Book Reviews

Cosmic Distances

The Cosmological Distance Ladder. Distance and Time in the Universe. MICHAEL ROWAN-ROBINSON. Freeman, New York, 1985. xii, 355 pp., illus. $35.95.

Scientists only mildly interested in astronomy may not have noticed that the universe is twice as big on Mondays, Wednesdays, and Fridays as it is on Tuesdays, Thursdays, and Saturdays. On Sundays, it's a toss-up. None of this is very amusing to the professional astronomer, who likes to think of astronomy as the first of the exact sciences, its roots reaching far back into antiquity.

Our current understanding of the size of the universe is based on measurements of the Hubble constant. Late in the 1920's, Edwin Hubble of the Mount Wilson Observatory was able to demonstrate that distant galaxies exhibit spectra in which, most noticeably, the absorption lines due to calcium are systematically redshifted—shifted toward longer wavelengths—in proportion to the galaxy's distance. This redshift is now universally interpreted as a velocity shift. The more distant a galaxy, the greater its redshift, and the greater its recession velocity. As a galaxy's recession velocity approaches the speed of light, two effects reduce the radiation we receive. First, the observed light is shifted to longer wavelengths, where the energy of radiation quanta is reduced; second, the arrival rate of the quanta diminishes, again reducing the amount of energy reaching us in a given interval. These two effects conspire to reduce the energy received from a galaxy. The energy is reduced to nothing when the galaxy recedes at the speed of light, and the galaxy drops from sight. We speak of a cosmic horizon, a distance beyond which we cannot observe. In a practical sense this horizon defines the edge of the observable universe and its size.

The Hubble constant, H_0, is the rate at which a galaxy's recession velocity increases with increasing distance. If the velocity is measured in kilometers per second and the distance to the galaxy is measured in megaparsecs (1 Mpc roughly equals a distance of three million light years) then the value of H_0 can be expressed in km/sec per Mpc. Over the past decade H_0 has been measured through increasingly varied approaches by two separate groups, one guided by Gerard de Vaucouleurs at the University of Texas at Austin, the other led by Allan Sandage at the Carnegie Institution of Washington and Gustav Tammann at Basel. Respectively, these groups have repeatedly argued for values H_0 = 100 km/sec per Mpc and H_0 = 50 km/sec per Mpc. As Rowan-Robinson tells us in the preface to his book, each group insists that its results are incompatible with those of the other.

The book has two aims. The first is to clarify the points of disagreement between these two groups; the second is to provide a self-contained textbook for undergraduates in their final year of study. Clearly, it is difficult to tackle both aims at the same time. The undergraduate generally will need to understand broad principles, whereas the sources of disagreement between professional groups tend to evolve around finer detail. Rowan-Robinson faces this difficulty by proceeding step by step up the ladder to increasing distances. Since distance estimates are largely based on astrophysical models, the author provides much of the required background. We need to know how a star orbits around a binary companion before the dynamics of the orbit can be used to compute a distance to the star pair. Similarly, we need to understand how submicroscopic dust grains selectively absorb radiation of different colors if we are to properly account for the dimming of stars by interstellar dust. Errors accumulate as one climbs up the distance ladder; mistakes made in estimating the distances to nearer stars and clusters propagate to reappear first in distance estimates for the nearer galaxies and then in distance measures for clusters of galaxies observed at extreme redshifts. The author takes pains to provide the reader with all this required information. Readers of *Science* will find this a valuable book that explains the methodology and the pitfalls of cosmic distance estimates clearly and with ample charts, tables, and references for those wishing to probe the subject in ever greater detail. Whether or not Rowan-Robinson's analysis of the differences between currently claimed values of the Hubble constant—or his own personal preference for an adjusted value, H_0 = 67 km/sec per Mpc—will be accepted by specialists in the field probably is not of greatest importance. What is more significant is that Rowan-Robinson has produced an informative book that guides the reader through the general problem of estimating cosmic distances, points out difficulties along the way, and assembles background data and references to the literature that a large number of astronomers and students will find useful.

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Atmospheric Evolution

The Carbon Cycle and Atmospheric CO_2. Natural Variations Archean to Present. E. T. SUNDQUIST and W. S. BROECKER, Eds. American Geophysical Union, Washington, D.C., 1985. x, 627 pp., illus. $28. Geophysical Monograph Series, 32. From a conference, Tarpon Springs, Fla., Jan. 1984.

Researchers concerned with atmospheric evolution have been heard to complain that there are no samples of ancient atmosphere, but the complaint can no longer be sustained. Snow on the permanent ice caps of Greenland and Antarctica incorporates air, which becomes trapped in bubbles as the snow is compressed and converted into ice. This unpromising resource has been successfully exploited by research groups in Europe to derive a record of atmospheric change that extends more than 100,000 years into the past. Results of this research, reviewed in this collection of 46 papers, contain clear evidence that the partial pressure of atmospheric carbon dioxide rapidly increased by about 50 percent at the end of the last ice age, some 10,000 years ago. This remarkable observation has stimulated much new research on the geochemical cycle of carbon, which is well summarized in this volume.

Photosynthetic plankton in the surface layers of the ocean extract carbon dioxide from the surrounding water and the atmosphere and incorporate the carbon into their cells. Moribund cells and particles of organic carbon settle into deeper waters, where they are consumed by respiring organisms and converted back to dissolved inorganic carbon. This biological activity increases the concentra-