Book Reviews

Models of the Early Universe

The Very Early Universe. G. W. GIBBONS, S. W. HAWKING, and S. T. C. SIKLOS, Eds. Cambridge University Press, New York, 1983. vi, 480 pp., illus. $49.50. From a workshop, Cambridge, England, July 1982.

Until very recently, modern theories of cosmology could not intelligently describe that tantalizing first millisecond after the big bang. Now physicists are soberly talking about the first 10^{-35} second. What has changed is that there has been a revolutionary synthesis of cosmology with particle physics. Most of the new work is expertly summarized in *The Very Early Universe*, a collection of 28 papers by participants at a Nuffield workshop.

A number of observed features of the universe have long escaped explanation. Why is it so smooth on the large scale, when insufficient time has elapsed since creation for homogenization (the "horizon problem")? Why is the gravitational energy of the universe approximately balanced with its kinetic energy of expansion, so long after the big bang (the "flatness problem")? Why are there about a billion photons for every proton in the universe? Where are the large number of predicted magnetic monopoles? How did galaxies begin forming, and when? There are other questions. Most of them can be swept under the rug by assuming various and special initial conditions. The papers included in *The Very Early Universe* attempt to provide less embarrassing explanations.

Many of the papers hinge upon the inflationary universe model (1981), nicely reviewed in a contribution by Alan Guth. A false vacuum at the grand unified theory (GUT) epoch ($t \approx 10^{-35}$ second) introduces into Einstein's equations a dominant "cosmological constant," which converts the conventional power-law rate of expansion into an exponential. In the ensuing period of anomalously rapid expansion, causally connected and smooth bits of space stretch to enormous proportions, the curvature of space flattens out to near zero, and the effective distance between magnetic monopoles increases beyond the scale of today's observable universe.

So far so good, but the gradually forming bubbles of true vacuum (today's universe) are too clumpily distributed in this model, and, upon colliding with each other, thermalize the energy released from the bubble walls at a temperature too low for baryon production or nucleosynthesis. A seeming remedy to these problems is the new inflationary universe model (1982), reviewed in mathematical detail by A. D. Linde. The key idea here is to postpone bubble formation until substantial exponential expansion has occurred, so that the entire observable universe fits cozily into a single bubble. A Coleman–E. Weinberg potential with a vanishing second derivative at the origin does the trick. However, this special mathematical property, which allows the GUT Higg's field to roll slowly toward the true minimum of the potential, requires fine tuning of the effective mass parameter of the potential. Whether this fixed-up version of the theory is more palatable than the original is a matter of taste. A number of investigators have converged upon another, perhaps fatal, deficiency in the new inflationary universe theory: the calculated amplitude of density perturbations (leading ultimately to galaxy formation) is too large by about 10^5.

Some investigators have faith that new supersymmetric theories (SUSY's) of particle physics can lead to more natural and workable inflationary epochs. Such a theory is outlined in a paper by Paul Steinhardt. SUSY's, which rest fundamentally on the idea that every fermion has a boson partner, may also possibly solve the "mass hierarchy problem": why is there such an enormous difference between the masses of GUT particles (10^{15} GeV) and those in the laboratory (1 GeV)? A worry repeated often by Frank Wilczek, and sufficiently serious to place everything on tenuous footing, is the lack of any explanation of why the cosmological constant today is at least 108 orders of magnitude lower than it was at the time of the GUT phase transition.

Still, most people now believe in an inflationary scenario of some kind. A clear and astronomically testable prediction of any such model is that the ratio of gravitational energy to kinetic energy of expansion should be virtually one today. Other astronomical facts of life are reviewed in the papers of Wilczek and Martin Rees.

All of this—the excitement, the confusion, and the optimism—comes through in the book. It is a technical book, but several of the review papers should be partly comprehensible to outsiders and are not much out of date. In any case, this is important stuff. Physicists, still high from some recent spectacular successes with partially unified theories, are now set on going all the way: a single theory, with perhaps one free parameter, that explains all the forces and particles of nature and how the universe began to boot.

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Limnology in the Tropics

Lakes of the Warm Belt. COLETTE SERRUYA and UTSA POLLINGHER. Cambridge University Press, New York, 1983. xii, 569 pp., illus. $89.50.

Lake Chad. Ecology and Productivity of a Shallow Tropical Ecosystem. J.-P. CARMOUZE, J.-R. DURAND, and C. LÉVÊQUE, Eds. Junk, The Hague, 1983 (U.S. distributor, Kluwer Boston, Hingham, Mass.). xvi, 575 pp., illus. $137. Monographiae Biologicae, vol. 53.

Lakes in the tropics offer extraordinary variety to the limnologist, and therefore the opportunity to test and expand perspectives largely derived from experience in higher latitudes. Though the scientific potential of tropical waters is far from realized, intensified research during the past 20 years has improved our understanding. The majority of investigations, however, remain largely descriptive and emphasize biological and, to a lesser extent, chemical features; very seldom is geophysics considered. The most comprehensive studies in Africa (for example, those of Lakes Chad, George, Chilwa, and Nakuru), the central Amazon, and southern India bear the stamp of the International Biological Program with its emphasis on biological productivity. Construction of reservoirs (for example, at Lakes Kariba, Volta, and Brokopondo) fostered monitoring programs primarily concerned with fisheries.

Lakes of the Warm Belt is an ambitious attempt to summarize our knowledge of a large subset of tropical and subtropical lakes. The book is divided