OPTICAL ASTRONOMY IN INDIA—PROSPECTS OF THE NEXT DECADE

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WHEN we attempt to visualize Indian ground based contributions to optical astronomy during the next decade of activity, we must be aware of the need of a certain measure of realism in our estimate if we do not want to be categorised as being too hypothetical. For, these contributions will originate principally from the existing light gathering facilities and those likely to be available in another four or five years. Any large telescope in the 4–5 metre class, that we would very rightly consider necessary for Indian Astronomy of the eighties, will not be capable of producing the results we seek in the forthcoming ten years. The simple reason is that it would take well over a decade for such a telescope to be completed, once work on it is commenced. The immediate future prospects lie, therefore, in the proper utilization of current light collection facilities with the maximum efficiency that today's technology can offer. Success today in this highly competitive field depends on a combination of choosing right problems and attacking them with instrumentation that utilizes to the fullest extent every photon that is received. The world astronomical community have still to take to this reasoning with a whole-hearted conviction. The population explosion in telescopes that we witness today is the result of a similar phenomenon amongst astronomers. We should give importance to the concept that the telescope is just a light collector and that our capability of extracting the maximum information from the stream of photons passing through the focal plane determines the measure of success that we can finally achieve. One can never overdo the repetition or stress of this philosophy.

In the widest sense of the term the Universe, the telescope and the equipment at the telescope focal plane and after, constitute a real physical laboratory. It is a laboratory that needs the capability of rapid adaptability to changing technological facilities. This capability can be achieved only by a combination of men, and adequate resources. With limitations imposed on our light-gathering facilities, we in India should be more than aware of this vital need of good technological backup resources at each observation centre in the country. Investment in this direction should have the highest priority, for we can then with our present telescopes still be in the forefront of astronomical progress with elegance and much finesse than by having large aperture telescopes of increased photon collecting ability with inefficient follow through of an information extraction facility.

Astronomical instrumentation is currently passing through a phase of upheaval that will, at the end of it very shortly, provide not only newer means of handling better the older problems we had but also open newer vistas hitherto beyond our reach. The principal actors in this veritable drama are the on-line computer and the image tube. Side by side with the photomultiplier and the photographic plate, these new entrants on the scene have revolutionized the limits of our horizons of capability. To have all these adjuncts at our disposal in India as early as possible should be our first goal.

We now have the light gathering power in the country to do wide band photoelectric photometry to magnitude 20 or fainter. One achieves this with off-set photometers refrigerated photomultipliers and good telescope drives that enable the use of small diaphragms. Photon counting with adequate sky subtraction ensures the easy reach of these instruments to objects in the Palomar atlas. Stellar spectrophotometry from 3000 Å to the limit of the S 1 photosensitive surface at 11000 Å is a major technique in our studies of stars and galaxies today. The use of an on-line computer with the conventional techniques of detection have greatly increased faintness of detection with accuracy. Polarization measurements, light measures of pulsar variability and the evaluation of rapid light changes in variables or in star occultations by the moon are many of the fascinating possibilities with the new methods of data handling by a computer in the telescope vicinity. The new image-dissector super scanner, which is a combination of cascaded image tubes and small computer, marks the facility of tomorrow when a spectrum of a faint object at the limits of the light collection can be recorded and utilized for radial velocity or energy distribution studies or for the search of some other characteristic. It takes very little cost, compared to that of increasing the light collection fourfold, to have these facilities today on our telescopes in the country, that will permit the penetration to limits of faintness even beyond what was the reach of the 200-inch, less than a decade ago.

In the field of high resolution stellar spectroscopy there have been many new and stirring developments. There have been striking advances in grating technology that permit the design of coude spectrographs of beam sizes much larger than that used in the Hale telescope. Improved image detection techniques with magnetically focussed image tubes with a digital SEC Vidicon readout have provided most impressive gains in speed over the conventional photographic methods. The possible loss in spectral multiplex advantage can be much reduced with the aid of the echelle grating which is increasingly coming into use in astronomical spectroscopy today. Interferometric techniques using the dielectric multi-layer coated Fabry Perot interferometer with premonochromator, the poly-etalon spectrometer, and the Fourier infrared spectrometer have made fantastic gains in resolution. These are some of the technological developments of today that will be responsible for the spate of new developments in Astrophysics of tomorrow.

Stellar kinematics and astronomy of position continue to be the basic touchstone of much of our concepts of stellar evolution and basic astrophysical theory. The need to go fainter with increased precision continues to be the principal theme. Newer techniques of wide angle photography call for large-scale measuring engines automated to have high measuring speeds and data output. Improved stellar Doppler meters that allow radial velocity measures of faint stars to be carried out directly at the telescope are now a reality. Measurement of radii of stars by lunar occultations or intensity interferometers provide a fund of basic information hitherto beyond our reach. Never before in astronomical history has there been so much promise of the means to unravel the mysteries of the Universe in that limited region of the electromagnetic spectrum that we call the optical domain.

What then are the possibilities for front line research with such accessories and the light collection facilities that we will possess by 1977? Virtually an infinite variety, is the answer. Some selection will, however, be called for an effective concentration of effort in some of these areas so that the contributions are substantial enough to be significant milestones of progress.

A very fascinating area of activity in extragalactic research of today is the study of the properties of the nuclei of galaxies. Here one may be witnessing in almost every galaxy some degree of violence that varies in scale from galaxy to galaxy. Monochromatic photography along with spectra are of importance for an understanding of the phenomena at play in these locations and which should perhaps have a significant control of the happenings elsewhere in the galaxy away from the nucleus. Search programmes for galaxies with blue nuclei will be necessary to give us the variety from which we can choose and examine in detail. The study of QSO's should be extended in selected regions of the sky for improved statistics and for studies of the likely differences between these objects and the QSS. Monochromatic photography of the spiral features show up the regions of the H II features and the course of the spiral arms. In some cases the H-alpha picture shows up intermediate arms that coincide exactly with the radio arms. The kinematic characteristics of such features and indeed of most of the galaxy, for galaxies of different types, are basic for any understanding of the dynamics of spiral structure. Spectrophotometry of the nuclei and of selected regions in different galaxies are our only means of conjecture on the nature of the stellar population and of the abundances of the elements in these locations.

Coming to the topic of our own galaxy, two areas of activity that stand out foremost are first, the study of the spiral structure of our galaxy and secondly the abundances of the elements and physical parameters in different stellar atmospheres. Optical studies of spiral structure are best carried out with spiral tracers like H II regions, O and B stars and very young cepheids. There is much scope here for the discovery of these objects to fainter limits of detection than possible so far and of measuring their distances. Not until there is a tremendous output of this information available, will we be able to have a picture of spiral structure of our galaxy with the finer details marked in. We have had so far only a minor sampling of abundance studies carried out on a few objects of diverse characteristics of origin. Clearly this is vital information for theories of element formation and for studies of stellar evolution. The need for improved techniques in this area is obvious, since we continue to use on the stars, spectroscopic resolution that was employed on the sun a half century ago. Studies of clusters, both galactic and globular, are still our best means for the study of stellar evolution at different ages. There is much that needs to be done on these objects specially at the fainter limits of the H-R diagram, a splendid opportunity for those who have a medium aperture instrument and good instrumentation for wide band photometry.

Moving in closer to the solar neighbourhood into the domain where distances can be measured by trigonometric methods, we come to the area of research that is of fundamental importance to all astronomy. Seven decades of parallax work have indeed given us many values of distance for several single objects. The time is now ripe with the aid of the automatic measuring machines and a wide angle telescope to extend these well over a hundred fold by going fainter until the 20th magnitude. It is here that the fainter end of the luminosity function in the solar neighbourhood can be studied effectively.

In following up these new trends in astronomical activity, we should not lose sight of the fact that much information needs to be added to the details we have today of stellar masses and radii. The binary systems are our principal mainstay for such information. Let us remind ourselves that almost all of our astrophysical conjecture is indebted to progress made in this area which can be done always with simple equipment.

Research in solar physics has indeed a long established tradition in this country covering over a century. The sun is the only star which subtends a disc large enough to facilitate study in detail. Here is the real testing ground of detailed astrophysical theory. We see here manifestations of several phenomena that vary from star to star in degree. The chromosphere, presence of a corona, prominence and sunspot activity, magnetic behaviour and its coupling with the velocity field and the visual manifestation of the hydrogen convection zone are all seen in detail and indicate what we may expect in stellar atmospheres other than the sun. The study of the sun is thus vital for progress in astrophysical experience and thought.

The recent years have seen much work done that impresses us with the role of the magnetic field in solar phenomena. The next decade will undoubtedly see the common use of multichannel vector magnetographs that can scan rapidly a given region on the sun in the photosphere, chromosphere or prominence area with high accuracy. These would show characteristics of transient phenomena as in flare regions or active regions on the sun. The study of inhomogeneities of very small dimensions of sizes one second of arc or less will yield much information on the properties of these features. Studies of this kind reveal the macroscopic characteristics, consideration of which must be definitely invoked in the non-LTE theories of tomorrow. The details of convection and the heating of the upper layers sponsored by it are best studied in the solar case. Prominence magnetic fields and the excitation and support of prominences are topics that call for intensive study.

Solar eclipses have long been the principal source of information of many aspects of the solar chromosphere and corona. It is thus a very important area of activity for the solar physicist, and one that must be kept well in mind in any Indian programme. The total solar eclipse on Indian soil in 1980 would undoubtedly be of considerable interest to us in this regard.

What then does the future after a decade call for in instrumentation? A large light collection facility in the vicinity of 500 cm will certainly be necessary for Indian astronomy. The 234 cm reflector to be built by the Indian Institute of Astrophysics should be in full operation in the late seventies. It should give Indian astronomers, the much needed opportunity of having soon a large facility on Indian soil. The 5 metre or larger light collection will definitely need to be available in the late eighties, planning for which should commence without much delay.

The mosaic telescope with large light collection area and short focal length holds the attractive possibility of being the large telescope of tomorrow. The limitation for this instrument may prove to be the small field available on-axis, though this may be more than offset by the short focal length and hence less susceptibility to seeing. Prototype models currently under construction at Kodaikanal and Tucson should be able to demonstrate their capabilities.

On the solar side, the ground based telescope still offers the maximum for high resolution study. The vacuum telescope located at a good site should be able to obtain spectra of features less than half a second of arc. Choice of sites in a wide expanse of water holds much promise. Very small islands, less than a hundred metres across in the ocean, are a good possibility. Much careful study should be made in this regard before locating a large vacuum telescope of the order of 150 cm in aperture. A bright solar image of large scale under almost perfect conditions of seeing would be the answer to the solar physicist's dream.