Space-Age Astronomy and Whale-Oil Lamps

A new window in the electromagnetic spectrum has been opened, but we should not close the older ones.

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A director at an eastern observatory was asked recently by his university's buildings-and-grounds chief when the astronomers were going to move to their new offices so the observatory could be torn down.

"Where are you going to move the telescopes?" asked the director.

"Move the telescopes?" responded the B-and-G man. "We didn't think you wanted them any more; we thought you were all doing space science!"

Mid-twentieth-century astronomy presents a unique spectacle. Some fields of research are lavishly supported, some are adequately supported, and some are bogged down by shortage of modern facilities. In no other scientific field is the practitioner expected to "bring home the bacon" with capital equipment dating from 1908, 1888, or earlier. It is a tribute to the ingenuity of the optical astronomer that he has done as well as he has; a classic example is Hynek's use of the image orthicon on his 1862-model telescope. Yet no amount of gadgeteering can surmount handicaps imposed by the quantum theory; no image tube can overcome limitations in the photon statistics imposed by inadequate light-gathering power. Modernization requires more than replacing the oil-lamp illumination of setting circles by electric lights.

Nor is mechanical and optical obsolescence the whole story. The performance of many telescopes has suffered because of deterioration of observing sites. The Mount Wilson Observatory, and more recently the Lick Observatory, are adversely affected by the gargantuan growth of nearby, well-illuminated, metropolitan centers.

The postwar development of radio astronomy impressively demonstrates what can be done with adequate support and modern technological developments. Fortunately, worth-while projects were supported in many different places, and no effort was made to concentrate all the work in one huge enterprise. The opening of the radio-frequency window has led to great advances in our knowledge of the planets, of the sun in both quiet and active phases, and of the structure of the galaxy, supernovae, and gaseous nebulae, and above all, to an appreciation of the importance of magnetic fields in nebulae and "empty" space. Unfortunately, many tempting leads in studies of gaseous nebulae and nonthermal sources have not been followed up; the necessary optical equipment has not been available, particularly in the Southern Hemisphere.

As radio astonomy opened up the low-frequency window, so will space astronomy open up the intriguing ultraviolet window. Fragmentary data so far obtained indicate that many of our extrapolations from optical data were sadly amiss; a host of surprises await us in this region. Just as radio astronomy focused our attention on optical objects that were sources of nonthermal radiation, so space astonomy will call the attention of the ground-based optical astronomers to a host of engaging objects. As an example I might mention the Crab nebula, where both radio and optical data were needed to disclose perhaps the most bizarre puzzle in all astrophysics.

Opportunities in the Southern Skies

In spite of a great increase in overall astronomical activity, very little has been done to provide the optical astronomer with adequate modern instruments. To be sure, a fair number of small, specialized telescopes have been constructed. Most are of restricted usefulness and not readily adaptable to the exploitation of technological breakthroughs. The Lick 120-inch reflector, the 80-inch Kitt Peak reflector, and the 60-inch Naval Observatory astrometric reflector are the only large, or medium-large, telescopes planned and constructed in the United States since World War II. The Soviet Union is constructing a substantial number of large telescopes; several other countries—including some so-called underdeveloped ones—have built reflectors.

Breakthroughs in nuclear astrophysics—such as checks on theories of element building in stars, the identification of stars or solar systems in the process of formation, and identification and interpretation of radio sources—can be achieved, and age-old problems of cosmology can be attacked, only with instruments of large light-gathering power.

The most promising leads to a solution of problems of stellar evolution are provided by the Magellanic Clouds, which lie near the south pole of the sky. In these nearest of all stellar systems are stars, clusters, and gaseous nebulae, similar to those in our own galaxy. All these objects are at essentially the same distance; hence, the intrinsic luminosities of stars and the sizes and brightnesses of clusters and nebulae can be compared with an accuracy not attainable in the northern hemisphere. The nearest and brightest of globular clusters and the center of our own galaxy with some of its brightest star clouds are in the Southern Hemisphere.

The greatest and most urgent need in optical astronomy is for adequate instrumentation in the Southern Hemisphere. Some modern telescopes are planned for South America, but to place a large reflector in Australia also is important. Some excellent sites have been found in a careful site-testing program. Further, there is a long tradition of scientific effort in Australia. The Australians have generously supported astronomy and astronomical education; they are the world leaders in radio astronomy. The 210-foot radio telescope at Parkes has no northern counterpart and places radio astronomy far ahead of optical astronomy in the Southern Hemisphere. It is particularly important, therefore, that an adequate

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optical facility be provided to exploit clues disclosed by this radio telescope, and to operate in close coordination with it. Finally, it is necessary to have adequate instrumentation in different longitudes. Radio and optical facilities in South America and Australia could be coordinated in observations of exotic variable stars, both in the southern Milky Way and in the Magellanic Clouds. Round-the-clock surveillance of a supernova would be of the utmost importance. Exploitation of the opportunities provided by the Southern Hemisphere is a challenge to radio and optical astronomers alike. The development of new types of equipment and the training of optical astronomers for both ground-based work and space astronomy will have to take place mostly in the Northern Hemisphere.

A telescope, unlike a particle accelerator (to mention another instrument requiring a large capital investment), can be used on only one program by one observer at a time. Some programs, particularly those pertaining to external galaxies and identification of radio sources, require huge expenditures of telescope time. Furthermore, weather imposes unpredictable shutdowns which may grievously curtail work in certain seasons of the year. All large and medium-sized telescopes in good locations are "saturated" and cannot meet the needs of those who would make good use of them.

Role of the Universities

The Kitt Peak National Observatory will play an indispensable role, but it cannot take care of all our needs in optical astronomy. A strong grass-roots program of support should be provided for universities whose departments of astronomy are able and willing to play their part but are prevented from doing so by lack of funds for such capital investments as adequate modern telescopes. With the proper support, such departments could develop and check out new techniques, train advanced students, and even carry out substantial parts of many research programs. The more difficult phases, requiring good seeing or large light-gathering power, or both, could then be carried out at Kitt Peak. These observatory facilities could be used with maximum efficiency, since visiting astronomers and advanced students would come there with well-defined problems and thoroughly-checked-out techniques.

Universities located in the West or Southwest have special natural advantages for optical astronomy programs. Yet so completely saturated are present observational facilities there that one department decided to heavily emphasize theoretical work, not just for its intrinsic merit but because "the time on telescopes is getting harder and harder to get, but there is no problem getting time on an electric computer." Good students in departments with archaic, inadequate equipment will almost certainly turn to theoretical work or to other fields (see *1*).

The fact that there is urgent need for supplying additional optical telescopes, moderate-sized to large, to promote astronomy in the West and Southwest does not mean that optical work should not be supported elsewhere. A moderate-sized "light catcher" of aperture up to 60 or 70 inches and short focal length would bring enough starlight into a coudé room laboratory to enable one to experiment with image converters, orthicons, spectrum scanners, and data handling equipment. It would be a novel and challenging experience to apply to optical astronomy some of the techniques that are standard, old-hat procedures in other areas of physical science. Much better work could be done if midwestern or eastern astronomy departments could establish their moderate-sized telescopes in field stations in good western observing sites.

Need for Capital Investment

Assessment and analysis of data are often handled by clumsy or archaic procedures because funds are not available for modernizing the 19th-century equipment with which they were obtained. It is possible to hire help; it is virtually impossible to get money for adequate capital improvements.

The need for capital investment in optical astronomy, particularly to exploit the opportunities offered by the southern skies, is an urgent one. It cannot be met at the local-university level; every college is pushed to the limits of its resources to provide buildings and staff to handle ever-growing numbers of students. Substantial support should be given to an agency such as the National Science Foundation so that worth-while projects requiring capital investments can be supported on their own merits.

Progress in astronomy depends on a judicious combination of ground-based radio and optical astronomy, and space astronomy. Each complements the other. The opening of a new window in the electromagnetic spectrum does not mean that we should close one of the old ones, or allow it to blacken up with the dust of obsolescence.

Reference

1. J. B. Irwin, *Science* **138**, 127 (1962).