as they continue to pour forth energy over ten decades or more of the spectrum.

The book is beautifully, almost poetically, written. Occasionally, however, the poetry conceals a lack of attention to detail. Rowan-Robinson is weakest in discussing the planetary system, making such mistakes as giving the wrong rotation period for Mercury and the wrong surface temperature for Venus. He also errs by a factor of about 10^9 in the figure he gives for the density of a neutron star, and many astrophysicists will blanch at the repeated assertion that the Balmer and Lyman lines represent the spectrum of *ionized* hydrogen. On the other hand, how can one resist an author who describes how it is possible for mechanical processes to transfer energy from the solar chromosphere to the much hotter corona by noting, "It's analogous to what happens when a human being, with a body temperature of only 37°C, rubs two sticks together to generate a temperature of several hundred degrees to light a fire." Rowan-Robinson's enthusiasm is contagious; one believes him when he writes, "For me it has been a wonderful time to be alive and to be an astronomer."

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Distant, Early Objects

The Universe at Large Redshifts. Proceedings of a symposium, Copenhagen, June 1979. J. KALACKAR, O. ULFBECK, and N. R. NILSSON, Eds. Royal Swedish Academy of Sciences, Stockholm, 1980. pp. 595–782, illus. Paper, 975 Sw. Kr. Physica Scripta, vol. 21, No. 5.

Light and other electromagnetic radiation that arrives here from the distant, early parts of the observable universe has a measured wavelength longer than the wavelength at emission. The ratio of observed to emitted wavelength is measured by redshift. Roughly, a redshift of 1 corresponds to looking about two-thirds of the way backward in time to the big bang; a redshift of 100 corresponds to looking back 99.9 percent of the way.

The Universe at Large Redshifts is an up-to-date conference report on the early universe—a summary of the observations that are currently available for redshifts greater than about 1, a discussion of their interpretation, and an outline of what observational improvements can be expected in the near future. A formidable panel of experts have combined to make a technical but surprisingly readable volume; unfortunately there are no contributions from the very active Soviet group.

The main kinds of electromagnetic radiation discussed are the light and radio waves from identified distant galaxies and quasars, whose redshift is usually, though not always, less than unity; the x-ray background radiation, believed to come from sources with redshifts in the range 1 to 3; and the famous microwave radiation, which probably was last scattered at much larger redshifts, say 1000. The observations on the clumping of galaxies are discussed in considerable detail; these observations may contain information about conditions as early as redshift 1000. Several papers concern the present particle content of the universe—photon to baryon ratio, helium abundance, and so forth—which probably provides clues to still earlier epochs. The earliest time discussed in any detail is the Planck time (so-called because it can be formed from fundamental constants including Planck's) of 10^{-43} second after the big bang.

Perhaps the strongest impression one has of the overall discussion is how well the standard hot big-bang model of the universe continues to stand up to new data. This model is by now quite venerable. The geometric aspects were worked out by Friedman, and others including Einstein, a half-century ago, using the familiar spatially homogeneous isotropic models. Even the comparatively recent scenario of an early hot thermal-equilibrium epoch during which helium was formed is now well into its teens—and is considerably older if we allow attempts that predate the discovery of the microwave radiation. In the book the standard hot big-bang model is not really debated—author after author simply takes it for granted as the most plausible zeroth approximation. The thousands of alternative models that have been discussed so excitedly during the last 50 years are mentioned in passing if at all.

So the recent results reported are for the most part "mere details" to fill in a well-known basic picture—but they are fascinating details. From the slight observed anisotropies in the background radiation and, perhaps more important, the lack of larger observed anisotropies in the microwave and x-ray data, as well as from the detailed observations of galaxies, a messy but plausible picture is building up of how the galaxies formed. Putatively they came from slight inhomogeneities present at the time the universe cooled down enough for the nuclei and electrons in it to combine into atoms.

One interesting recent idea that is clarified in the book is that the "random" velocities of galaxies and clusters of galaxies are not necessarily hangovers from earlier times that are gradually damping down owing to the general expansion; such velocities may be caused by the gravitational attraction of overconcentrations of matter acting during most of the lifetime of the universe. If so, the observed random velocities, in particular the velocity of our own galaxy, can give information about such overconcentrations and corresponding underconcentrations.

It is quite a way from such a comparatively mundane inference to the idea that the recent "grand unified theories" of particle physics may perhaps provide an explanation of the present structure of galaxies (via the implications these theories have for fluctuations in the universe at fantastically early times). The book gives a rather balanced view of these and of most of the other key points in our gradually emerging, ever more realistic model of the universe.

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Adsorption of Microorganisms to Surfaces. Gabriel Bitton and Kevin C. Marshall, Eds. Wiley-Interscience, New York, 1980. xii, 440 pp., illus. $32.50.

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Agricultural Energetics. Richard C. Fluck and C. Direlle Baird. AVI Publishing Company, Westport, Conn., 1980. viii, 194 pp., illus. $19.

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