Book Reviews

A Problem in Physics

Quantum Gravity. Papers from a symposium, Chilton, England, Feb. 1974. C. J. ISHAM, R. PENROSE, and D. W. SCIAMA, Eds. Clarendon (Oxford University Press), New York, 1975. xii, 606 pp., illus. $29.50.

The papers in this book are the product of an attempt to bring together people interested in various approaches to the problem of the quantization of gravity. Except for one, they were all delivered at a symposium held at the Rutherford Laboratory, and they range from an excellent introduction to the problem by C. Isham to detailed descriptions of current research.

The quantization of gravity looms as one of the key unsolved problems in theoretical physics. Quantum theory and the geometrical description of gravity given by Einstein have so far resisted all attempts at marriage. This volume is thus a report of the hopes and of the failures of some who have tried to achieve that union.

To me the most exciting approach is that of R. Penrose with his twistor theory. To Penrose, the fundamental "events" from which physics is to be built are the paths of massless particles. The points in space-time themselves are derived quantities, expressible as the intersection of such paths. While representing a radical change from the conventional view of space-time, the technique holds the promise of making contributions not only to a quantum theory of gravity but also to a theory of elementary particles. The unusual and difficult mathematics required, together with the scarcity of publications by the group around Penrose, have prevented ready access to the theory by most physicists, but I believe this approach holds as much hope for an eventual quantization of gravity as any of the more conventional approaches. The papers by Penrose expounding twistor theory and by G. Sparling giving an introduction to the algebraic topology necessary for work with twistors are thus very welcome.

The field-theoretic viewpoint in which the metric is regarded as a field to be quantized in the usual way remains firmly impaled on its infinities. Although it has had some success, as in showing that this viewpoint leads in a natural way to the geometrical viewpoint in the classical (low energy) limit, the second quantized version of this theory results invariably in unrenormalizable infinities. The techniques used and problems encountered are reviewed in papers by S. Deser and M. Duff.

An alternative approach, that of somehow quantizing the geometry itself, remains inundated by mathematical difficulties. Even highly simplified model geometries present seemingly unresolvable ambiguities and difficulties in quantization. The general techniques used and some of the simple models that have been examined are briefly reviewed by C. Isham and M. MacCallum, respectively.

Although he ignores the problem of quantizing gravity, the results presented by S. Hawking, that quantum effects can lead to evaporation of black holes by the quantum emission of particles, have been the greatest spur of the past year to workers in the field of quantum gravity. Although the exact mechanism of particle production is still in dispute, this result has highlighted the unusual effects that a union of quantum theory with gravitation could produce.

In the absence of any solid theory, however, one can but speculate. A. Salam again presents his hope that the quantization of gravity, properly done, will resolve most of the mathematical ambiguities and infinities affecting even other field theories. J. Wheeler and G. Patton, concerned with the question of the meaning of a fully quantized theory of the universe, present a report of their largely unsuccessful search for a philosophical and mathematical framework in which such a theory could be constructed.

For anyone interested in the quantization of gravity, this would seem a good introduction to the current state of the problem.

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Views of the Cosmos

The Nature of Scientific Discovery. A Symposium Commemorating the 500th Anniversary of the Birth of Nicolaus Copernicus. Washington, D.C., April 1973. OWEN GINGERICH, Ed. Smithsonian Institution Press, Washington, D.C., 1975 (distributor, Braziller, New York). 616 pp., illus. $15. Smithsonian International Symposia Series, 5.

Although the prediction of the future is a hazardous enterprise it would seem a fair assumption that in the year A.D. 2473 man will celebrate the one-thousandth anniversary of the birth of Copernicus with the same ceremony that the 1973 quincentenary occasioned. The heliocentric concept of Copernicus defied both common sense and millennia of tradition. In 1549, six years after the death of Copernicus, the influential academic and Protestant reformer Philipp Melanchthon challenged the idea that the earth was in motion by referring to the witness of the eyes that the heavens revolved in the space of 24 hours—"but certain men, either from the love of novelty, or to make a display of ingenuity, have concluded that the Earth moves . . . it is a want of honesty and decency to assert such notions publicly, and the example is pernicious. It is the part of a good mind to accept the truth as revealed by God and to acquiesce in it." Indeed, the Copernican concept, contrary to the apparent evidence of the senses, and breaching a thousand years of established philosophical and theological doctrine, must surely rank as one of the most courageous episodes in human thought.

The eventual rationalization of the heliocentric theory through the work of Kepler, Galileo, and Newton emphasized the revolutionary nature of the Copernican outlook—revolutionary not merely for astronomy, but for the whole of science and the entire philosophical framework of man's belief about the universe. It is therefore understandable that in 1973 Copernicus was honored on an international scale. In the United States the week of 23 April was designated by a presidential proclamation as "Nicolaus Copernicus Week." This book is a record of the festival, symposium, and collegia held in Washington at that time, organized by a joint program committee of the National Academy of Sciences and the Smithsonian Institution and serving simultaneously as the Academy's spring meeting and the Smithsonian's fifth international symposium.

It may be remarked without hesitation that this book, prepared under the skilled editorship of Owen Gingerich, is a most

valuable and important document. Twentieth-century scholarship illuminates pages in which we may find a contemporary assessment of Copernicus and of the epoch in which he promulgated his great work. So much may have been expected. More unexpected and remarkable are the parts of the symposium and collegia dealing with our present knowledge of and outlook on the universe and our projections into the future.

The attempts to deal with the question whether science has a future, or what kind of future faces scientific investigation, are of especial interest. For example, in a remarkable lecture "Tradition in science" Werner Heisenberg maintains that we must abandon the 2500-year-old tradition extending from the time of Democritos that leads physicists to search for the fundamental elementary particle: "Even if quarks could be found, for all we know they could again be divided into two quarks and one antiquark, etc., and thus they would not be more elementary than a proton.... We will have to abandon the philosophy of Democritos and the concept of fundamental elementary particles. We should accept instead the concept of fundamental symmetries, which is a concept out of the philosophy of Plato."

Indeed, the contributions of Heisenberg and John Wheeler, and the discussions in which they took part, raise the entire problem of knowledge and of the relation of man to the universe in an acute sense. We have known for half a century that the Einstein equations of general relativity predict an evolutionary, expanding universe. We have been well aware of the observational evidence in support of the cosmological expansion, but until recent years we have never faced directly the physical meaning of the singularity at the zero of time in the Einstein equations. The impossible concept of a physical interpretation in terms of a universe of infinite density and infinitesimal size at a time zero has been evaded in the hope that the singularity would prove to be a mathematical difficulty. Now we have the apparently incontrovertible observational evidence from the microwave background radiation for the high-density, high-temperature state of the early universe, seconds after the beginning of the expansion. The world of physics and the nature of our understanding of the external world have quite suddenly moved to a crisis. The quantum theory led to a revolution in our understanding of the meaning of observation. We cannot observe without influencing the object of our investigation, and the statistical nature of quantum mechanics is well understood. Apparently our observations of the universe today imply that in the beginning the universe was a single entity of infinitesimal dimensions to which the application of quantum theory is inadmissible. Further, the homogeneity and the number of particles and the forces between them in the embryonic universe narrowly determined that galaxies, stars, and eventually life could evolve in the universe. Are physics and astronomy returning us to a belief in the partnership of the mind of man in the foundation of the universe? It is a question asked and debated in this volume. Wheeler remarks that the three mysteries of the quantum, the universe, and the mind call out for clarification. He knows of none more deserving to be called "the heart of darkness."

Will the human race survive to solve this problem? Where lies the foundation of ethics? Is ethics created by man for the sake of survival, or is there a fundamental ethic inherent in our existence in the universe? Must there be ethical limits to scientific discovery if we are to survive? One ends this volume with these questions uppermost and with a feeling of entreaty and hope that man will survive so that the genius of a future Copernicus can penetrate the heart of darkness.

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The Coastal Zone

Estuarine Research. Papers from a conference, Myrtle Beach, S.C., Oct. 1973. L. EUGENE CRONIN, Ed. Academic Press, New York, 1975. Two volumes. Vol. 1, Chemistry, Biology, and the Estuarine System. xiv, 738 pp., illus. $31.50. Vol. 2, Geology and Engineering. xvi, 588 pp., illus. $27.50.

The most interesting and important aspect of estuaries is their function in support of the biota. The intricacies of life in estuaries have always fascinated scholars and will probably continue to do so as long as curiosity itself survives. But curiosity alone does not drive science. Economic interests, industrial development, and the surge in regulatory activities of governments account for much of the current interests in estuaries. "Management" is the term that is used to encompass the continuous jostling and bargaining among champions of the various mutually incompatible objectives in the use of coastal resources. Much of the science that is done is undertaken with at least the tacit understanding that it is likely to show that the seemingly mutually exclusive are in fact compatible and everyone can have his share of the coastal zone. Although these compromises are probably necessary to maintain stability in the political system, one wonders what has happened to truth and hopes that a book on research in estuaries will set forth the issues clearly. That rarely happens, but this two-volume work evidences some progress.

The 68 papers in these two volumes were delivered at a meeting of the Estuarine Research Federation, a conglomerate of small Atlantic Coast scientific societies that share an interest in estuaries. What do the papers have in common? Estuaries? Not that. They treat topics from marshes to the Peruvian upwelling, from geochemistry to the effects of power plants. There are sections on chemistry, biology, and modeling. The second volume treats geology and has a section on vegetation as a tool in the management of coastal lands. The emphasis is on the East Coast, and the papers are research reports, not reviews.

The program was arranged by a group of "conveners," who took individual responsibility for segments of it. The segments are of uneven quality and depth, and many appear to have been casually constructed. Two of the more comprehensive treatments are papers on modeling by Kenneth Mann and by John Walsh. Mann challenges those who aspire to build complicated and detailed models of estuaries with the simple statement that such models are inappropriate because the data available do not support the detail required by the models. One hopes that Mann's criticisms are overdrawn; with a few exceptions, modeling seems to be taking its proper role as a tool rather than as either an end in itself or a panacea.

The last comprehensive review of estuaries (G. H. Lauff, Ed., *Estuaries*, AAAS) was published in 1967, and this new collection, while hardly a review, is welcome. It is refreshing to find that most papers, including these by chemists, mathematicians, and geologists, reveal an emphasis on living systems. It is refreshing, too, to see progress being made by new, young scientists in interpreting estuaries as segments of the biosphere that must be managed as intact units. This book will soon be followed by a similar set of volumes reporting on the second conference of the Estuarine Research Federation, which promises to be a somewhat more comprehensive review.

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