was reasonable and that quantum mechanics was an incomplete description of matter. (It is interesting that even though Schrödinger presented the Cat Paradox to show the incompleteness of quantum mechanics, some authors say that he presented the paradox to show the difficulty of interpreting quantum mechanics.)[5]

In conclusion, the views of the quantum world range from there is an objective reality independent of our observations (Einstein and Schrödinger) to there is a potential at the quantum level that our observation actualizes (Bohr and Heisenberg). Is the Bohr-Heisenberg view consonant with the Christian view that the order of the universe is contingent upon God?

Religious View

Different religions answer this question in different ways. The Zen Buddhist regards the physical world as an illusion.

Unhappiness and suffering come from the acceptance of the illusion. Christian Science in the West shares this same basic view, denying the reality of a physical world. The Christian Science emphasis on healing is based on the belief that the physical body does not really exist; therefore, it cannot be sick or injured. Within Buddhist thought *enlightenment* allows a soul to escape the illusion and reemerge with their concept of the divine or unconscious universal spiritual reality.

Hinduism in its diversity has some similarity with this perspective. Hinduism would affirm the existence of the physical world as an aspect of the divine but would tend to deny the differentiation of the physical world. In other words, everything is a part of the whole, which is actually spiritual rather than physical. This view is reflected in the statement from the *Vedas*, "That thou art." In pointing to any object (that), it can be said that each person is that object. A person is the flower they pass in the garden; they are the rain that falls on their face; they are the dust beneath their feet. Everyone is a part of everything else, and things only appear to be distinct from one another.

Christians, Jews, and Muslims believe the physical world really does exist. They believe that God created the physical world as a good thing. They believe that all of creation is separate and distinct from God. Furthermore, they believe that each aspect of creation has a clear distinction from every other aspect. Though the enormous number of aspects of creation may have an intricate interrelationship, like a family, still everything is unique and separate. Creation behaves in such a way that it can be known consistently over time. Because of the consistent behavior of creation, people can function within it on a day-to-day basis with certainty about how it will behave.

The doctrine of *creatio ex nihilo* (creation out of nothing) expresses the idea that God created the physical world out of nothing. Nothing existed, and then something existed. The findings of quantum mechanics suggest that "nothing" continues to play a role in the substructure of atoms. Between one orbit and another orbit, does the electron cease to exist? Is nothing there? As we saw in chapter 5, the activity of calling creation into existence described in the first chapter of Genesis is a continuing action. Is quantum existence an on-again, off-again existence of an electron that continually reappears from nothing? While quantum theory developed around the behavior of "large" pieces of the atom, we now know that the atom has a vast array of subatomic "particles" even smaller than the electron. The deeper we look, the more we find. The atom now looks more like a solar system that has the potential for being a galaxy. The atom now appears to be mostly empty space dotted with bits that sometimes are not there. In the face of quantum theory, the doctrine of *creatio ex nihilo* suggests that God continues to call the physical world into being from nothing.

Do We Live in a Deterministic Universe?

Quantum theory presents a challenge to the concept of the universe conceived by Sir Isaac Newton. Newton thought of the universe as a place that operated like a machine, but quantum mechanics suggests a much more subtle universe full of uncertainty at its core. If this uncertainty rests at its core, then does it "infect" the whole universe to the macro level?

Scientific View

Causality refers to the case where two events are in a cause-and-effect relationship. The first event causes the second to occur. If one knows the first event, then one can predict what will happen in the future. Philosophically, causality can be extended to *determinism,* which says that every event is the consequence of a preceding event. Determinism also says that every future event is predictable by a knowledge of scientific laws and current physical conditions. Quantum theory presents two challenges to causality and determinism: individual events cannot be predicted with certainty and the Heisenberg Uncertainty Principle.

Uncertainty in calculating individual events. When one thinks of causality, one thinks of Newton's Laws of Motion and universal gravitation of classical physics. To predict the future values for a physical variable of a system, one begins by specifying current values of the variables, usually position and momentum that are observable. These values are then entered into Newton's equations in order to calculate (predict) future values for position and momentum. In classical physics, one can calculate with certainty the behavior of an individual event. As this book is being written, Mark McGwire and Sammy Sosa are again battling to see who can hit the most home runs in a season. Knowing the position and momentum of the baseball as it leaves the bat, one can theoretically calculate its path under the influence of gravity and air resistance and thus predict whether the hit will be a home run.

In quantum mechanics, the important variables of the system are represented by the wave equation which is not observable. The Schrödinger wave equation performs the same function as Newton's equations; the Schrödinger wave equation allows the calculation of how the system changes with time. In classical physics, definite values are predicted for the future state. Quantum mechanical calculations result in only probabilities of allowed outcomes (the eigenvalues). The calculations result only in probabilities of which energy level is most likely, or probabilities of the region of space with the greatest probability of finding an electron. If hitting a baseball were a quantum event, one would receive a calculated probability for a home run, for an in-field fly, as well as all other possibilities. The standard or Copenhagen Interpretation says that these probabilities remove all information about causality or the trajectory of the electron or quantum baseball.

Another quantum event where one cannot obtain information about individual objects is radioactivity. Radioactive decay is a quantum event. One can determine the half-life of a radioactive substance. As an example, radioactive iodine, which is used to diagnose and treat thyroid diseases, has a half-life of eight days. If one has a pound of radioactive iodine, after eight days one knows that only one-half pound of radioactive iodine will be left. However, there is no way to predict whether or when an individual iodine atom will decay. It could decay in the next second, minute, day, month, and so on. All one can determine is that one-half of the iodine atoms will decay in eight days. One cannot make any accurate prediction about the individual atoms.

Heisenberg's Uncertainty Principle. This principle states that for all physical properties that come in pairs, one cannot know accurately and simultaneously both properties at the same time. Examples of these pairs are position/velocity and energy/time. For example, if one knows accurately the time that radioactive decay takes to produce an alpha particle, one cannot simultaneously determine accurately the energy of the alpha particle. In fact, the Heisenberg Uncertainty Principle further states that the more one knows about one property, the less one knows about the other. Since position and velocity are important in determining future behavior, one is left with an inherent uncertainty at the quantum level.

What have been the responses to these quantum challenges to causality? One response is represented by Einstein, Planck, and Schrödinger. They believed that the uncertainty of quantum mechanics was due to human ignorance. They thought the universe at all levels was causal and that ultimately a better theory would arise to reveal causality at the quantum level.

Heisenberg at first thought that the uncertainty arose from the limitations of experimental design. Electromagnetic radiation is used to probe the quantum world. As we discussed in chapter 10, electromagnetic radiation is about the same size as the subatomic particles. Thus, the probing of the quantum world by electromagnetic radiation should cause changes and thus uncertainties. This explanation of quantum uncertainty does not explain the inability to predict which individual atom will undergo radioactive decay. Heisenberg later said that this uncertainty is a fundamental property of nature; no experimental design modification will remove it. This is the critical realist view that scientific theories reflect how nature really is. The results of the EPR Paradox experiments seem to me to say that quantum mechanics is complete. Thus, the uncertainty reflects the ontology of nature.

Religious View

The idea of a deterministic world in which all of the courses of nature are determined in advance, including the course of human lives, has figured prominently in a variety of religious systems. Within the Hindu frame of reference, *karma* represents one of the central teachings. Every person has a karma that they live out. Ancient Greek and Roman religious perspectives included the idea of *fate*. Every person has a fate allocated. Even the gods are subject to fate. Among the Celtic peoples of Europe, the Druid religion included a view that the destiny of the gods and all people is woven into the great rope of life by a group of sisters. Often a deterministic religious view also includes a sense of progression, or "historical" movement, toward a goal or end. Within Hinduism this end will occur when Kali dances the final dance of destruction and Vishnu the Destroyer brings all things to an end. Within the Celtic religion, the end comes when the gods are consumed in flames along with their stronghold of Valhalla.

Within Christianity, Islam, and Judaism, the view of a deterministic world is overshadowed by belief in a personal God. God is not subject to fate, destiny, karma, or any exterior force, goal, or value. This God who created the universe, nonetheless, has power and authority over it. In classical Judaism, Christianity, and Islam, the God who created all things will also bring all things to completion at a final day of judgment, the end of the world.

Within the Christian community, the concept of determinism emerges from one's understanding of how God exercises authority to bring the world to a conclusion. If the end has been determined, then what events between the beginning and the end did God determine? Concerning revelation, is prophecy based on what God knows about the future or about what God has determined about the future? The classical formula of how God brings about his will may be stated that God has absolute sovereignty without violating human freedom.

The issue of human freedom has been increasingly important since the Reformation and the Enlightenment. The growth of humanism as a significant cultural perspective in the West led to a democratizing of theology and a tendency to exaggerate the polarities of divine sovereignty and human freedom. As has been common in so many areas of life and thought in the modern era, people tended to opt for either a sovereign God or a free human. This trend was accelerated by the spirit of revolution that challenged monarchy and the rights of kings in England (1642), the American colonies (1776), France (1789), and across Europe (1848).

Science contributed to the fragmentation of the understanding of sovereignty and freedom through the work of Isaac Newton. Newton conceived a totally deterministic cause-and-effect universe governed by laws that allowed one to know where the universe was going and where it had been. It was only a matter of time and experiment to understand what was determined by the laws of physics. This new determinism cut God out of the equation and led to the religious view call *Deism*. Deism conceives of a God who created the universe and established the laws of motion but is no longer involved. People could now have the security of scientific determinism without the burden of obligation to God.

The Western philosophical preference for either/or categories has led to a division in the Protestant community between Arminians (free will) and Calvinists (divine sovereignty). The breakthrough in quantum mechanics has sent shock waves through the scientific community. It had flourished for two centuries based on the security of the mechanical, deterministic universe of Newton. Science has now lost its certainty. For Christians the issues surrounding how God relates to the world include prayer, miracle, Incarnation, prophecy and fulfillment, salvation, and the final destiny of all things—to name but a few.

Quantum mechanics suggests that the modern preference for either/or needs to regain some of the ancient understanding of both/and. Quantum mechanics suggests that at the subatomic level, the universe is quite wide open. Whereas laws operate in a deterministic way at the macro level of everyday experience, the micro world operates in an indeterminate way. This permits God the freedom to interact without violating any of the macro laws.

The structure of quantum mechanics also demonstrates a dual feature of determinacy and indeterminacy. The position and velocity of an electron are indeterminate, and the "orbit" of the electron has a range within which it operates. The energy of the electron, however, has a fixed, determinate quality. It does not vary. Whereas the position, velocity, and orbit are indeterminate, the electron also has a determinate ontological dimension in terms of its relationship to the nucleus. It does not exist except in relationship to the nucleus.

The problem of quantum mechanics arose in part because of the model used to describe the relationship of the electron to the nucleus. The term *orbit* brought with it a huge collection of unspoken assumptions based upon what people know about the planets and other bodies that orbit the sun. These orbits have a deterministic character or regularity about them which is not present in the "orbit" of electrons. While the electron does change position all around the nucleus, it does not do it like a planet changes position around the sun.

The same problem arises when theologians apply a biblical model for God to the wrong attribute. The Bible describes God as both King and Shepherd. Both models are true, but they describe different activities of God. They do not describe the nature of God. Theologians have tended to use the model of the King to describe God's sovereignty while overlooking the model of the Shepherd. The King model describes God's right to rule and establish moral law, as well as his right to enforce the law and punish the offender.

In fact, the model of the King only describes the fact of sovereignty, not the manner of exercising sovereignty. The biblical model of the Shepherd describes how God exercises sovereignty. Like a shepherd, God allows a certain amount of freedom within bounds, but he keeps the flock together. As long as the sheep stay within the acceptable range, they are allowed great freedom of movement. If they wander outside that range, however, the Shepherd does what is necessary to bring them back. While the Shepherd model is neither Arminian nor Calvinistic, it is biblical and demonstrates how determinacy and indeterminacy, sovereignty and free will interrelate. This feature of quantum mechanics suggests the integral relationship of determinacy and indeterminacy, of divine sovereignty and human freedom.

Can Something Express Contradictory Properties?

One of the most prominent ideas in Western approaches to thought is known as the *Law of Noncontradiction*. According to this principle of logic, two contradictory ideas cannot be true at the same time. Both waves and particles may exist, even though they are contradictory ideas. From our macroworld perspective, their properties are mutually exclusive of one another. The problem arises, however, if a single thing is said to have mutually exclusive properties. An electron behaves like a wave and a particle. What does this scientific discovery do to the tradition of Western logic?

Scientific View

In certain experiments, electrons display the particle properties of mass (9.109×10^{-31} kilograms) and electric charge (1.602×10^{-19} coulombs). In other experiments, electrons display the wave property of wavelength. (A beam of electrons at an energy of 54 electron volts has a wavelength of 165 picometers.) Protons, neutrons, hydrogen atoms, helium atoms, hydrogen molecules, and fullerenes also show similar behavior. As we discussed in chapter 10, particles and waves are contradictory, with particles being discrete and waves being continuous. Thus, the same object can express contradictory properties.

Bohr developed the Complementarity Principle to explain these particle and wave phenomena. He stated that these properties are mutually exclusive and cannot be simultaneously observed. Bohr is saying that if the experiment detects waves, the experiment gives no information about particles. Many believe that Bohr was comfortable with combining these opposites because of his readings in Eastern religions. Bohr went as far as placing the yin and yang on his coat of arms.

Religious View

Eastern religion has a high tolerance for contradiction and paradox. Zen Buddhism is noted for its spirituality based on the contemplation of contradictory or irrational ideas, such as the question, "What is the sound of one hand clapping?" Hinduism is not a single religion and certainly not a systematic theology. It represents a vast religious heritage of many different peoples who have lived in the Indian subcontinent over the last four thousand years or more. Hinduism has a high tolerance for contradictory religious ideas which are then relativized as aspects of one greater whole that people experience through enlightenment. For this toleration of contradiction to work, Hinduism denies the substantial reality of the possible opposites, polarities, and extremes of existence as everything is regarded as part of a single whole. Thus, nothing can actually contradict something else, because everything is the One.

Even within the religions that appear to tolerate contradiction and paradox, however, the toleration veils a more subtle form of resolution. By reducing everything to the One, the modalism of Hinduism rejects the contradiction and says the polarities only appear to be mutually exclusive. The yin and yang of Tao collapses the "opposites" into a single unity so that the opposites are complimentary aspects of one another. The dualism of Zoroastrianism, on the other hand, allows no relationship between the opposites that war with each other. In both modalism and dualism, the paradox is not allowed.

Christianity in its classical formulation insists on retaining the paradox or contradiction as the most critical foundation of its faith. While it shares with Judaism and Islam the basic beliefs about a Creator God, its faith in the Incarnation of that God distinguishes Christianity from other religions. The Nicene Creed states the contradiction:

> I believe in one God the Father Almighty, Maker of heaven and earth, and of all things visible and invisible. And in the Lord Jesus Christ, the only-begotten son of God, Light of Light, very God of very God, begotten, not made; being of one substance with the Father, by whom all things were made: Who for us men and for our

> salvation came down from heaven, and was incarnate by the Holy Ghost of the virgin Mary, and was made man; and was crucified also for us under Pontius Pilate.

The basic heresies of Christianity are judged on the basis of their refusal to cling to the contradiction. The tendency of people to reject the contradiction has resulted in a variety of heresies from the early Christian era that continue to reappear. The *Docetists* said that Christ was fully divine, but only *appeared* to be human. The *Arians* claimed Christ was fully human but not fully divine. The *Ebionites* claimed Christ was adopted by God and denied the genuineness of his deity. The *Apollinarians* believed Christ was half man and half God, denying the completeness of his humanity. The *Nestorians* believed a divine and a human person inhabited Christ, denying the intrinsic union of human and divine. The *Eutychians* believed Christ had only one nature after the Incarnation, denying the continuing presence of two natures. What all of these heresies have in common is their attempt to collapse the contradiction and explain it away.

Apparently the laws of physics and the laws of logic collapse as we approach infinity (physical world) and eternity (spiritual world). Rationality does not leave, but the traditional ways of understanding rationality operate with a different paradigm at the level of quantum mechanics and the Incarnation. Natural revelation (nature) and specific revelation (Bible) are as reliable as ever for knowledge, but the human philosophical systems used by scientists and theologians are fraught with dangers.