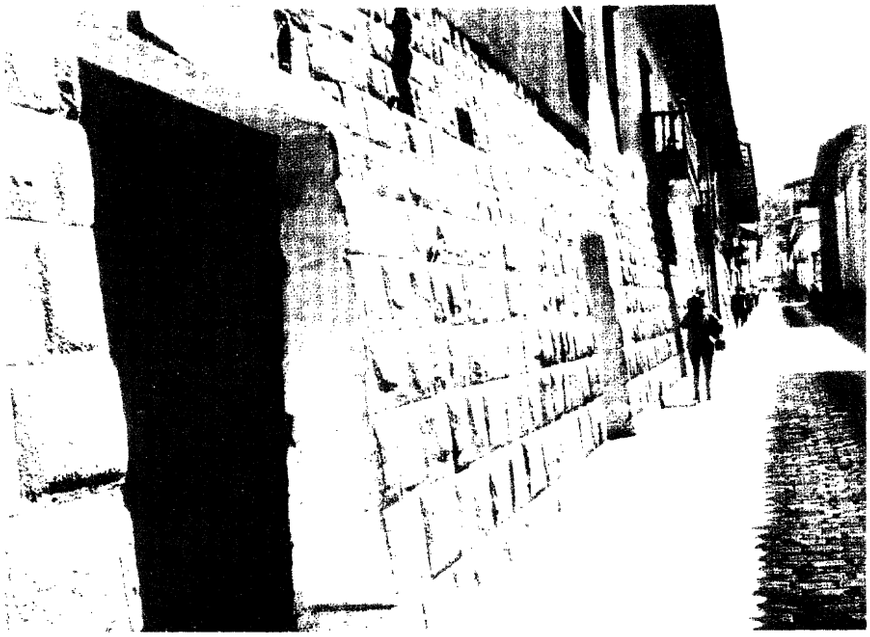

Inca *kancha* walls, Cuzco, Peru, with new doorways and upper story with Spanish flavor, "an example of spatial and temporal historical stratification and continuity of life in the city." The concept of the *kancha*, "a walled rectangular block enclosing groups of one-room buildings destined for dwelling and other uses . . . was widely used by the Incas. . . . After the Spanish conquest, these great spaces suffered multiple divisions and distributions. . . . Doorways were opened in the enclosure walls . . . and a second story was added in the Spanish formal tradition." [From *Inca Architecture*]

craftsmen, and by implying lack of ability smack of racism as well.

The authors describe and illustrate a wide variety of this Inca construction and have produced by far the best and most comprehensive description of Inca architecture yet to appear in print. The book should appeal to professionals working in Andean archeology, to amateur archeologists, and to persons interested in the history of architecture and technology. With admirable care, the authors bring ethnohistorical data from the chronicles and ethnographic analogy from modern peasant construction to bear on the archeological remains, arriving at painstaking reconstructions of the buildings themselves and suggestions as to their functions, which in some cases may have been multiple. Especially noteworthy are the carefully qualified drawings reconstructing some of the destroyed parts of buildings, notably the roofs and their supports, which were built of perishable materials. It is here that the authors' knowledge of architecture and engineering is particularly valuable. Most important, the authors describe the architecture and its functions within the context of the political and economic organization of the Inca state. This is imperial architecture, and it functions in a symbolic as well as a normally practical way. Yet its imperial nature also explains in part its sometimes monotonous regularity by comparison with other architectural traditions such as that of the Maya.

The 324 illustrations, crucial in a book of this sort, include photographs, plans, drawings, and occasional reproductions of older illustrations that give evidence of features now destroyed. They are of outstanding quality, far superior to the average "record" shot. I could quibble with a few details such as some redundancy, but it is hardly worth the trouble given the breadth of the selection. The book is enhanced by a foreword by John Murra, in which he places the work within the context of Andean research.

I do not wish to give the impression that this book is the final word on Inca architecture. Persons wanting greater detail on any particular site for research purposes will still have to consult the primary sources. Moreover, as the authors themselves admit in the preface, the data are remarkably limited, and much work remains to be done. New details will be added and interpretations will change as excavations continue. For the present, however, this book provides an outstanding and up-to-date introduction to Inca architecture as an expression of Inca culture.

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The Invisible Universe

Cosmic Landscape. Voyages Back along the Photon's Track. MICHAEL ROWAN-ROBINSON. Oxford University Press, New York, 1979. x, 150 pp. $12.95.

Astronomy is a science that appeals to our visual senses, and Michael Rowan-Robinson makes this appeal the theme of his book of "voyages back along the photon's track." In this he opposes the trend in scientific writing away from the descriptive and toward the analytical. Rather than organize his material around such specific objects as quasars or black holes or such themes as the birth and death of stars, Rowan-Robinson paints dazzling word-pictures of the universe as seen in different wavelengths of radiation.

The revolutions in astronomy of the past three decades have derived in large part from the opening up of the invisible wavelengths. Often, the newly revealed sky has been remarkably different from the visible universe that had been studied since the time of Galileo. For instance, when radio astronomers first mapped the heavens they "saw" the familiar sun and the Milky Way, but no stars—what were at first called "radio stars" turned out to be bizarre and often immensely distant objects, such as exploding galaxies. Only later did understanding increase to the point that some of the gaps between spectral regions could be bridged. There still remain major gaps, of course—for instance, in the infrared and submillimeter part of the spectrum, where no comprehensive sky surveys have been carried out, or in the realm of the gamma rays, where the events that generate brief bursts of energy are as mysterious to us as the visible stars were to Babylonian astrologers 4000 years ago.

Rowan-Robinson's book, written for "someone who might never have read anything about astronomy," presents us with six cosmic voyages, each exploring a different spectral region. They are ordered not by wavelength, but approximately in the sequence in which the appropriate astronomical tools were developed: visible, radio, ultraviolet, x- and gamma-ray, infrared, and microwave. In each voyage, we begin with objects in the solar system, take a look at the sun and nearby stars, and then expand our horizon outward in distance and backward in time. Some classes of objects are noticeable in only one or two bands, whereas others, such as the quasars or the neutron-star supernova remnant of the Crab Nebula, appear again and again

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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