THE HUMAN DIMENSIONS OF TWENTIETH CENTURY PHYSICS

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INTRODUCTION

There is a strong and inextricable relationship between the ever-changing scientific description of reality and the way in which human beings define themselves within that reality. The history of philosophic thought, especially relating to humankind's origin, nature, and destiny, is strongly correlated with the concurrent physical description of the universe. The 20th century physical description of the universe, however, has become too complex and mathematical (essentially too far away from experiential knowledge) for most people to grasp. At the same time, the natural interpreters of the physics world view - the philosophers - have evolved too far away from their historical roots to be able to serve this function, and the task has thus fallen by default on the scientists themselves. Their attempts to translate mathematical concepts into verbal descriptions generally lead to the appearance of paradox and, even worse, have been used to justify the most outlandish forms of mysticism, the existence of extrasensory perception, and pernicious forms of moral relativism. The current world view in physics is strange enough in itself without adding on pieces of spiritualistic, psychic, or behavioral baggage. As someone with a degree of familiarity with the new physics, though without the fundamental grasp of the area which only comes from deep involvement with the equations, I will attempt to describe how our concept of the universe has changed in this century, and suggest what this change implies for a new humanistic philosophy.

PARALLEL EVOLUTION

The concept of the earth as the center of the universe - a pervasive idea that, in one form or another, was a central theme of philosophy and religion until the Renaissance - implied that our world, and the people of that world, were special in a multitude of ways. The earth was the center of creation, and human beings were the chosen inheritors of a unique and wonderful destiny indicated by their placement within it. "Not a sparrow falls..." and other relevant passages in the Bible mirror our special relationship with the creator of this universe, and in turn imply our responsibilities as the recipients of such bounty.

The Copernican revolution altered this world view, placing the earth in rotation around the sun like the other planets. We no longer occupied a special niche in the universe. Instead, with the development of Newtonian physics, the realization that the distant points of light seen at night were actually stars like our own sun, and the development of scientific inquiry, we found ourselves living in a universe governed by "natural law", a mechanical and mechanistic construct often likened to a clock. There were rules that reproducibly related cause and effect in the experiential world, and these rules also seemed to hold true for the movements of bodies in the heavens. By analogy, there should be rules or laws governing moral and ethical behavior, because we too were part of the clockwork universe, and the schools of philosophy that developed during this time sought to discover them. There was little distinction between the scientist and the philospher (Kant, for example, published papers on cosmology which presaged the modern view of the universe), and "natural philosophers" made important contributions in both areas.

In a sense, the theory of evolution was a natural outgrowth of a cosmos governed by universal laws. Just as the physical world could be accurately and reproducibly represented by a set of mathematical relationships, so the origin and development of life on earth was found to be governed by a discoverable set of rules (e.g., natural selection, development from less complex and specialized to more complex and specialized). The biological world, with all its abundance, could thus be seen as simply another example of natural laws in action, and humankind the latest development in this continuing process.

It is at this time, however, that world views arising from different concepts of the nature of universe came most clearly into conflict. The Judeo-Christian concept of humankind's place in the universe was a logical corollary of the old world view of the earth as the center of creation. The increasing success with which the universe could be described in alternative terms, culminating with human beings as the latest product of an ongoing "mechanistic" process, brought the newer world view into direct conflict with religion. This is best exemplified in; the series of essays published by Thomas Huxley (as the proponent of the "new" world view) and Matthew Arnold (as the defender of the "old" world view). For. those who successfully reconciled these two sets of thought, the concept of a God had to become one that was increasingly remote from everyday world experience. Rather than the being who was intrinsically and personally involved in every aspect of creation, including people's lives and the way they lived them, God was the clockmaker who set up the mechanisms and started the clock running. And then, perhaps, went away...

The 19th century scientific concept of the universe affected much more than traditional religious thought, however. New conceptions of religion - the Ethical Culture movement, for example - which were centered on natural moral law began to evolve at this time, as did other religions (e.g., Christian Science) which "solved" the conflict between the old and new world views by rejecting reality (the world of sense perception) partially or entirely. Also born in that time were new religions of "revelation" - the Church of the Latter Day Saints and Ba'hai, for example - which implicitly or explicitly demonstrated that the God of the old world view was still personally concerned with human affairs.

Other movements which resulted from the new world view were philosophical and socio-political. The roots of existentialism can be traced back to this period of ferment (e.g., Kierkegaard), as can the beginnings of logical positivism. The utilitarian philosophies of Bentham and Mill were both a reaction to traditional religion. and an attempt to quantify proper human behavior, and modern neo-utilitarian philosophy continues along these lines. The political philosophies of Hume and Burke were attempts to create societies based upon balance and law (cf. the Constitution), in the same way that the solar system was balanced and moved according to Newton's laws of motion. The development of Marxian political philosophy can also be interpreted in this context. But the ultimate (mis}use of the new world view was in the development of social darwinism and associated laissez-faire political and socioeconomic philosophies, which remain strong influences in our society today.

A brief description of the universe as seen at the end of the 19th century would sound very familiar to the reader, because it is essentially the world view held by most lay people (and far too many scientists and engineers) today. The universe is a vast, infinitely large space, empty except for the widely spaced galaxies (of which our own Milky Way is one) which are clusters of millions of stars. The universe is governed by natural laws which can be discovered and quantified, and which hold true throughout its unimaginable extent (e.g., Newton's Laws of Motion). There is a direct relationship between cause and effect, which means that the same experimental result can always be obtained if the same initial conditions are used; it also means that we can predict what will happen in various situations based upon our own previous experience. All matter is composed of atoms, the irreducible minimum unit, and these atoms can combine together in various ordered ways to form new molecules whose properties may be very different from any of their constituents. If we are very sophisticated, we also know that electricity and magnetism are simply different manifestations of the same wave phenomenon. Thanks to Darwin and Wallace, it became clear that the evolution of living things from primordial conditions is also a process that is governed by natural laws. Since the universe and everything in it obeys universal laws, the nature of which can be characterized, it is essentially mechanistic, deterministic, and reductionist.

20th century "common knowledge" has done little to alter the prevailing world view. Many people know that the speed of light is a constant which provides an upper limit on possible velocity. They have also heard of relativity (although they do not know what it means in physical terms) and E=mc2, and probably know that they live in an expanding universe. In addition, they live with the idea of atomic energy (power plants, atomic and hydrogen bombs), X-rays and cosmic rays, lasers (as weapons and as supermarket checkout equipment), digital watches and computers, etc. This list can be extended indefinitely, but the important point here is that the science and technology associated with these items is completely outside of the 19th century world view that most of us continue to hold.

THE END OF THE (MECHANISTIC) WORLD

The beginnings of the new physics are rooted in a few minor observations that could not be explained by 19th century theory. These observations were not minor, of course, since they led to a complete revolution in physics, but the attitude of many physicists at that time was that all the work that remained was dotting the 'i's and crossing the 't's. One of these observations had to do with the nature of light. For almost every physicist, it was clear that light had to be a wave; one could demonstrate constructive and destructive interference (diffraction) by light in the same way that sound waves and even water waves showed these properties. However, unlike other types of waves, the speed of light propagation was a constant irrespective of how it was measured. For example, if we measure the speed of light in the same direction the earth rotates, it should be faster than if we measured it in the direction opposite to the earth's rotation; this is analogous to the effect of the jet stream on the time it takes to get from New York to London versus the longer time it takes to get from London to New York. Because the speed of light is independent of the direction in which its propagation is measured, it cannot be viewed as a classical wave being propagated through the "ether". Other experiments exploring the nature of light also led to contradictions of 19th century wave theory.

At about this time, scientists were also beginning to learn about a whole new class of phenomena, including radioactivity, X-Rays, and gamma rays. Not only could such observations not be explained by the 19th century physicists and chemists, they also indicated that the idea of the atom as the smallest indivisible unit of matter was seriously flawed. Furthermore, no energy form with which scientists were familiar could explain how the sun was capable of providing so much energy over the years it had been in existence; a ball of coal of the same size which released the same amount of energy per second would be burned out in about 10,000 years, and while the scientists of the time did not know how old the sun was, it HAD to be millions of years old since the earth was millions of years old.

THE BEGINNINGS OF A NEW REALITY

These and other problems led, within 20-25 years, to a completely new view of the nature of matter - quantum mechanics - and a completely new view of tne universe based on Einstein's Special Theory of Relativity and General Theory of Relativity. The only way in which the nature of light could be adequately understood, and the results of experiments with light explained, was to interpret light as a stream of massless (at rest) units called photons. A photon is a discrete packet (or quantum) of energy, and the wavelength of light is related to the energy contained in the packet by a proportionality factor termed Planck's Constant. In effect, the entire electromagnetic spectrum is generated by photons of different energy levels and, at the atomic level, it can be seen that the effect of electromagnetic beams is discontinuous. In trying to describe light or any other part of the electromagnetic spectrum, then, we are faced with a serious language problem. Light has wave-like properties (e.g., interference), but it is not a wave because it travels at constant speed; *it* is discontinuous (quantized), and does not need anything to "push against" in order for it to be propagated.

Within a very short period of time after the discovery of radioactivity, gamma rays, etc., the "solar system" model of the atom was formulated, where the newly discovered protons and neutrons formed the atomic nucleus, and electrons orbited around the nucleus. (This model is fundamentally incorrect, but will serve as a rough analogy to what passes for reality at the quantum level.) For each atomic element, there was a unique number of protons and electrons, and chemical reactions occurred through elements sharing one or more of their electrons in the outer "orbit". These "orbits", like photons, are quantized, indicating that electrons can only occupy certain energy levels around the nucleus and that any transition between levels requires the absorption or emission of a specific quantum amount of energy (a photon of characteristic wave-length). The underlying rules for chemical reactions, the structure of atoms, the properties of the various subatomic particles, and the nature of particle interactions can all be obtained through the fundamental equations of quantum mechanics.

Without going into detail, quantum mechanics is the extension of the concept of "duality" from the electromagnetic spectrum alone to all aspects of matter and energy. Like light and other regions of the electromagnetic spectrum, the behavior of matter at the atomic and subatomic level cannot be described using either Newtonian physics or wave theory alone. While electrons, for example, have mass (unlike photons at rest), they can exhibit both particle-like activity and wave-like activity. It is in trying to describe how this is so that quantum descriptions of events begin to sound like mysticism. E.g., in order to define fully the motion of an object in Newtonian terms, one determines its position and momentum. If we try to do this for an electron, however, we .run into two related sets of problems. One is experimental: the only way we can "see" an electron is by using a beam of (e.g.) photons, which will interact with the electron and affect our results; in effect, all of the entities with which we are dealing in such an experiment can interact with each other, like using a bowling ball to "find" pin # 8. But, more fundamentally, there is an intrinsic universal limit to the accuracy with which we can measure anything, which turns out to be Planck's Constant, the proportionality factor which relates wavelength and energy. The errors in measuring position and momentum, when multiplied together, can never be smaller than or equal to this intrinsic limit. Thus, the more accurately we know the position of the electron, the larger the uncertainty in our measurement of its momentum and vice versa. This intrinsic limit to the accuracy with which we can describe the motion of a subatomic particle is called Heisenberg's Uncertainty Principle.

Because Planck's Constant is infinitesimally small, this "uncertainty" is irrelevant to our experiential world, and the equations of quantum mechanics reduce to the more familiar classical (19th century) description. At the level of molecules, atoms, and subatomic particles, however, its size is comparable to the sorts of numbers we want to collect. The end result is that we cannot "know" about electrons and other subatomic entities in the same way that we "know" events in the perceptual world. The equations describing a given electron, then, do more than create an apparent contradiction in our understanding of its nature, which essentially has no analogy in the experiential world; they also associate a given property of our electron with a probability. Since all the possibilities for (e.g.) location must add up to unity, our electron may actually be anywhere in the universe; however, the probability that it is in the middle of the Horsehead Nebula rather than associated with a given hydrogen atom is vanishingly small.

In terms of the equations, this probabilistic model leads to some very strange conclusions, which nevertheless have been shown experimentally as well as theoretically. For example, since a given electron can be anywhere in the universe, our attempts to observe it "force" the electron to manifest itself in the region of our apparatus; this is sometimes called "collapsing the wave function." In a sense, the very act of observation changes the universe by changing the probabilities associated with aspects of it. Furthermore, the very nature of our observation determines the properties that the electron manifests: if we want to study an electron's particle-like properties, it will behave like a particle; if we want to study its wave-like properties, it will behave like a wave; and if we change the ground rules of the experiment in the middle, the electron "knows" this and "changes" properties. In addition, we can make an electron behave like a wave and exhibit interference-type behavior in the absence of other electrons; we could say that the electron-as-wave is interacting with the probability waves of other electrons that we are not looking at during that given time.

These conclusions are interpreted in two different, but equally non-intuitive, ways. One way says that all possibilities (with their associated probabilities) coexist simultaneously until, by observing, we .choose one. But there are other universes in which the choice was not made, or a different choice forced a different type of collapse of the wave function; each choice, no matter how trivial, leads to a bifurcation of possible universes. This is the Many Worlds hypothesis. The second way is similar to the first, but implies only that we ourselves change the universe every time we collapse a wave function by changing the probabilities describing it. The equations do not distinguish between the two.

Although the study of an individual electron leads to the kind of error and apparent duality of properties described above, if a LARGE number of electrons or photons or other quantum entities are studied simultaneously, their behavior can be described quite accurately. Analogously, a political poll cannot predict how a given voter will vote (or even if he/she will bother), but can predict fairly well how, on the whole, a large number of potential voters will behave. For an individual, there is a probability associated with whether or not they will vote and, if they vote, which candidate will be selected. And in terms of the observer problem, one could even say that the very act of a pollster asking a voter's preference "collapses the wave function" by forcing the voter to make a choice. So, without fully understanding or being comfortable with the quantum world, many scientists can use the equations for further studies and engineers can translate their implications into technology. A modern electron microscope is a good example of this, since it takes advantage of the dual nature of electrons. The electron beam is "focused" by a magnetic field on the sample and, like light, it forms an image of the sample on standard film; alternatively, by changing the shape of the beam, one can collect the diffraction pattern of the sample on film, another "wave" phenomenon. But, at the same time that we are taking advantage of the wave-like nature of the electrons, we can also use its particle properties. When a high-speed electron hits an electron contained in an atom of the sample, the particle-particle collision can result in the emission of an X-ray; the wavelength of this X-ray can be monitored to perform an analysis of the elements composing the sample at the same time the image is being generated on the film. The modern electron microscopist can thus be both an anatomist and a chemist, thanks to the special properties of the entity we call an electron.

It should be mentioned here that over the last twenty years, even the picture of the quantum world has changed enormously. While everything that I have already described still holds true, it has become clear that the fundamental building blocks of matter are not protons, electrons, and neutrons, or even the incredibly long list of "new" particles that have been generated in accelerators, synchrotrons, and the like, but a class of entities (I do not want to call them particles) termed quarks. Quarks have various attributes which can be described mathematically, but which again have no analogy in the experiential world. So, in language, one can say that quarks have "color", "charm", "strangeness", etc,; we could call quarks something else instead, and describe their attributes in terms of "texture" or whatever. When one combines them together in various ways (and holds them together using gluons!), one can generate all of the observed entities (protons, pions, intermediate vector bosons, etc.) and even some that cannot be observed. Despite the fact that this is an even more abstract mathematical construct than quantum mechanics, it works both descriptively and predictively, the two elements of a good model.

QUANTUM MECHANICS AND THE COSMOS

At the other end of the size spectrum, we have the universe. 20th century physics - thanks to Einstein and subsequent workers - has completely redefined what the universe is, how it came to be, and its eventual destiny. In effect, the very latest ideas about the universe have come about through the marriage of quantum mechanics and cosmology - the integration of the smallest and largest - and some of the non-observed particles predicted by quark theory could only have existed under conditions associated with an infinitesimal time after its "creation" in the Big Bang.

The first, and most fundamental, contribution to the new universe came from Einstein as the Theory of General Relativity. The universe can be described as a four-dimensional entity, consisting of length, width, height, and time. This "space-time continuum" can be conceived of as a four-dimensional sphere in the sense that it is finite, but has no ends or edges. The sphere analogy is of only limited value, however. A sphere implies an inside and an outside, but the Einsteinian universe has no outside. In essence, the size of the universe is determined by its own unique properties. Gravitation, one of the fundamental forces of the universe, can be understood in terms of this theory as a local distortion of the continuum. The analogy generally used is of a rubber sheet stretched out flat. If we put weights at random locations on this sheet, it will sag around the weights. If the sheet were flat, we could roll a marble across it, but if we tried to do that near one of the sags, the marble's path would be affected. It would roll around the depression caused by the weight, and eventually come to rest in the depression.

So the universe is of finite size and age, rather than being infinite. Actually, one does not need Einstein's theories in order to know this experientially. If you look at the night sky, it is dark except for the stars. However, if the universe were infinite in size, then there should be a star at every possible dark location (because there would be infinitely many stars and galaxies). And, since the universe is infinitely old, the light from each of these stars would be reaching us. So the sky, at night or during the day, should be a blinding, unresolved hemisphere of light. The fact that it is not a clear indication that the universe is finite.

In addition to being finite, the universe is expanding; the galaxies are receding from each other rapidly. For this and many other reasons, the current view of the universe is that it arose in a Big Bang. There are a number of Big Bang theories around, but what they all have in common is that, about 15-20 billion years ago, all of the contents of our present universe was packed into a superdense sphere of incredibly small size (less than I divided by 10 followed by 42 zeroes cm; a hydrogen atom, in contrast, has a diameter of about I divided by to followed by 8 zeroes cm). In a series of reactions explainable by quark theory in part, the superdense, superheated initial sphere expanded incredibly rapidly, going through reactions that led to the type of matter, energy, physical laws, forces, and temperature that we are familiar with today. In terms of the space-time continuum, the original size of the universe was equal to the size of the original superdense sphere; as it expanded outward in the Big Bang, the universe became bigger. (It is NOT the case that space-time already existed, and that the matter and energy from the Big Bang is expanding into this available volume. Rather, the universe defines its own dimensions and properties.)

Cosmologists can now describe what happened from about I divided by 10 followed by 35 zeroes second up to the present time, but two fundamental questions remain. One (the obvious one) is what happened BEFORE; how did the superdense supersmall sphere which led to the universe we know come to be? The other, equally obvious, is what is the eventual fate of the universe? The exciting part about the new cosmology (or the scary part, depending on your point of view) is that physicists expect soon to be able to answer both these questions.

At this time, there are two theories about the origin of the universe before the Big Bang. One suggests that the universe itself is a singularity, arising from nothing as a quantum mechanical fluctuation. Associated with Planck's Constant are related constants, Planck time and Planck distance. An electron can do "impossible" things, just as long as it does it within the period of time defined by Planck time. If the universe arose as a fluctuation of Planck distance in diameter for a time less than or equal to Planck time and exploded (expanded rapidly) within this time limit, then the universe could come into existence in this way. A second theory rejects the idea of a singularity, suggesting instead that our own Big Bang is one of an infinite set of cycles of expansion and contraction, each one resulting in a universe with possibly the same or possibly different universal constants.

The second theory contains within it the answer to the question of the evcntual fate of the universe, but it is by no means certain at this time that, however it arose, the universe will eventually return to its original condition. In order for the expanding universe to reverse itself and someday begin to contract, there has to be a certain minimum amount of matter in the universe; this would make it "closed". If there is not enough, the universe will continue to expand, and eventually die a heat death; i.e., the degree of disorder (the amount of entropy or the amount of energy unavailable for use) will increase. This is an "open" universe. Of course, the extent of openness or closedness will depend on how far away from the critical amount of matter the universe contains. Our own universe is balanced on the knife edge between open and closed, as unlikely a possibility as the initial singularity which may have given rise to it, so we do not yet know which fate lies in store for it.

A CALL **FOR** A NEW **pmLOSOPHY**

How does 20th century physics impinge upon our own world view? The answer, for most people, is little or not at all. We take the technological innovations developed from quantum mechanical theory for granted, without knowing or caring that these innovations are actually the tangible expression of a completely novel approach to the nature of our universe. Our concept of the relationship of humankind to the cosmos remains rooted in a mechanistic, reductionist grounding or - even worse in an ancient, anthropocentric philosophy that became outmoded half a millenium ago. The former reduces humans to insignificant deterministic mechanisms in an infinite and uncaring clockwork universe, while the latter confers upon humanity a central importance (and perhaps freedom from moral responsibility) that is equally unrealistic. In both cases, however, the purpose of human existence and the development of related philosophies of existence have been drawn by analogy from the nature of the universe as it was formulated at that time.

In a similar fashion, the modern picture of the nature of the universe, and of how things work within this universe, can be used to develop an entirely new perspective on humanity's relationship to the cosmos. The universe is finite in both age and extent; it came into being as a unique event, and has been growing, changing, and developing since that event. At some point in time, it will also cease to exist, either dying the heat death of an increase in entropy or disappearing back into the singularity from which it arose. Every entity within the universe, whether a star, a planet, a human, or a proton, also goes through the same "life" cycle of birth, life, and death, but only some of these entities - like the universe itself - can change throughout their time of existence. Human beings are one such entity, and they share with the universe one further aspect which stars and planets do not: they define themselves. The universe IS the space-time continuum, which is constantly redefining and reshaping itself; human beings, over the course of their own lives, can do the same. Or, like the stars and the planets, they can accept a passive definition of their lives, going through their cycles without attempts at alteration or growth, obeying the letter of universal "law" without exploring its spirit.

For the nature of our cosmos implies neither the determinism of the clockwork universe nor the untrammelled free will of the anthropocentric one. At every level of organization - from that of subatomic events to that of the universe itself - the nature of reality is probabilistic. All events, all possibilities, all of reality - every aspect of the universe (including its very existence) has a probability associated with it; left untouched, the most probable event will probably occur. But probabilities can be changed ("collapsing the wave function") by intervention, by observation, by making a decision. And, since every element in the universe is interconnected with every other one, each alteration in the probabilities can change the universe.

In a very real sense, then, consciousness is a means by which the potentialities of the universe can be realized, an integral part of the universe's evolution. As conscious, decision-making entities, we can affect the universe of which we are a part. We affect it through our perceptions and the choices we make, and are in turn affected by the perceptions and choices of others, as well as by the ever-changing set of probabilities that we experience as reality. We can both literally and figuratively create the world in which we want to live and the person we want to be, just as the universe defines itself through its own existence. As conscious, decision-making beings, we are thus both active and interactive participants in the universe's development and, by analogy, each a universe in ourselves, with responsibility for our own development. Because we can contain the universe conceptually within our minds, and even imagine other universes with different attributes, we are also metaphorically outside the bounds of the universe, transcending its physical limitations.

The concept of conscious entities being both a part of and separate from the universe simultaneously is as paradoxical a dualism as the quantum mechanical representation of matter and energy, and yet it is ultimately just as important for our inner development as quantum mechanics has been for our technological development. We CAN affect the world by our actions - or lack of them and therefore we must take responsibilty for our decisions. We CANNOT separate ourselves from others or from physical reality, because each is part of the others and of the whole. Our very interconnectedness with the universe and everything in it gives physical reality to the Golden Rule, and extends this reciprocity beyond other human beings to the rest of the world. At the same time, we are each a universe in ourselves, and can shape and define this separate reality. Our interconnected ness, combined with our recognition of each individual's unique separateness, makes it imperative that we make possible the full development of the potential within each of us.

There have been a few memorable times in my life when I experienced the interconnectedness between myself and the universe directly, and more times when a "peak"experience has weakly resonated with this wordless insight. I have been awed by the beauty and immensity and majesty of the universe, but I have never been diminished by it. The lack of certainty intrinsic in the universe is more than compensated by the unfolding of infinite possibility and infinite connectedness; this new vantage point makes accessible to us all a form of freedom and potentiality in our lives that has never before been explored - a wholeness and sense of belonging within and along with the cosmos that is the antithesis of existential nihilism.

We have traded the certainty of universal law for the uncertainty of free choice, but we have been liberated by this conceptual change from determinism to self-determination. We have lost the infinite universe, in which we were infinitesimal specks in an unimaginable vastness, but have gained both a connectedness with an imaginable cosmos and a realization that each of us is more vast than our universe. Humanity has found a new place to stand in relation to the universe - not in the center and not lost in the infinite reaches, but encompassed by and encompassing all.

REFERENCES

There are several books available that present the ideas of quantum mechanics, quark theory (quantum chromodynamics), and cosmology in non-technical fashion. They are not easy, but a little effort on the part of the reader will be well rewarded. John Gribbin. *In Search of Schrodinger's Cat: Quantum Mechanics and Reality,* Bantam Books, 1984. John Gribbin, *In Search of the Big Bang: Quantum Mechanics and Cosmology,* Bantam Books, 1986. James S. Trefil, *The Moment of Creation: Big Bang Physics From Before the First Millisecond to the Present Universe*, Charles Scribner's Sons, 1983. The first two books are the easiest I could find that are also, in my opinion, accurate descriptions of quantum "reality." For a history of the development of modern physics through the eyes of the people involved, I strongly recommend: Robert P. Crease and Charles C. Mann, *The Second Creation: Makers of the Revolution in 20th-Century Physics,* Macmillan, 1986. Finally, for a taste of the mystical approach to quantum physics and the universe, one can read *The Tao of Physics* and/ or *The Dancing Wu-Li Masters,* both available in paperback. One should, however, read one or more of the previous references first.