Book Reviews

Quantum Gravity

Quantum Theory of Gravity. Essays in Honor of the 60th Birthday of Bryce S. DeWitt. STEVEN M. CHRISTENSEN, Ed. Hilger, Bristol, 1984 (U.S. distributor, Heyden, Philadelphia). xvi, 483 pp., illus. $54.

It is often said that in science finding the right question is more difficult than finding the right answer. Whatever general truth this may have, it surely applies to what has come to be called the problem of quantum gravity, that is, the problem of reconciling our macroscopic understanding of space-time (or "gravity") with the quantum character that nature manifests on very small scales.

For a long time this problem was taken seriously only by a very few scientists, such as Bryce DeWitt, who were motivated by the need to restore to physics the unified foundation it had once possessed. Recently, however, fashions have changed to such an extent that the 30-odd contributions to the present festschrift for DeWitt are able to do no more than summarize a limited part of the effort now being devoted to the quantum gravity problem.

In part this change in fashion can be traced to the growing conviction that non-Abelian gauge theories provide the correct means for describing the interactions of subnuclear particles. The close mathematical affinity of such theories to general relativity has meant on the one hand that techniques developed for quantum gravity have become useful in particle theory and on the other hand that it has become possible to view gravity (that is, the space-time metric) as a stray classical field that could and should be brought into the quantum corral by the use of methods and criteria that have proved effective in flat space-time.

This relationship is well brought out in the contribution by Vilkovisky, which in particular contains a succinct exposition of DeWitt's geometrical approach that treats both general relativity and gauge theories as special cases to be handled within the common technical framework of covariant quantization. In fact the bulk of the technical contributions fit naturally into the program of bringing gravity within the flat-space tradition, and taken together they furnish the reader with a representative overview of work in that direction. Specifically there are four papers concerned with supersymmetry, three with higher derivative Lagrangians, and six with the properties of non-gravitational quantum fields in curved, but still non-quantum, space-times.

In flat space-time most quantum field theories are inconsistent in the sense that they predict infinite answers for the results of various experimentally accessible observables, and naively quantized general relativity is no exception to this rule. The main aim in formulating supergravity was to embed standard general relativity in a larger theory with precisely the right multiplicity and type of fields that all such infinities cancel, leaving behind well-defined, finite answers. In particular the hope is that the right choice of additional fields will be suggested by the requirement of supersymmetry, which pairs bosonic particles (such as the graviton) with fermions in a definite way. That such remarkable cancellations can actually occur has been confirmed in certain model theories, and the description of these results lends the papers on supersymmetry a certain excitement.

After finiteness, the next best thing to try for is "renormalizability," and several contributors deal with the attempt to attain it for gravity, not necessarily by adding more fields, but by modifying the gravitational field equations. These attempts also have promise and are well reviewed in the book. In addition, a paper by Boulware contains a valuable collection of formulas needed for the canonical quantization of such theories.

But even in the most optimistic of these papers the reader can sense a certain uneasiness. Perhaps what is being asked, that gravity be brought within the flat-space tradition, is not appropriate. But then how should one go about finding the "right question"? Several contributions bear directly on this issue, including Smolin's closely reasoned presentation of a new interpretation of quantum mechanics, Hartle and Kuchař's analysis of the role of time in the so-called path integral formulation of quantum theory, Deutsch's complaint that such methods of quantization are not yet "quantum enough," and Unruh's and Wheeler's reminders that it might be wise to pursue formal developments in closer conjunction with a study of how (or even whether) the basic objects introduced in the theory could in principle be measured. In addition, papers dealing with black holes and cosmological particle creation bring out some of the actual physical relationships (notably black-hole entropy and the smallness of the cosmological constant) that any ultimate theory will have to explicate. In this connection Parker's "quantum-gravitational Lenz's law" seems a particularly tantalizing heuristic principle.

Of concrete alternative proposals, though, the reader will find few except for Isham's discussion of quantum geometry. In the sense that current work on small-scale topology, on higher-dimensional gravity, and on asymptotic, complex, and other formulations of quantum gravity is barely represented, the title of this handsomely produced volume could be regarded as misleading. But no summary can cover everything, as I have been only too aware in writing the present review.

However, I cannot avoid a final observation, in connection with Christensen's absorbing historical paper. After describing his work on anomalies he writes, "We were under the extra pressure of secrecy. Once again we were in competition with other groups and not real happy about it." This sort of competition is something that had been absent among relativists until very recently, at least in my experience. We can only hope that the price of our being brought into the physics mainstream is not the loss of a working atmosphere fostering the cooperative and disinterested pursuit of truth, which, after all, is what scientific research in general is supposed to be about.

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Atmospheric Physics

Atmospheric Electrodynamics. HANS VOLLAND. Springer-Verlag, New York, 1984. x, 205 pp., illus. $35.50. Physics and Chemistry in Space, vol. 11.

"Atmospheric electrodynamics" is an apt term chosen by Hans Volland to describe the wide variety of electrical phenomena occurring in the lower and upper atmospheres. These phenomena include cloud electrification, lightning,