Book Reviews

Cosmological Possibilities

Action at a Distance in Physics and Cosmology. F. HOYLE and J. V. NARLIKAR. Freeman, San Francisco, 1974. xii, 266 pp., illus. $15. A Series of Books in Astronomy and Astrophysics.

The fundamental laws of physics are time-symmetric, but the world is not. This is a problem that most physicists are able to ignore by confining attention to local physics and a thermodynamically determined arrow of time. But perhaps our local physics is governed by the structure of the universe as a whole, and the problem is the key to the link. *Action at a Distance in Physics and Cosmology* brings together the work that Hoyle and Narlikar have done over the last decade or so in attempting to deal with this matter.

Imagine the world lines of a collection of charged particles laid out before us with a given arrow of time. We can use any combination of retarded and advanced solutions of Maxwell's equations to relate the electromagnetic field at one time to the particle motions and fields in the past and the future. All descriptions are mathematically equivalent, yet in some sense nature seems to prefer the retarded solution: while we see outgoing fields correlated with the motion of a charge, we rarely see incoming fields so correlated. Wheeler and Feynman showed that symmetric solutions (half-advanced plus half-retarded) could lead to retarded interactions if one assumed the universe to be a perfect absorber; that is, every emitted photon must be absorbed somewhere. The advanced field of the absorber charges, "the response of the universe," acts on radiating charges to produce retarded interactions.

The natural approach to such a theory, where radiation emitted is also absorbed, is a direct particle interaction picture. Here we bring in the whole universe to the physical laws. This is the starting point of Hoyle and Narlikar's book. Of course, if the universe absorbs perfectly in both the past and the future there is again no asymmetry. Can we look to the cosmological arrow of time in an expanding universe to provide the asymmetry? Not if the big-bang Friedmann models of Einstein's relativity theory are appropriate to our universe, because these are not future perfect absorbers. However, Einstein's theory is inconsistent with the basic philosophy; if electromagnetism is an action-at-a-distance theory, gravity should be too. It is hoped that this will lead to "better" cosmological models.

To carry out this program, the authors need two ideas: first, a version of Mach's principle, different from Einstein's, that the inertial mass of a body is a function of the masses of all other bodies, and second, that the equations of physics should be invariant under changes of scale which are functions of position.

Finally, if the action-at-a-distance picture is correct it must be possible to quantize it. Hoyle and Narlikar take up the problem where Feynman gave up. They show that effects usually attributed to vacuum energy, hence to the independent existence of the photon field, can in fact be derived from the quantum response of the universe.

Not all of these interrelated themes of the book are linked with equal clarity, possibly because the reader is expected to be aware of the background material, more likely because of the "multidimensional" structure of the book. The authors have preserved the lecture style even to the extent of numbering the lectures within each chapter. This is supposed to allow the reader to dip into the book. One can only imagine the original lectures addressed to an audience in perpetual flux. In any case, the absence of an index of notation and any substantial subject index undermines the attempt.

A new theory of this character might be expected to produce new results on a dramatic scale. That this one does not is its weakness. For how can it be tested? The authors state that from an astrophysical point of view it is desirable to find new cosmological possibilities. It is not clear that the point of view is not more metaphysical. So abhorrent is the idea of a beginning in time for the universe that it must be abandoned at any cost. If the steady-state theory is no longer defensible, then the big-bang model must be attacked. In the end there is the possibility that the big bang may arise from viewing a model with no singularity in a singular conformal frame. The conclusion is that the universe is probably much larger than is usually supposed (!).

There are some occasional tangents such as an isolated remark on quantum gravity (in a completely direct particle interaction theory there should be no gravitational field to quantize). There are some absurdities: Question: how does a particle travel on a space-like curve? Answer: it goes via the universe. But the book is nicely produced with a sensible use of appendices and is a good read.

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Emotion and Bias in Science

The Subjective Side of Science. A Philosophical Inquiry into the Psychology of the Apollo Moon Scientists. IAN I. MITROFF. Elsevier, New York, 1974. xvi, 330 pp., illus. $11.50.

Ian Mitroff's *The Subjective Side of Science* is a sociological, psychological, and philosophical study of some 40 scientists who were involved with the Apollo moon program. As I see it, the question raised by Mitroff is how an objective science is possible when our best scientists seem to be anything but objective in conducting their research. Is it necessary, in other words, for all scientists as individuals to behave in accord with traditional notions of scientific objectivity if science as a whole is to be an objective enterprise? If individual objectivity is necessary, says Mitroff, we are clearly in trouble because many individual scientists seem to behave quite differently much of the time.

The great strength of this book is the convincing argument Mitroff makes in chapter 7 that science as a whole can hope for objectivity *only* if scientists, at least some of the time, behave in ways quite different from the way a traditional notion of objectivity would have them behave. Its great weakness is that Mitroff takes too much time and expends too much effort before he comes to the point.

Much of the book reports results from an intensive, tape-recorded four-wave interview study, conducted by Mitroff himself, of the scientists. Each