MODERN ASTRONOMICAL DEVELOPMENTS IN INDIA

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1. Perspective

Modern astronomy came to India in tow with the Europeans and was institutionalized more than 200 years ago by the (English) East India Company with the establishment in 1790 of Madras Observatory for assistance in navigational and geographical surveys. One hundred years later, in 1899, it was replaced by a solar observatory at Kodaikanal set up by the government to meet the European scientists' demand for sunny skies and in the hope that a study of the Sun would help predict the failure of monsoons, the key factor then as now in Indian economy. It is mildly interesting to note that, when the scientific agenda was laid down by the Royal Society, no mention was made of climate or rains [1].

During the nineteenth century there were half-hearted attempts by the Indian princely states to set up observatories. The Nawab of Oudh's Lucknow Observatory established in 1831 became defunct within 20 years, while the Trivandrum Observatory (1837) wisely shifted to location-specific equatorial magnetic studies. Note that in these observatories the academic control was British.

The positional astronomy slot vacated by Madras was sought to be filled by Nizamiah Observatory, set up at Hyderabad by a nobleman. Nominally attached to the Osmania University, its period of worthiness was the participation during 1914-46 in the international *carte-du-ciel* programme.

Routinely engaged Kodaikanal and nearly defunct Nizamiah were the only astronomical facilities at the time of independence in 1947. Looking for symbols of new nationhood, India extended support to all branches of astronomy: solar and night-time astronomy; radio, balloon and satellite astronomy.

The chief financiers of astronomical research in India are the central government departments of atomic energy, space, science and technology, and education (through the university grants commission). Not unexpectedly, these agencies operate without consultation among themselves. The scientists also tend to build individual bridges to their fund-givers rather than hold consultations among themselves.

2. Solar Astronomy

Of all the branches, solar astronomy has remained the least favoured. The Kodaikanal spectroheliograph and the 15cm refractor (1850 Lerebours and Secretan remodelled for solar photography) are probably among the world's oldest scientific instruments still in use. The most modern facility, the 38cm tunnel telescope, is about 40 years old. Recently Udaipur Solar Observatory has joined the GONG network for helioseismology.

Significantly, Indian efforts in regularly observing solar eclipses and in observing the Sun from Antarctica have been successful ventures. This is so because in field astronomy the advantage of sophisticated instrumentation back home disappears and relatively low-technology science that can be done provides a level playing field.

J. Andersen (ed.), Highlights of Astronomy, Volume 11B, 894–897.

3. Optical Astronomy

Night-time astronomy has been modernized during the last three decades. India has at present one 2m and four 1m class telescopes (Table 1). Out of these four, only one is attached to a university, but has been detached from the skies for the last three years.

TABLE 1. Table 1. Major Optical Facilities

No.	Aperture	Year	Make	Location	Remarks
1	2.28m	1986	Home-made	Vainu Bappu Obsy, Kavalur	
2	1m	1972	Zeiss	as above	1
3	1m	1972	Zeiss	Uttar Pradesh State Obsy, Naini Tal	1
4	1.2m	1968	J.W.Fecker	Japal-Rangapur Obsy, Osmania University	2
5	1.2m	1995	Home-made	Gurushikhar, Mt Abu	3

Remarks: 1. Identical Telescopes, 2. Dysfunctional for last three years 3. Optics repaired in U.K.

Now, the Inter-University Centre for Astronomy and Astrophysics, Pune (IUCAA) has ordered a 2m telescope from Royal Greenwich Observatory for installation at 1000m high Girawali site in the Western Ghats, about 80 km from Pune. Measurements made during November 1996 to February 1997 place the median seeing at about 1.4 arcsec. To begin with, the telescope will be provided with an optical and a near-infrared imager-cum-spectrograph. "This facility, which would primarily be used by the astronomers from the Indian university sector, is expected to be operational in the year 1999." [2]

A 2m-class infrared optical telescope is planned to be installed by the Indian Institute of Astrophysics, Bangalore, at the 4500m high Dipka Raja Ree peak near Hanle in Ladakh region, close to the Tibet border, at an estimated cost of a million dollars. "The proposed 2m telescope can be operated remotely using a satellite-based computer-to-computer communication link," and is expected to be made fully operational during the next five years [3]. The telescope is being ordered from EOS Technologies, Tucson, U.S.A.

From "the first year of continuous site survey" it has been concluded that "this high altitude (4500m) cold desert merits serious consideration". As for seeing, "the rms image motion measured on one of the trails recorded in 1996 in six steps of 18 seconds duration...(leads to) the estimate of image size 1.15 arcsec for a large telescope. This is an upper estimate since the telescope vibrations are not filtered out. Also the topography of the current location is not best-suited for obtaining the best seeing...the topography of the peak is conducive to very good seeing. More detailed measurements from the peak have been planned on a routine basis." [4]

There is in addition a proposal to install a 3m telescope at Devasthal near Naini Tal jointly by the Tata Institute of Fundamental Research, Mumbai, and Uttar Pradesh State Observatory, Naini Tal.

4. Radio Astronomy

After feeble attempts in the 1950s to monitor solar and galactic radio noise, Ooty radio telescope was set up in 1970. Now, a giant metre-wave telescope is under construction near Pune. It will consist of 30 parabolic dishes of 45m diameter. At present 21 of these are ready for use as individual telescopes; any eight of them can be joined to give cohesive signals. Efforts are on to commission and cohesively join all the dishes.

5. Space Astronomy

India's space programme had its genesis in cosmic-ray research. There is a national balloon facility at Maula Ali, Hyderabad, which specializes in X-ray, infrared and atmospheric studies. Indian satellites have carried small X-ray astronomy payloads (e.g. IRS-P3). The main emphasis, however, is on developing marketable launch capabilities and on remote sensing. Still the Indian Space Research Organization (ISRO) proposes to launch during the next five years an Indian Multi-wave Astronomy Satellite (IMAS). The aim is to make X-ray observations in the range 2-80 keV and to use "the same platform to make observations in optical, ultraviolet and near-IR bands coaligned with the X- ray telescope axis" [5].

6. Critique

India was among the first non-western countries to take to modern science. India's own government and the public at large have been very supportive of science. The following comments based on the Indian experience and the generalization thereof may be of some interest to relatively late entrants to the modern science club. Astronomical research is particularly suited for giving a feeling of worthiness. Unlike in the case of laboratory sciences where a sophisticated laboratory renders the lesser ones redundant, astronomical facilities, big and small, are complementary rather than exclusive.

For physiological, historical and cultural reasons, laypersons, educators and fund-givers, all are most fascinated by the eye astronomy, that is optical astronomy. The practice of optical astronomy in India has been characterized/influenced by a number of factors.

(i) Mainland India does not provide easily accessible good astronomical sites. This is not surprising. You cannot be a monsoon-blessed ancient culture and a modern astronomer's delight at the same time.

(ii) Paradoxically, while astronomy is the most Brahminical of all sciences, it requires artisan support of the highest order at a sustained level.

The technical requirements of optical astronomy are such that Indian industry cannot extend any worthwhile support to it. This is in contrast to radio astronomy which has been able to establish a symbiotic relationship with India's fairly competent electronics and electrical industry. Similarly, space-astronomy has been drawing support from India's prestige-oriented space programme.

(iii) More fundamentally, because of the pre-industrial mindset, India attaches greater glamour to theoretical studies than to dirty-hand labours.

(iv) Maintenance of telescopes and ancillaries is one problem. Another is lack of sustained interest from one generation to another. The key difference between industrialized society on the one hand and a pre- or semi- industrialized society on the other is that a pre- or semi-industrialized society ranks individuals higher than institutions. Consequently, even when reasonably well-equipped observatories are set up, very often, normally after the work-span of the founder, they become victims of AIDS, that is Astronomical Instrumentation Deficiency Syndrome.

(v) In India tendency has been to support big research at the top, wishing that benefits will trickle down. This does not happen; law of gravity does not operate in the intellectual domain.

(vi) Indian college and university system is academically very weak, and what is worse almost anti-astronomy. Absence of rigorously trained M.Scs is a major bottleneck in scientific progress in India. The fact that the problem is not peculiar to astronomy is hardly a consolation.

(vii) The extended databank provided by 150 years of astronomy in India during the colonial period permits some insights to be obtained which are of general applicability.

Madras and Kodaikanal observatories remained in existence because they were depersonalized. They remained astronomically active because they had at hand workshop facilities, either external or in-house. They obtained their best results when they were furnished with state-of-the-art equipment. Madras produced Taylor's southern star catalogue (1831-43) with the new transit and mural telescopes. Similarly Kodaikanal discovered Evershed effect thanks to the calcium-K spectroheliograph.

Unfortunately very often lessons of history remain confined to the students of the past even when they need to be learnt by the actors of the present.

(viii) When we look at the history of civilization, two points emerge. In the culturally interactive part of the world, the greatest contribution to astronomical and related sciences has come from a culture that was at that time materially the most affluent. Thus the centre of gravity of astronomical activity through the last three or more millennia has moved from Babylonia to Greece to India to West and Central Asia to Europe to United States of America.

(ix) Secondly, when cultures and nations have been striving to establish themselves, they have sought to use astronomy for profit. (Throughout astronomy's history fear of the enemy has been a greater driving force than the love of stars: fear of the gods, high seas, and of terrestrial enemies have resulted in major breakthroughs.) When the cultures feel assured and confident they seek to support astronomy for prestige and pleasure.

Can this historical trend be simulated? Historically, commercial and academic interest in astronomy preceded, and in fact triggered, industrial revolution. Today, in parts of the world that were left out earlier, can encouragement to astronomy facilitate acceptance of machine-shop culture?

(x) Today in the post-colonial era of cultural Copernicanism when no culture is assigned (in principle) any superior position, we talk of science as a cumulative civilizational activity. However historically colonial empires were built with the help of modern science. And to provide legitimacy to the exercise, science was periodized as, e.g., Hindu science, Muslim science, and modern science with modern science projected as western science superior to, and distinct from, its antecedents.

Consequently, the ex-colonies have sought to distance themselves from the intellectual aspects of "their" modern science and to defend, protect and reinvent "our" ancient science. This defensive mindset works against the development of modern science (including astronomy) in the formerly subjugated countries. To enhance astronomical research and education in these countries it would be necessary to de-emphasize the past watertight periodizations in these countries, but more so in the west, which still sets the agenda.

(xi) Finally a suggestion. For the benefit of countries planning to set up new or enlarged astronomical facilities, IAU should publish an authoritative manual covering various aspects of site survey, choice of telescopes and ancillaries and other guidelines.

7. References

(1) The hard-core information in this and subsequent sections comes from Kochhar, R. K. (1991) The Growth of Moderen Astronomy in India *Vistas in Astronomy*, **34**. 69-105, and from Kochhar, R. K. and Narlikar, J. V. (1995) *Astronomy in India: a Perspective.*, Indian National Science Academy, New Delhi.

(2) *Khagol* (A Bulletin of the Inter-University Centre for Astronomy and Astrophysics, Pune), (1997) January and April issues.

(3) Lok Sabha (lower house of Indian Parliament), unstarred question 2827, 11 December, 1996.

(4) HIROT Team (1996) Recent astronomical site survey at Hanle, Ladakh. *Bull. Astr. Soc. India*, **24**, 859-869.

(5) Communication from Indian Space Research Organization, Bangalore.