Fixing Extragalactic Distances

Supernovae as Distance Indicators. NORBERT BARTEL, Ed. Springer-Verlag, New York, 1985. vi, 226 pp., illus. Paper, $13.70. Lecture Notes in Physics, vol. 224. From a workshop, Cambridge, Mass., Sept. 1984.

Supernovae are the brightest and most spectacular objects that occur in galaxies. Because of their high luminosities they are potentially valuable distance indicators. To investigate this possibility in detail the Harvard-Smithsonian Center for Astrophysics sponsored a workshop the proceedings of which contain a number of excellent papers on radio and optical observations of supernovae and on theoretical models of supernova explosions.

In recent years particularly rapid progress has been made in the detection of supernovae at radio wavelengths. Unfortunately, no clear pattern has yet emerged that allows one to relate the optical and radio properties of supernovae. Furthermore, radio observations by Kronberg and his collaborators now appear to have established that starburst galaxies, such as Messier 82, are particularly active producers of supernovae. Owing to absorption by interstellar dust these supernovae had not previously been observed at optical wavelengths. At the workshop Bartel presented the first very long baseline interferometer observations of the expansion of young extragalactic supernovae.

The workshop produced a consensus that massive supernovae of type II exhibit a wide range in maximum luminosities and are therefore not suitable as distance indicators. Cadonau, Sandage, and Tammann argue that supernovae of type I, with a dispersion of only 0.3 mag at maximum light, are excellent distance indicators. Wheeler and Sutherland show that type I supernovae may be modeled by carbon-deflagration models of stars that have carbon-oxygen white dwarf progenitors. From a discussion of the amount of ^{56}N that decays into iron in such supernovae they find that the Hubble parameter must lie in the range 40 to 70 km sec^{-1} Mpc^{-1}. Unfortunately this beautifully simple picture is destroyed by ugly new facts presented by Panagia. He shows that there are, in fact, two distinct types of supernovae of type I, which differ in luminosity by a factor of about 3. Furthermore the faint subtype does not exhibit the absorption feature at 6150 Å that is seen in the bright subtype. All of the faint type I supernovae so far observed occur in spiral galaxies. The hope therefore remains that the species of type I supernovae that occurs in elliptical galaxies may still turn out to be a standard candle that can be used to measure extragalactic distances.

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The Theory of Supermanifolds

Supermanifolds. BRYCE DEWITT. Cambridge University Press, New York, 1984. xiv, 316 pp. $59.50. Cambridge Monographs on Mathematical Physics.

Einstein's general theory of relativity explains the physical phenomenon of gravitation in terms of the geometry of space-time, which is viewed as a manifold in the standard mathematical sense. Ever since this theory was formulated, physicists have dreamed of a unified geometrical explanation of all the basic phenomena of nature. Within the last decade, the advent of supersymmetric field theories such as supergravity and superstring theory has brought this dream much closer to reality. These theories require that space-time itself be viewed as only a small part of a larger geometric object called superspace. Supermanifold theory is the branch of mathematics that develops the geometry of objects like superspace. It provides the mathematical foundation for supergravity and superstrings in the same way in which classical differential geometry provides the foundation for general relativity. Formally, it is an extension of classical differential geometry in which the coordinates on a manifold may take values in a graded algebra ("Grassmann algebra") that is larger than the algebra of real numbers and contains anticommuting elements.

Despite the strong geometric flavor of supergravity, even specialists in the field frequently rely only on a formal analogy between supergravity and general relativity and are unaware that supermanifold theory can be developed as a rigorous branch of mathematics. DeWitt has done a great service in providing a careful and detailed exposition of this theory. Although mathematicians may not find the book sufficiently rigorous, physicists will find in it clear and complete treatments of many issues that are often glossed over in the research literature. These include the concept of the "body" of a supermanifold, which explains the relation between superspace and physical space-time; the relation between integration over a supermanifold and integration over its body; precise definitions of tensors, forms, and similar geometric structures on supermanifolds; and the connection between Lie supergroups and superalgebras. The geometry of supergroups and their coset spaces is worked out in detail, and the supergroups and superalgebras of the Kac classification are constructed, although the completeness of the classification is not proven.

Notational conventions, especially concerning signs and indices, require special attention and care in this subject, and they receive it in this book. New notations are explained clearly and in great detail when introduced in the text.

This book was originally intended as a two-volume collaboration with other authors, covering not only supermanifold theory but also its application to supergravity. The elementary applications that are beautifully treated in chapter 5 made me regret that this plan was not carried out. These include the extension of ordinary Hilbert space theory that is needed when operators may have Grassmann eigenvalues, the classical mechanics of Grassmann variables and its quantization by both canonical and path integral methods, and an introduction to supersymmetric quantum mechanics. I hope that eventually a book on supergravity will appear that makes full use of the theory of supermanifolds.

No author's decisions about what material to cover and what to omit can please all readers, and I have two minor complaints. First, several different definitions of a supermanifold exist in the literature: in addition to DeWitt's, those of Rogers, Berezin-Leĭtes, and Kostant are popular. All these definitions are suitable for physical applications, but they are quite technical, and physicists who want to make use of supermanifold theory are often unsure which version is most convenient for their purposes. A detailed comparison of the various definitions in DeWitt's clear style would have been appreciated by these physicists. Second, Riemannian supermanifolds are given more attention in the book than their usefulness would seem to warrant. A discussion of supermanifolds obeying the curvature and torsion constraints of $N = 1$ supergravity would have been preferable.

Supermanifold theory promises to become even more important in particle physics with the recent explosion of interest in the geometry of superstrings