Chapter 6.2

SMALL TELESCOPES IN RESEARCH AND EDUCATION

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Historical Perspective

About 200 years ago, a 9.5 cm (3 inch aperture telescope was called a large telescope. London was then the centre of the world optical trade with John Dollond (1706-61), his son-in-law Jesse Ramsden (d.1800) and son Peter Dollond (d.1820) as the leading telescope maker in England. At that time it was not possible to make good quality flint glass blanks of larger size, and the lenses were ground by trial and error. Credit for providing a scientific basis for optical engineering as well as for making large-sized lens telescopes goes to Munich-based Joseph Fraunhofer (1787-1826) who started his career as an 11 year old orphan in virtual bondage at an optics shop and rose to such eminence that on his death he received a state funeral.

Originally, reflecting telescopes were made from the unwieldy speculum metal, an alloy of copper and tin. The invention, in 1856, of the silver-on-glass technique by the chemist Justus von Liebig (1803-73) in a different context made it possible to make large, low-weight astronomical mirrors. The problem of casting strong mechanical mountings suitable for large telescopes was solved by the use of the steam hammer invented by James Nasmyth (1808-90).

With the advent of large telescopes, the centre of astronomical activity shifted from Europe to the United States of America (US) which had the requisite clear skies, funds and a desire for intellectual leadership. In recent times, advances in technology, telecommunications and international cooperation have freed observatories from the limitations of

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national boundaries and made it possible to collectively install large telescopes at globally-selected sites.

In one important aspect, astronomy is unlike experimental sciences. Setting up of a modern sophisticated laboratory often means the eclipse of earlier ones. The advent of large telescopes however does not mean redundancy of small telescopes (aperture less than 1m). This is so because from any place on the terrestrial globe only half the celestial sphere is visible. Therefore, no observatory, no matter how well equipped, can cover the whole sky. Secondly, since astronomical events cannot be manipulated or repeated, each independent observation is a valuable addition to the databank. Also, for continuous monitoring of certain class of objects, receipt of round-the-clock data is needed.

These data can be obtained by observers located at different longitudes. Thus while astronomy today depends on large (and space-borne) telescopes for breakthroughs, it solicits contribution from as many telescopes of various sizes as possible.

Astronomy is more than a branch of modern science. It is a symbol of the collectivity and continuity of humankind's cultural heritage. That is why many developing countries, particular those with memories of past contribution to science, are keen to renew their acquaintance with astronomy and contribute to its growth. Paradoxically the factors which favoured astronomy in ancient times now work against it. Astronomy was the preferred activity of ancient cultures which owed their prosperity to agriculture which in turn depended on rain.

Thus there was a direct correlation between astronomy and rain. In contrast, modern astronomy today prefers sites that are dry throughout the year and away from civilization. In other words, inheritors of ancient astronomical tradition are unlikely to find suitable sites in their midst worthy of huge investments that large-scale modern astronomical facilities now require. This handicap notwithstanding, developing countries can still contribute to the enrichment of astronomy through small telescopes, because as we have seen astronomical facilities are not competitive or exclusive but additive.

1. Small Telescopes

There is another reason why developing countries should develop facilities centered around small telescopes: Although astronomy has been and still is the most Brahmanical of all sciences, today it requires artisan support of a high order. Astronomical ambition should therefore be pegged at the level of the available infrastructural support. Many developing countries, in their impatience to make up for lost time, have tended to begin with big science -at the top, hoping that the benefits would slowly trickle down. This has not happened, because the law of gravity does not apply in the intellectual domain.

Very often, the facility is acquired from abroad on a turnkey basis on the initiative of a single individual. Countries with a pre-industrial mindset tend to rank an individual above an institution. The facility is often seen as an extension of the founder's personality, so that its golden age becomes coterminous with the workspan of the founder. Even though the observatory does not actually die, it becomes a victim of AIDS, astronomical instrumentation deficiency syndrome.

If the facility is to emerge as an institution, the acquisition of equipment should be accompanied by the provision of (i) training of manpower, (ii) maintenance of equipment and possible upgrading, and (iii) sustenance of interest.

To be productive, a telescope should be supplied with users. No doubt, in the beginning, trained manpower will have to be acquired from outside. But it is essential to have an in-house training programme so that generation after generation of users are available. The most effective way of solving the manpower problem and ensuring the success of long-range research programmes would be to involve the universities. The universities have a regular intake of students, a well defined curriculum, and a rigorous examination system. If a telescope facility is made part of a teaching programme, it will be assured of manpower at a reasonably competent level. Of the large number of students that enter a university, even if a small fraction can be motivated beyond the compulsions of a degree, long-range needs will be met. Furthermore, to meet the university requirements, the observatory will have to be maintained at a certain level, independent of the idiosyncrasies of individuals.

There is need to establish a symbiotic relationship between the telescope and the workshop. An instrument should be a tool in the hands of a user. It should not overwhelm him or her. If a snag develops, the user should feel confident of setting it right and affecting improvements.

2. Research and Education

Small telescopes illustrate the veracity of Ernst Rutherford's aphorism, "We have not got the money, so we have got to think." Given a well-maintained, well-equipped small telescope a persevering astronomer with a well thought-out programme can obtain data of genuine research value.

Two fields are particularly suited for small telescopes: variable stars, and the sun and the solar system objects.

2.1 Variable Stars

Variable stars are stars whose light output varies. The variation can be due to a number of reasons and may involve timescales ranging from a few minutes to many years. More than 50,000 variables are known, divided into a number of groups. Their study is important because it tells us about the properties and evolution of the stars as well as about the physical processes occurring in them.

Variable stars can be observed with small telescopes using the technique of photoelectric photometry. Photometry of bright variables is not very sensitive to background light; observations can be made even when the Moon is full.

It however does require observing time, so that the location of a (small) telescope near the observers is of great help. Actual observations are not difficult to make. Objects should however be chosen with care keeping in mind the characteristics of the site and the instruments and as part of an international programme. Instrumentation should be standardized and observations carried out on a long-term basis.

In addition to the variable stars, solar system objects can be studied using small telescopes. One can begin with the Sun itself. To image the Sun, the light-gathering power of the telescope may be reduced by using neutral density filters. Solar patrols can be maintained at various longitudes, and white-light flares can be searched for.

2.2 Comets

There are a number of reasons why comets should be studied. First, they are a spectacular sight. More fundamentally, their chemical composition tells us about the conditions at the time of formation of the solar system. They contain condensates from the solar nebula and possibly even interstellar grains. Finally, they are the natural tools for probing the solar wind, especially away from the ecliptic.

Comets are not easy objects of study. They are often large in angular size, low in surface brightness, close to the sun when bright, and fast-moving. Their observation requires international cooperation of a high order; often their highly inclined orbit making it necessary to have data from the northern as well as southern hemisphere.

In particular, there is need for wide-field photographs of the comet's tail. Within a matter of hours, the ionic tail "breaks off" and is carried away by the solar wind while a new tail emerges from the coma. The process is too slow for a single observatory to photograph in a single night, but too fast for the observatory to observe the next night. To understand the theoretical processes involved, it is essential to have, courtesy a number of observatories, a good sequence of photographic images. In addition to coordinated photography, coordinated photometry will also be useful.

2.3 Asteroids

Asteroids are sufficiently numerous so that new ones can be discovered photographically and old ones studied. Unlike the comets they retain their original orbits and masses. Unlike the larger planets, they have not chemically evolved.

Consequently, they provide extremely valuable information on the origin and evolution of the solar system. Towards this end, it is important to learn about the asteroids' masses and volumes as well as geometry, rotation and surface properties.

An important project can be the observation of the occultation of background stars by minor planets. Given the large number of asteroids, such events are quite common. These events can tell us about asteroids what we cannot learn from the earth in any other way. A typical occultation lasts 10 to 20 seconds.

If immersion and emersion are timed at a number of selected sites to within 0.1 second, a level of accuracy easily achieved with simple photoelectric equipment, then the data can be combined to obtain a direct estimate of the dimensions of the face of the asteroid.

In a similar manner, photoelectric observations of occultations of stars by the Moon can be made. It is instructive to recall that rings around Uranus were discovered during a stellar occultation by the planet.

3. Teaching

The research programmes carried out with small telescopes can easily be integrated into formal teaching programmes. The observation of variable stars as well as analysis and interpretation of data can form a project at BSc and MSc levels. Similarly, solar spectroscopic studies can easily be integrated with laboratory spectroscopy.

3.1 Initial training

Training of manpower to initiate astronomical studies requires close attention. In this important area, it would be advisable to enlist support of these countries which have had a head start and which are culturally and economically close to countries with manpower requirements.

It has been seen that projects involving an offer of training by industrialized countries do not produce the desired results. Because of the glamour and the pecuniary benefits associated with a "foreign" visit, the opportunities are "grabbed" by persons high up in the hierarchy who are inclined to treat the visit as a personal honour rather than as an opportunity for obtaining hands-on experience. Also, in the case of younger elements, cultural discontinuity can have a demoralizing effect. Additionally, in the case of capable candidates, an opportunity not to return to their own countries can arise.

It would be far more profitable to make arrangements by which experts from neighboring countries can spend a few months helping the hosts in setting up facilities and training young astronomers. It will also be a help if regional refresher courses can be arranged at regular intervals, and handbooks prepared.

4. The Indian Experience

India was the first country outside Europe to acquire, at Madras in 1786, a modern astronomical observatory, thanks to the colonial use of astronomy as a navigational and geographical aid. During its existence in the 19th century, the Madras Observatory remained rather poorly equipped, its chief instruments being two refractors: a 15 cm aperture English-mount telescope by Lerebours & Secretan, acquired in 1850, and a 20 cm equatorial by Troughton & Simms, with optics by Fraunhofer's successor George Merz, acquired in 1861. The Observatory was kept in working order with the help of the mechanics at the workshop maintained by the government's public works department for its own use.

In contrast to the Madras Observatory stood the short-lived Lucknow Observatory established in 1831 by the king of Oudh (correctly Avadh) who had a European wife and a magpie-like fascination for novelties. The Observatory was placed in charge of a British astronomer and equipped, as befit a king's observatory, with the best instruments money could buy. The Observatory was commissioned in 1841 but closed eight years later by the new king. In the early years of the present century Kodaikanal Observatory emerged as a state-of-art solar research facility under the scientific leadership of George Evershed, who built a number of spectrographs for his own use. In addition, in 1911 he made an auxiliary spectroheliograph and bolted it to the existing instrument to make it more versatile. Not surprisingly, Evershed's stay at Kodaikanal coincided with the golden age of the Observatory.

In recent years, a number of small telescopes have been purchased by various agencies in India, some of which are being profitably used. Significantly, research-wise the most successful has been the one that is the most primitive. This telescope is a 34 cm Cassegrain reflector made in the Indian Institute of Astrophysics workshop and attached to a preexisting mounting vacated by an old 15 cm Cooke refractor. Thanks to the pooled efforts of the astronomers and the workshop staff, this rugged telescope has been successfully used for creating a database on the photometry of rotating variable stars, especially of the RS CVn and T Tauri type. The success of this telescope proves that for an astronomical facility to be successful, engineers and astronomers should work together.

5. Conclusions

1. When a new astronomical facility is set up, it should be at a level consistent with the workshop facilities and infrastructure support available. The equipment should not overwhelm the user.
2. For the initial training of manpower, cooperation should preferably be sought from countries which are culturally akin to the host country.
3. Attempts should be made to integrate astronomical facilities with the teaching programme
4. For best results, observational programmes should be chosen so as to form a part of international campaigns.

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