Finding Quasars

Proceedings of a Workshop on Optical Surveys for Quasars. (Tucson, AZ, Jan. 1988.) PATRICK S. OSMER, ALAIN C. PORTER, RICHARD F. GREEN, and CRAIG B. FOLTZ, Eds. Astronomical Society of the Pacific, San Francisco, 1988 (distributor, Brigham Young University Press, Provo, UT). xvi, 378 pp., illus. $32. Astronomical Society of the Pacific Conference Series, vol. 2.

Imagine a gaseous sphere with a diameter less than 1/10,000 that of our Milky Way galaxy. Then imagine packing this astronomically minuscule chunk of gas with luminous energy equal to the brightness of 100 to 1000 galaxies. Viewed from Earth across a distance so vast that its light has taken billions of years to reach us, this object called a quasar appears as a brilliant point in the center of an otherwise ordinary galaxy. Currently, many believe that the actual source of energy in a quasar is a monstrous black hole. For this reason alone, large numbers of astronomers have been studying quasars since their discovery nearly a quarter century ago. But of equal interest are the insights quasars suggest into the infancy of the universe.

Proceedings of a Workshop on Optical Surveys for Quasars is a collection of 46 reviews and poster presentations that demonstrates immense progress in one narrow but important area of quasar research, the production of large samples of quasars. Sponsored by the National Optical Astronomy Observatories, the workshop gathered participants from almost every group active in the field. The papers are highly technical, but the optical survey data are of wide astronomical interest. The compendium of 20 surveys alone makes this book a unique resource.

Some of the key questions to be answered by such large samples of quasars include:

1) When did quasars first form? The strategy is to establish the time when the numbers of quasars appear to increase rapidly. If found, that epoch may also be a clue to when the surrounding galaxies first formed.

2) What are the relative numbers of *intrinsically* brighter and fainter objects? Time evolution of these distributions directly reflects the statistical ensemble of quasar births, evolution in brightness, and perhaps final demise. Quasars may also show the effects of optical distortions (such as multiple imaging, brightening, or variability) due to the lensing or bending of light from the gravity of intervening objects, luminous or otherwise. Thus quasars provide a probe of the "dark matter" most astronomers believe to permeate space.

3) Are quasars clustered? If so, changes in any clustering with time may be used to track the competition between the pull of gravity and the expansion of the universe. We can take advantage of Einstein's theory of general relativity to relate the inferred matter density to the geometry of the universe. At distances beyond which gravity has had time to rearrange matter, clustering provides a fossilized imprint of the fluctuations in the universe during the first moments of the big bang.

4) What are the correlations among the observable properties of quasars? These properties include luminosity, spectral features, time scales of variability (related to the size of the quasar emitting region), the presence of neighboring quasars and galaxies, and distance. Such correlations constrain quasar models and cosmologies.

Only five years ago, sufficient data to address these questions were practically nonexistent. Three new technologies, however, have revolutionized the speed and accuracy of quasar searches: faster computers for automated data reduction and simulation of errors and selection biases, charge-coupled devices (CCDs) as detectors with near-perfect efficiencies, and multiple-object spectroscopy using optical fibers.

The most impressive evidence of recent progress is the survey by B. Boyle and his colleagues. They have detected, identified, and obtained distances to 420 quasars that are 100 times fainter than the largest previous survey of 114 quasars completed by M. Schmidt and R. Green in 1983. Contrary to the widespread belief that quasars were once much more plentiful in the early universe, these new faint surveys suggest that, on average, quasars were actually about the same in number but 100 times brighter.

Progress has also been made in surveys for quasars more distant than those studied by Boyle. Three teams led by S. Warren, C. Hazard, and M. Schmidt have broken the record for finding the most distant quasar several times in the last two years. (The previous record stood for nine years.) As the searches continue, the teams are finding dozens of quasars that do not break records but are very distant. Whether their data show an increase of quasars with time, and thus detection of the epoch of quasar creation, remains controversial.

Within the next few years, these three surveys and several other extensive ones described in the book will be finished. And as promised, all the key questions identified above will be answered at some level. But the history of astronomy warns us that new information, improved statistics, fainter limits, and more sophisticated questions will undoubtedly arise and keep these quasar surveyors busy for years to come.

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Seafloor Discoveries

Seabed Pockmarks and Seepages. Impact on Geology, Biology and the Marine Environment. M. HOVLAND and A. G. JUDD. Graham and Trotman, London, 1988 (U.S. distributor, Kluwer, Norwell, MA). xii, 293 pp., illus. $117.

Webster's Collegiate Dictionary defines "pockmark" as a mark or pit due to smallpox. But the present book obviously does not deal with an oozing medical problem; rather, it is concerned with geological features for which the medical term seems appropriate: concave, crater-like depressions that occur on the seafloor. Before 1970, pockmarks were not included in geological jargon, and only in the latest edition of the American Geological Institute's *Glossary of Geology* (1987) does the term make its appearance. But since 1970, when seabed pockmarks were first observed with the aid of the then-new side-scan sonar on the continental shelf off Nova Scotia, they have been reported to be present on the seafloor in many parts of the world.

This book does an outstanding job of summarizing the occurrences of seabed pockmarks worldwide, with particular attention (two chapters) given to the North Sea, an area of significant petroleum development. Not only are the morphological, mineralogical, and biological aspects of pockmarks considered in detail, the processes that may form them are discussed at length. Although pockmarks are defined in the AGI *Glossary* on the basis of morphology, this book implies a genetic element in the definition by emphasizing the role of fluid escape