Book Reviews

The Properties and Origins of Quasars

Quasars. Their Importance in Astronomy and Physics. F. D. KAHN and H. P. PALMER. Harvard University Press, Cambridge, Mass., 1967. xii + 112 pp., illus. $5.50.

Quasi-Stellar Objects. GEOFFREY BURBIDGE and MARGARET BURBIDGE. Freeman, San Francisco, 1967. xii + 235 pp., illus. $7.50. Astronomy and Astrophysics Series.

The extraordinary properties of quasi-stellar objects, or quasars, were not recognized until 1963, when Maarten Schmidt discovered the red shift of 3C 273. Much excitement was generated by the discovery of objects of stellar appearance which not only were strong radio sources but had large red shifts and which might therefore be the most distant observable objects in the universe. As a result, the first Texas Symposium on Relativistic Astrophysics was held in Dallas in that same year, 1963. The proceedings of that international conference were published under the title *Quasi-Stellar Sources and Gravitational Collapse* (University of Chicago Press, Chicago, 1965).

Until recently, this has been essentially the only book on these mysterious objects, although chapters have been devoted to them in several recent books such as William A. Fowler's *Nuclear Astrophysics* (American Philosophical Society, 1967) and Fred Hoyle's *Galaxies, Nuclei, and Quasars* (Harper and Row, 1965). There have been a number of good review articles [for example: H. J. Smith, *Appl. Opt.* **5**, 1701 (1966); E. M. Burbidge, *Ann. Rev. Astron. Astrophys.* **5**, 399 (1967)], but the quantity of published papers on quasars is now so vast that there has been a need for a more complete summary of the subject. Thus two new books on this topic are very welcome.

Quasars, by Kahn and Palmer, is the smaller of the two, and is addressed to "the general reader who has scientific and astronomical interests." The authors are both at the University of Manchester; Kahn is professor of astronomy and a theorist, and Palmer is senior lecturer in radio astronomy and much involved with the Jodrell Bank measurements on radio sources. This book is basically an updated version of a series of lectures given at Manchester in 1965. Quasars are not the only subject; the authors introduce much background material, in chapters on relativity, cosmology, radio galaxies, stars, and other topics. The book is well illustrated with photographs of radio and optical telescopes, galaxies, and a few quasars. There are not many equations or tables, and no references.

The book gives good, if somewhat brief, descriptions of the optical and radio properties of quasars—the rapid fluctuations in brightness, the almost unmeasurably small angular sizes, the unusual spectra. Not until the last chapter is the question of their nature taken up seriously. The authors assume, as is customary, that the observed red shifts are of cosmological nature, although the possibilities of gravitational or local Doppler-shift explanations are briefly discussed. They point out, however, that on the cosmological basis which they prefer, "These large luminosities and energies worry some astrophysicists. Their anxiety is deepened by the observation that the radiation from many quasars is not steady, but shows sudden and irregular fluctuations, occasionally on a time scale of a few days only. One expects that such luminous objects cannot be confined in a small space. But if the object is large and uniform then the disturbances we observe should not be sudden because synchronization cannot be achieved. . . ."

They believe that these troubles are overcome by the cosmological model which they propose, a hierarchy of massive gravitational condensations, all in mutual orbit. They are nevertheless open-minded as to the true nature of quasars, and assign, at the end of the book, 20 percent odds of success to various local models, 35 percent to their own model, and 45 percent to other cosmological models.

Although this book gives only an introductory treatment of quasars, and is definitely not a reference book, it is well written and interesting and is recommended as informative reading for non-astronomers, both laymen and scientists.

Quasi-Stellar Objects is a book of quite different character. It has been written by Geoffrey Burbidge and his wife Margaret Burbidge, who have previously made many contributions to this field, both jointly and separately. Both are professors at the San Diego campus of the University of California, Geoffrey in astrophysics and Margaret in astronomy. Their new book is not written for the general reader, but is an excellent source book and textbook, discussing in some depth most aspects of quasi-stellar objects. It summarizes very well the present observational knowledge of these objects and the various theories put forward to account for their puzzling characteristics.

Among the valuable features of this book for research workers or advanced astronomy students are 12 reproductions of photographic spectra, eight pages of references, and 18 tables. The tables, some four or five pages long, include very useful lists of the known quasi-stellar objects, of the 100 measured red shifts known as of early 1967 (many measured by the Burbidges), and many tables of absorption and emission lines.

This book should be invaluable to anyone who is seriously interested in quasi-stellar objects. It is an excellent critique and guide to the literally overwhelming number of published papers in this field. The Burbidges recommend the name "quasi-stellar objects," both for those with measurable radio strength and for the blue stellar objects which have perhaps the same characteristics except for radio output. Astronomers and astrophysicists who have tried to account for all the strange characteristics may prefer the name "crazy stellar objects," credited to the 10-year-old daughter of the Burbidges.

The observational data which are discussed at length here include the apparently anisotropic distribution of quasi-stellar objects (QSO's) in the sky (favoring the poles of our galaxy), the unexpectedly rapid fluctuations of optical and radio strength, the apparent cutoff of red-shift values near $z = 2.2$ ($1 + z$ is the ratio of red-shifted to normal wavelength), the puzzling ab-

sorption lines at $z \simeq 1.95$ in objects with larger values of emission red shift, the lack of expected Lyman-α absorption, and the lack of any evidence of association with distant galaxies. These observations, and others, are not easily compatible with cosmological distance and would tend, as the authors point out, to favor a more local explanation of QSO's.

After presenting the complete experimental picture, the Burbidges discuss the various cosmological models of Schmidt, Woltjer, Colgate, Barnothy, and others, the more local models of Hoyle and Fowler, Arp, and the Burbidges, and the very local model of Terrell. They discuss the very real difficulties for cosmological models, such as the problem of preventing overwhelming Compton loss of energy by relativistic electrons in a radiation field necessarily as intense as inside a laser, which have been largely ignored by those who would be highly disappointed if QSO's should turn out not to be at cosmological distance.

As the authors point out, "The local hypothesis has bothered those who may have believed consciously, or subconsciously, that if the quasi-stellar objects are local they are not such great discoveries as if they are cosmological . . . But if they are comparatively nearby they are exceedingly interesting in the problems that they pose." The Burbidges originally favored cosmological distance but were eventually persuaded by the evidence that a more local explanation, such as ejection by our own or nearby galaxies, was probably necessary. They now think that most of the red shift may be due to gravitational effects, at moderate distances, which might account for the puzzling predominance of the absorption red shift $z = 1.95$.

The Burbidges also discuss the objections to various local models, such as the belief that there is a continuous transition of properties from radio galaxies to cosmological QSO's (Heeschen's diagram), and the feeling that ejection of local QSO's from galaxies requires excessive amounts of energy. One puzzling lapse occurs in their discussion of Terrell's local model, in which they state that the lack of observable proper motion puts the QSO's at distances of at least a few megaparsecs (that is, $\gtrsim$ 10 million light-years), with correspondingly large energy and mass requirements. They have evidently forgotten that, with origin at the center of our galaxy, little of the relativistic recession speed would now appear as a transverse component, so that the distances could easily be less than a million light-years. (*Note added in proof*: T. A. Matthews has recently reported that QSO 3C 287 cannot be at more than this distance, because of rapid changes in the size of an associated jet.)

One cosmological model too recent for inclusion in this book is that of Cannon and Penston, McCrea, and (independently) Gamow, who have suggested occultations by transversely moving dark bodies or absorbing clouds as a mechanism for producing rapid fluctuations. However, as Geoffrey Burbidge has pointed out since the writing of this book [*Nature* **214**, 1213 (1967)], this model would actually worsen the problems associated with cosmological models, since the dimensions of such light sources would have to be a matter of only light-minutes, much less than the relativistic upper limit imposed by the fluctuations alone.

Although the Burbidges make no secret of their present leaning toward a local model of QSO's, they have attempted to treat all the possible explanations fairly. They state that "none of the arguments is watertight, and much of the observational evidence is highly incomplete." In this book they have made an admirable effort to present the whole picture of our present knowledge of quasi-stellar objects.

JAMES TERRELL
University of California
Los Alamos Scientific Laboratory,
Los Alamos, New Mexico

Prehistory: Africa Depicted

Atlas of African Prehistory. Compiled by J. DESMOND CLARK. Maps by EVE KEMNITZER. University of Chicago Press, Chicago, 1967. Twelve maps and 38 overlays, boxed, with explanatory booklet (64 pp., illus.). $32.

The publication of this atlas marks the completion of a ten-year project. The compiler, assisted by an advisory committee of six and drawing on information received from some 60 collaborators, has produced a unique work —the first atlas dealing with the prehistory of a whole continent.

The atlas consists of 12 base maps and 38 overlays printed on loose sheets of clear plastic; a white background is provided against which these can be viewed without the use of a lightbox. The first group (11 base maps, 26 overlays) is drawn to a scale of 1:20,000,000 (sheet size 45 cm by 40 cm); a second group (one base map, 12 overlays) is drawn to a scale of 1:38,000,000 (sheet size, 23 cm by 22 cm).

The base maps of Group I provide a wide choice of ecological conditions which may have affected the biological and cultural evolution of man on the African continent. These include topography, geology, soils, rainfall, and vegetation, as well as an intriguing series of hypothetical situations in which vegetation zones are projected for conditions with 50 percent and 150 percent of present rainfall (temperature held constant), and with rainfall at the present or at 150 percent of the present level (temperatures 5°C lower). The overlays from Group I provide further environmental information (drainage, diseases, faunal distributions), locations of fossil-man sites, and a full inventory of lithic sites from the Oldowan through the Neolithic. A very large number of combinations is possible; by selecting, for example, map 9 (hypothetical vegetation zones, 150 percent of present rainfall, temperatures as today), and combining it with overlays 1 (drainage) and 23 (Neolithic industries of North Africa), the user can approximate conditions in the Sahara during the Neolithic Wet Phase. As a precautionary measure, the explanatory booklet provides a sketch map to show the relative intensity of prehistoric research in different parts of Africa.

The map and overlays of Group II provide outlines of present-day discontinuous distributions of seven mammals (for example, the white rhinoceros and the diadem monkey) and five bird species (for example, *Alcippe abyssinicus* and *Neocossyphus rufus*).

Notes on the atlas appear in the explanatory booklet, which also includes chronological charts of the lithic industries; lists of African fauna for different time levels of the Pleistocene; and map coordinates for lithic sites, indexed by country and industry.

This atlas is a magnificent publishing venture in which the compiler and his collaborators can take pride. Its success whets an Africanist's appetite for similar compilations of ethnographic, linguistic, and protohistoric data. Publication was generously subsidized by the Wenner-Gren Foundation; the atlas is probably worth twice its price.

NIKOLAAS J. VAN DER MERWE
Department of Anthropology, State University of New York, Binghamton