Commentary

INDETERMINACY, MYSTERY, AND A MODERN EPISTEMOLOGY

by William G. Pollard

In the first part of his paper Brown points to the function of models in both science and theology.[1] He describes a three-step process in the development of a model in physics and shows how much the same process applies to models in the humanities and in theology. This is an important point. The same idea has been developed in a full and detailed manner by Harold K. Schilling in his book *Science and Religion*.[2] Schilling distinguishes three phases in science: the empirically descriptive (data gathering), the theoretical (model building), and the transformative (application and verification). He points out that religion has the same three phases with theology constituting its theoretical phase. Since each phase depends upon and informs the other, there is a circularity among them. Detailed examples in both fields are worked out in this illuminating book.

In his discussion of models, it seems to me that Brown confuses the issue in the examples he gives. The caloric and energy theories of heat are two different and alternative models of which one or the other is to be chosen as most faithfully representing its subject. The wave-particle theories of light on the other hand are not alternative models but through the Bohr Principle of Complementarity are required together to constitute a single complete theory of the phenomenon of light. We could note in passing that theology too, as Bohr has pointed out, involves just such complementary structures as the wave-particle dualism. Examples are the duality between freedom and grace, or that between transcendence and immanence.

Brown is correct in pointing to boundary values in physics as a

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significant concept for theology. It seems to me, however, that he does not pursue this idea sufficiently. The laws of classical mechanics find their most beautiful confirmation in the motions of the planets and their satellites. The precision with which the positions of the planets and eclipses of the sun and moon can be predicted and, more recently, the accuracy of orbits of artificial satellites and trajectories of the Ranger and Mariner spacecrafts, are striking examples of the rigor of these laws. The laws by themselves are not sufficient, however. In order to apply them, it is necessary to insert into them initial conditions at a specified instant of time. For an artificial satellite this is the position and velocity of the spacecraft at the moment launch is complete. For the solar system it is the position and velocity of each planet and its moons at a particular time. These "starting" values constitute the boundary values for the classical mechanics solution of the problem for the system in question.

Eugene Wigner has pointed out that it seems to be generally true for every physical system in the universe that the farther back in time that boundary values are imposed, the more indeterminate they become. For the solar system, if the initial conditions were inserted one thousand years ago, the behavior of the planetary system would still be rather accurately described by the equations of classical mechanics. But if we used the values a million years ago, the predictions today would show considerable error. If we go back five billion years, the boundary values become completely indeterminate since at that time we have only a turbulent mass of interstellar gas and dust out of which the sun and planets will later be formed by gravitational condensation. This feature of the boundary-value problem gives to every system which science describes its own place in the history of the universe and its own unique history from birth to death within the context of that total history. The indeterminacies involved place a fundamental limit on the completeness of any scientific account of such a history. This limit manifests itself in the appearance of chance and accident all along the way. If the same history is also taken to have a teleological dimension on theological or metaphysical grounds, then the boundary between the scientific and the theological accounts of the total history of the system is formed by the points at which chance and accident enter into it.

Brown rightly points to cosmology as a fruitful area of physical science for theological insight. It is certainly true that older ways of considering the universe in a steady state were not fruitful. Not only can we follow individual stars and galaxies from birth to death, but the same may be true of the universe as a whole. The opening session of the centennial celebration of the National Academy of Sciences a few years ago was devoted to a symposium on "The History of the Universe." Jesse L. Greenstein opened his paper in this symposium with the following significant statement:

> The universe is enormous, strange, and untouchable; man's technical means and intellect are small and short-lived. Discussing stellar or galactic evolution is a large task made no easier by the lack of astronomical meaning in such commonly used words as history, evolution, birth, life, and death of atoms and stars. Let us maintain belief only in presently known sources of energy and in the irreversibility of the second law of thermodynamics. We have no definite observational evidence that the expansion of the universe will reverse itself, or that matter and energy now appear out of the vacuum. Our locally observable universe is on a one-way road 10 billion years in length, the same for the oldest atomic nuclei on the earth and for the oldest groups of stars in our galaxy as that indicated by the red shift of distant galaxies.[3]

The observation of quasars at the far limit of the universe and the recent detection of the expanded radiation filling all space from the initial fireball at the beginning of the universe seem to further substantiate this picture. Perhaps the universe began ten billion years ago with equal quantities of matter and antimatter and what is left now after the early phase of matter-antimatter annihilation are randomly scattered matter or antimatter stars or galaxies kept apart by the vast distances in the expanding universe.

As Barbour pointed out in his commentary, the theological application to the evolution and future of man which Brown calls for has been accomplished most fully by Teilhard de Chardin in *The Phenomenon of Man* and *The Appearance of Man*.[4] I agree with Barbour's evaluation of the importance of these contributions.

In his commentary on Brown's paper, Hayward pointed to both meaning and mystery which are encountered at the boundaries of experience. It seems to me that what differentiates twentieth-century physics from that of the nineteenth century is a renewed sense of mystery. For the last century nature seemed shallow and her secrets just below the surface of things where one great formula would in time be found which would explain everything. This view of science is still prevalent among the public at large and is responsible for much of the contemporary "scientism" which even now is affecting theological thought. But the mood and character of modern physics are very different. In the very large, the quotation from Greenstein given earlier reflects this mood with its sense of strangeness and mystery about the universe as a whole. In the opposite direction of the very small, matter seems to have well-nigh inexhaustible depths of structure. The recent breakthrough in the discovery of SU (6) symmetry and its capacity faithfully to delineate the whole spectrum of strange particles, antiparticles, and mesons which make up matter hints at a new underlying level of reality. It suggests that neutrons and protons along with all the other "elementary" particles are themselves structures composed of odd underlying entities called "quarks." On the other hand, nature may prove to be so constituted that quarks cannot exist by themselves. If so, the basic constituents of matter as we now know it may be systems of sub-units which themselves do not exist as observable entities. Or to put it another way, what we know as matter may prove to be only a shadow formed by a six-dimensional special unitary transformation in Hilbert space.

One is reminded of a comment by Hermann Weyl: "As scientists, we might be tempted to argue thus: 'As we know, the chalk mark on the blackboard consists of molecules, and these are made up of charged and uncharged elementary particles, electrons, neutrons, etc. But when we analyzed what theoretical physics means by such terms, we saw that these physical things dissolve into a symbolism that can be handled according to some rules. The symbols, however, are in the end concrete signs, written with chalk on the blackboard. You notice the ridiculous circle.' "[5] This in turn is reminiscent of a famous passage in the *Chhandogya Upanishad* in which a father instructs his son about various operations such as peeling an onion or dissolving a grain of salt in water. As layer after layer is removed, the boy finally reaches a point at which he finds nothing at all. There is a void at the heart of the onion, and the salt disappears as the last layer dissolves. Yet the father says that invisible central point is the ultimate essence not only of the phenomenal universe but of the boy himself: "That which is the subtil essence, in it all that exists has its self. It is the True. It is the Self, and thou, O Svetaketu, art it."[6]

Clearly the emphasis on epistemology which Northrop calls for in his commentary is justified. Physicists in their search for the secret of matter may in time come to a void at the heart of things where they simply face a shadow of their own blackboard with their own chalk marks on it. There is genuine mystery here, very different from the substantial substructure of nineteenth-century science with its confidence about explaining everything away. Hayward is right when he says that the basic data for theology are the combination of meaning and mystery, of meaning bounded in mystery, but with the mystery itself pregnant with meaning. It is the recovery of this sense of mystery, along with its recognition of indeterminacy, which, it seems to me, is the greatest resource which contemporary physics has to offer to theology.

NOTES

1. See Sanborn C. Brown, "Theological Resources from the Physical Sciences: Can Physics Contribute to Theology?" *Zygon,* I (March, 1966), 14–21, and "Commentaries on Resources from the Physical Sciences" (*ibid.*, pp. 22–42) by F. S. C. Northrop, Ian G. Barbour, John F. Hayward, and John R. Platt.

2. New York: Charles Scribner's Sons, 1962.

3. Jesse L. Greenstein, "The History of Stars and Galaxies," *Proceedings of the National Academy of Sciences,* LII (1964), 549.

4. New York: Harper, 1959 and 1965, respectively.

5. Quoted by Gerald Holton in his Introduction to "Science and Culture," *Daedalus* (Winter, 1964), p. xxv.

6. Quoted from T. H. Robinson, *A Short Comparative History of Religions* (London: Gerald Duckworth, 1951), p. 80.