Twenty five years of observational astronomy at the Indian Institute of Astrophysics

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This is an account of the work done on observations of stars and galaxies mainly from the Vainu Bappu Observatory (VBO), Kavalur, over the last 25 years. The Indian Institute of Astrophysics, of which the Vainu Bappu Observatory is a field station, was created as an autonomous research institution on 1 April 1971. This article is written in commemoration of the Silver Jubilee of IIA. Although astronomical observations started in Kavalur as early as 1968, it was only in 1972 with the commissioning of the 102 cm Zeiss reflector that Kavalur Observatory attained the status of a fullfledged stellar observatory. Without being technical, the article attempts to give the reader a flavour of the research the astronomers in IIA have been engaged in, with special reference to the observations done at VBO.

Beginnings

In June 1972, the name of a sleepy little village, hidden in the depths of the sandalwood forests in the Javadi Hills of Tamil Nadu, received sudden attention in international press, for close to it in an observatory that bore its name, astronomers of the Indian Institute of Astrophysics had just then carried out an important observation which, for the first time, gave an indication of the existence of an atmosphere in the Jovian satellite Ganymede. We shall never know if the villagers ever got to know of this sudden leap to fame of their village, although some of their kith and kin had probably already been associated with the observatory in some activity or the other – tending its gardens, maintaining its newly built buildings, keeping watch at its imposing gate or cooking meals for the astronomers. For the astronomers of the newly created Indian Institute of Astrophysics it was a fulfilling experience as it was perhaps the first significant use they made of their newly acquired 102 cm Zeiss telescope.

It was just over a year ago that The Observatory at Kodaikanal was reborn as an autonomous institution freed from the stifling hold of the India Meteorological Department. The newly christened IIA inherited at birth the rich traditions of astronomical research from its parent. The Observatory at Kodaikanal functioned since 1899. Its parent was the Madras Observatory established by William Petrie in 1786 (ref. 1).

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By the standards of the 1960s and from the point of view of stellar observations, the facilities in Kodaikanal left a lot to be desired. The sky conditions permitted only a few clear observing nights during a year. The largest telescope was a mere 51 cm reflector and the focal plane instruments were primitive. No serious astronomer would have been contented with the prevailing situation, nor was M. K. Vainu Bappu, the young and dynamic director of the observatory who assumed charge in 1960 at the relatively young age of 33. Needs of the handful of stellar astronomers that Bappu gathered around him had far outgrown the telescopes and the equipment available. It was clear that if Optical Astronomy were to survive and thrive in India, radical measures were required.

As early as 1962, Bappu had started the search for a good astronomical site in peninsular India where a stellar observatory could be built. A decade-long effort led him finally to the spot in Javadi Hills where the Vainu Bappu Observatory stands today[2].

Stellar observations started in Kavalur in 1968 nearly three years before the formal creation of IIA. A 38 cm telescope housed in a roll-off shelter was the first instrument in operation. Situated at a latitude of 12° 34′.6 N, a telescope in Kavalur can peer into the southern skies, an ability which was to work to its special advantage years later in 1987 when it was perhaps the only observatory in the northern hemisphere to take spectra of SN 1987A. The 102 cm Zeiss reflector arrived in crates in March 1969 and the team of German engineers arrived in January 1972 to instal it. The telescope started operating in May 1972 and within a month made its presence felt with the successful observation of the occultation of SAO 186800 by Ganymede[3]. The talk of a much larger telescope, one of 2-m class, was already in the air. Although it was not yet certain that the large telescope would also be installed in Kavalur, the air was thick with expectation. It was only in 1976 that the IIA Council finally approved the location of the large telescope in Kavalur. Kavalur was poised to take off as a major observatory. It has been the main seat of observational work in IIA.

Maturity

Kavalur Observatory formally attained maturity in January 1986 when the then Prime Minister of India, Rajiv Gandhi inaugurated its 234 cm telescope and named the telescope and the observatory after its creator, M. K. Vainu Bappu. Rajiv Gandhi's visit to Kavalur was dictated by an astronomical event – the appearance of Comet Halley on its second sojourn to the solar vicinity in this century. The youthful and scientifically aware Prime Minister wanted to have a good look at this celestial wonder and expressed a desire to visit Kavalur. M. G. K. Menon, Chairman of the IIA Council, seized the opportunity to convert the PM's visit into a gala affair of commemoration. The 234 cm telescope, Bappu's dream project, was nearly fully ready. The first photograph with it was already taken in November 1985. It was, therefore, in the fitness of things that the Prime Minister's maiden visit was utilized appropriately to have the telescope formally inaugurated. Eye-witness accounts suggest that the Prime Minister thoroughly enjoyed his visit to Kavalur. He even climbed into the prime focus cage of the large telescope and peered into the dark skies with singular satisfaction. Comet Halley eluded him though. Instead Gandhi saw the more permanent celestial wonders like the Orion Nebula and Jupiter and its moons.

By the mid-eighties the observatory had already produced a substantial amount of work with its smaller telescopes. In March 1977 it had participated in the Uranian occultation experiment and was one of the small group that was responsible for the discovery of the rings around the green planet[4,5]. A number of Ph D dissertations had been completed and several more were in progress. The number of astronomers had grown from less than a dozen in 1972 to more than twenty in 1985. Astronomers, whose research life had started with the establishment of the Kavalur Observatory, matured along with it and they were now leaders of groups, while a younger generation was being inducted into active astronomical research. Bappu never lived to see these developments. He died in August 1982 due to complications following a heart by-pass surgery.

In January 1996 the Vainu Bappu Telescope completed ten years of its formal existence. It has been operated as a National Facility. It attracts proposals from all over the country and sometimes from outside India. But the needs of the IIA astronomers have already outgrown this telescope and the facilities at VBO. Demands of their science have taken them far and wide to telescopes in Australia, Chile and the United States. They have also used space-based facilities like the IUE and data from IRAS and EXOSAT to pursue their specialized interest. Today there is hardly an area of observational astronomy that is neglected by the astronomers in IIA. At least 30% of the publications in the last few years are based on observations carried out elsewhere.

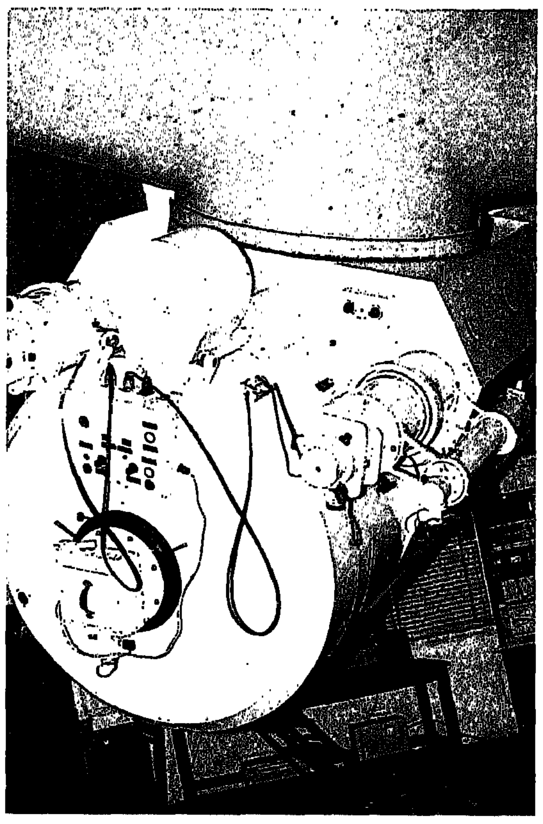
Observational astronomy in IIA

Although science is based on hard facts, on experimentation and unbiased observations, its chronicling is often coloured by the personality of the scientist as an author. The prejudices and preferences of the chronicler creep in consciously and unconsciously, and affect the perception of what is important and relevant. Description of the observational work done in IIA as related in this article is perhaps flawed for the same reason. There is no serious attempt here to be comprehensive. Instead I highlight some of the important contributions made by my colleagues in the areas of stellar, galactic and extragalactic astronomy; I also try to explore if there had been an underlying theme in much of the research that has been done and if there were certain expectations in the minds of the users of these facilities, what is the extent to which they have been fulfilled.

To start with, the telescopes in Kavalur had relatively modest focal plane instruments. These included cameras for fast photography, photoelectric photometers, a single-channel photoelectric spectrum scanner, a medium resolution spectrograph, and a quartz-prism calibration spectrograph. Later an InSb infrared photometer, an image tube spectrograph, a Universal Astronomical Grating Spectrograph from Zeiss (UAGS) and a polarimeter were added to the complement of instruments at the Cassegrain focus. Photographic plates were the principal detectors in the early days. Some microprocessor-controlled photon counting systems were designed and fabricated some years later and these have been used in a variety of observational projects.

The first doctoral thesis of IIA was by Rajamohan who had already started his work with the 51 cm Bhavnagar Telescope in Kodaikanal. His thesis was a detailed spectroscopic study of the Scorpio–Centaurus association. Rajamohan determined rotational velocities of more than a hundred members of this association using the Bhavnagar spectrograph on first the 51 cm and then the newly acquired 102 cm telescope. At the 102 cm telescope Rajamohan further obtained hydrogen and helium line profiles of a few bright members of the association using the newly designed coudé echelle spectrograph

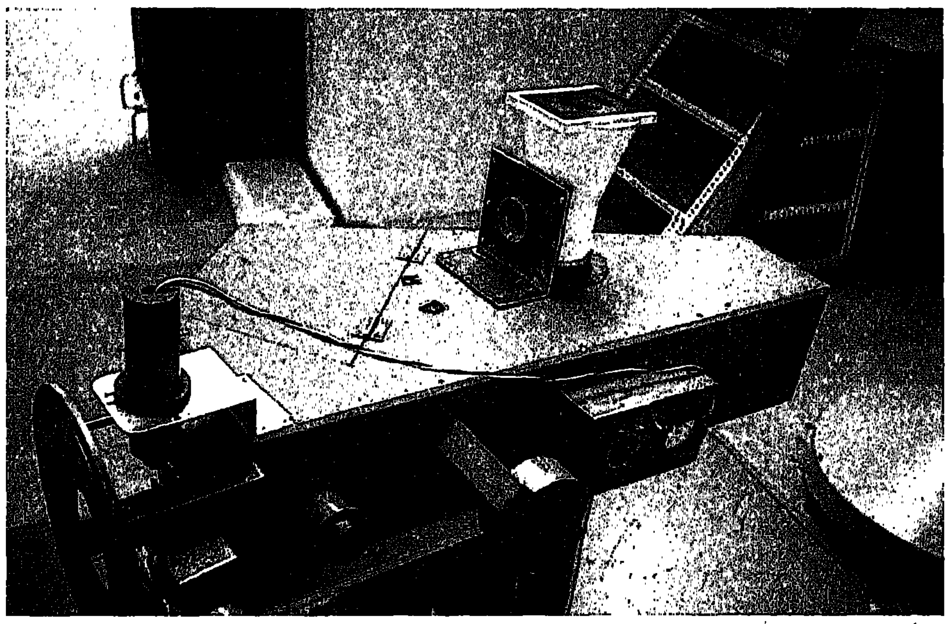
38 cm reflector, the first astronomical telescope in Kavalur.



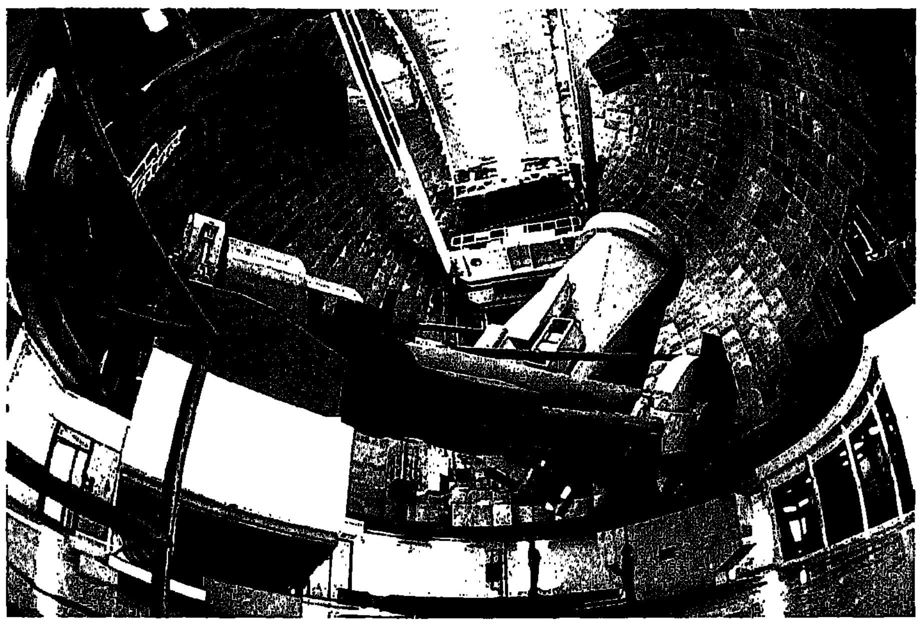
102 cm (40") Zeiss reflector.

A view of the 40" reflector building with the dome shutter open.

75 cm (30") telescope building in front and the 40" building in the background.

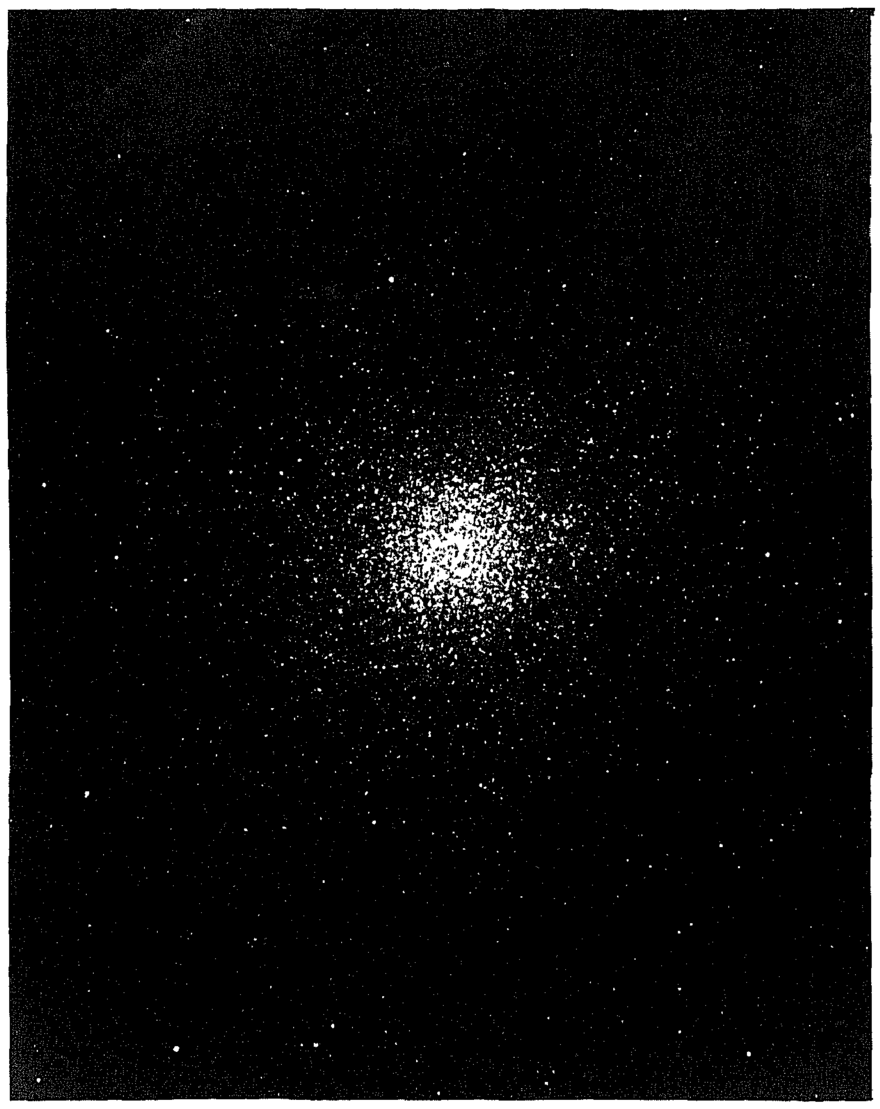


The coudé echelle spectrograph used at the 102 cm reflector.



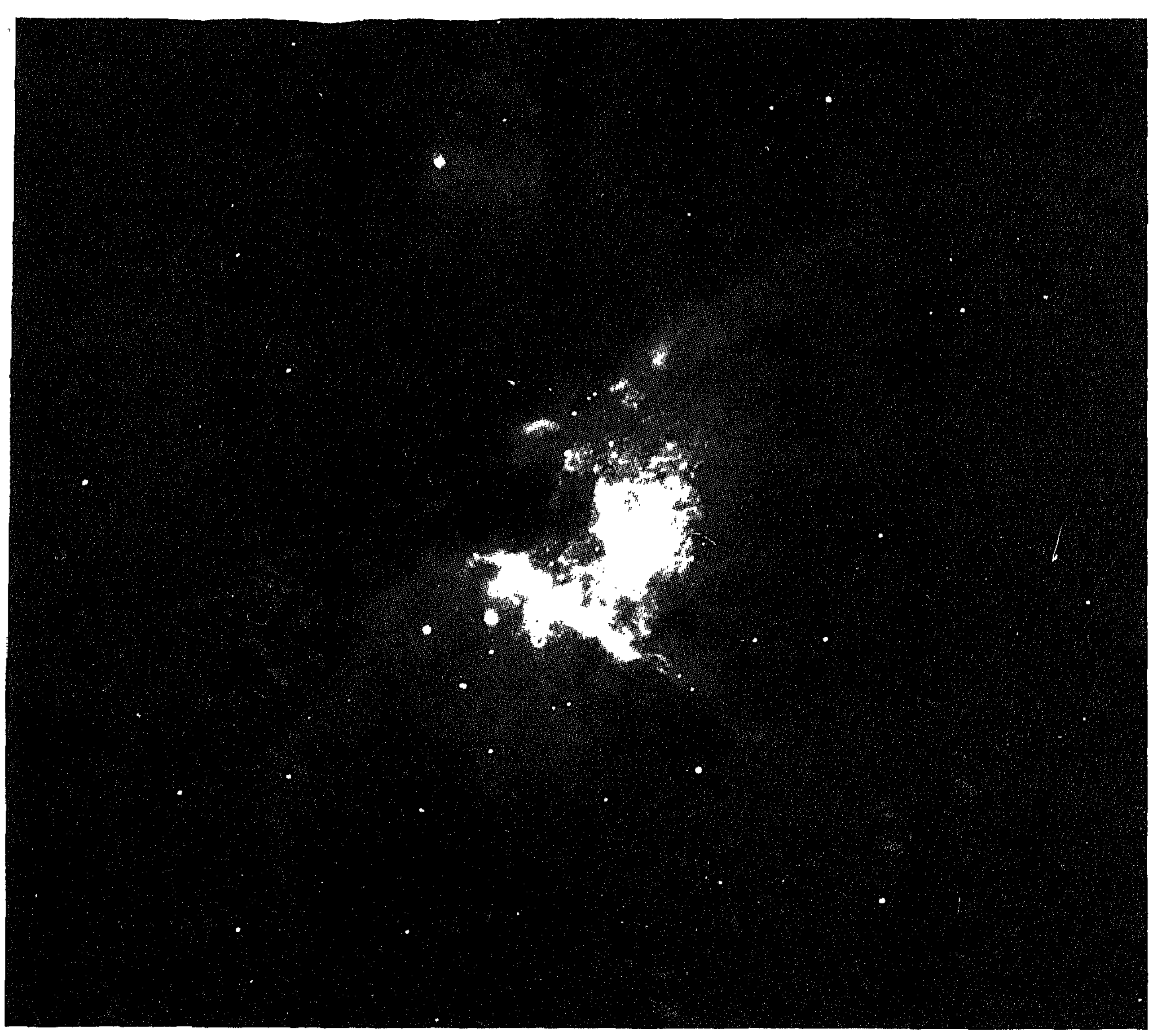
The 234 cm Vainu Bappu Telescope, an early photograph before the removal of the cover panels in 1989–90.

A panoramic view of Vainu Bappu Observatory, Kavalur.



Omega Centauri, the Southern globular cluster. (102 cm photograph)

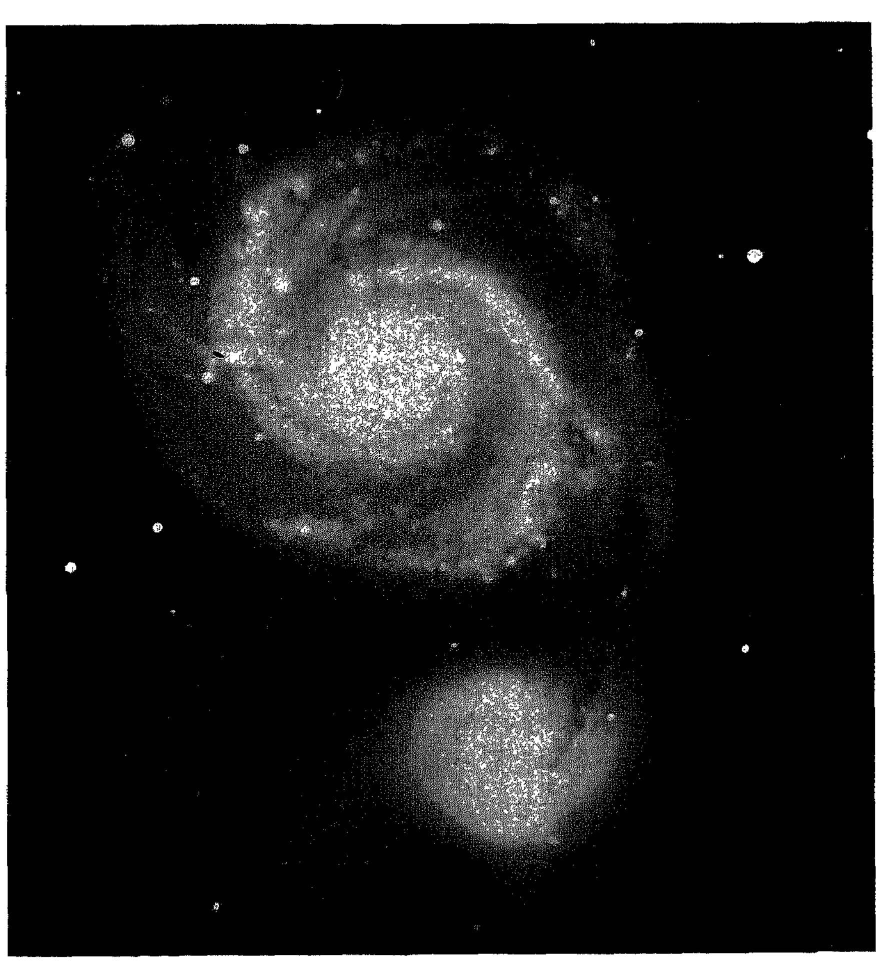
The Carina Nebula (102 cm photograph).



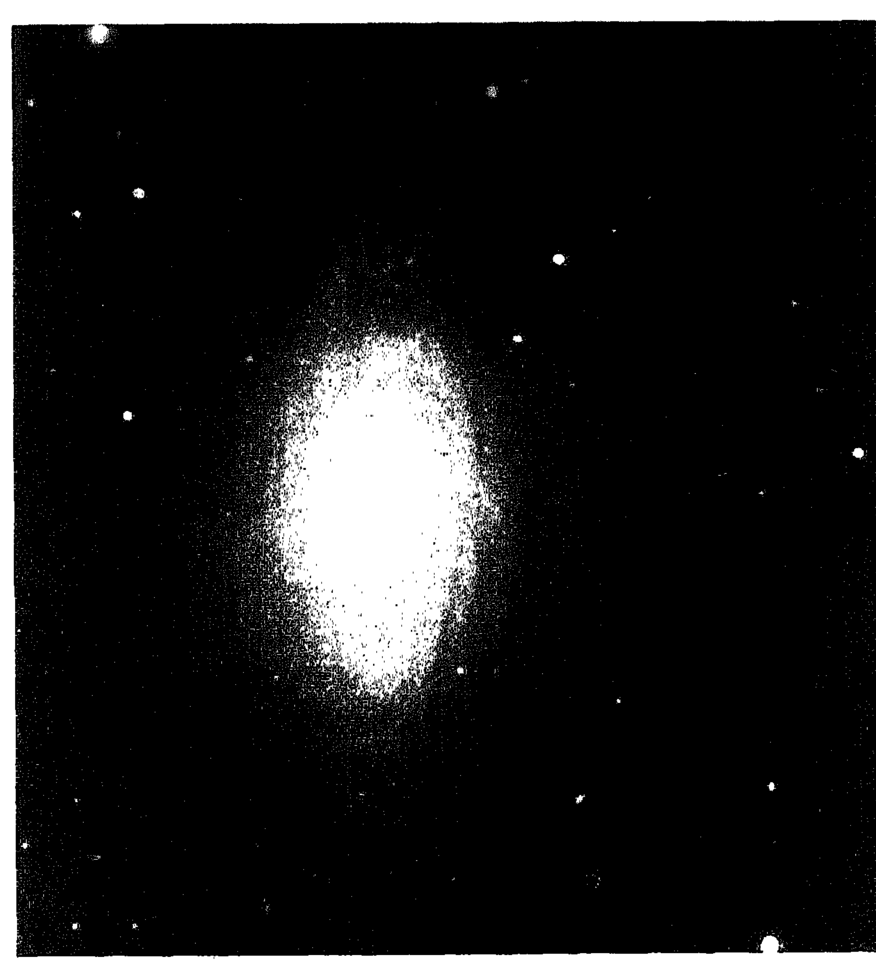
The Orion Nebula seen in the light of the forbidden S^+ doublet λ6724. (102 cm photograph)

A BVR composite image of the galaxy NGC 2903. (234 cm photograph)

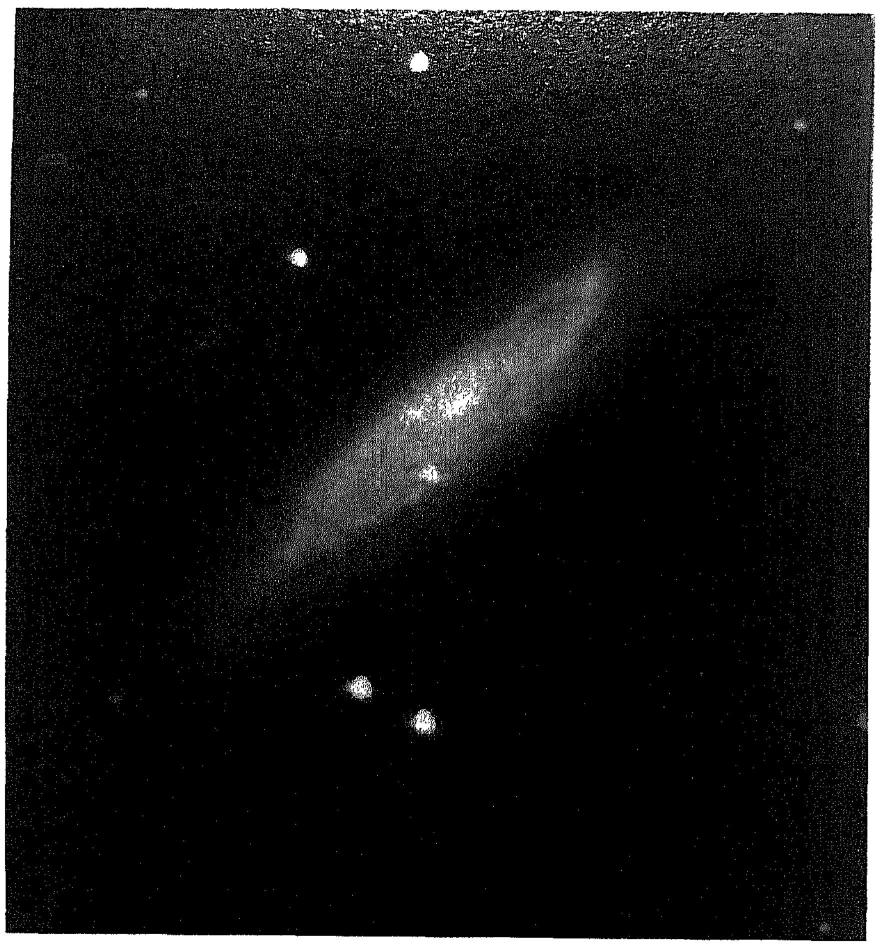
A BVR composite image of the barred spiral NGC 1365. (234 cm photograph)



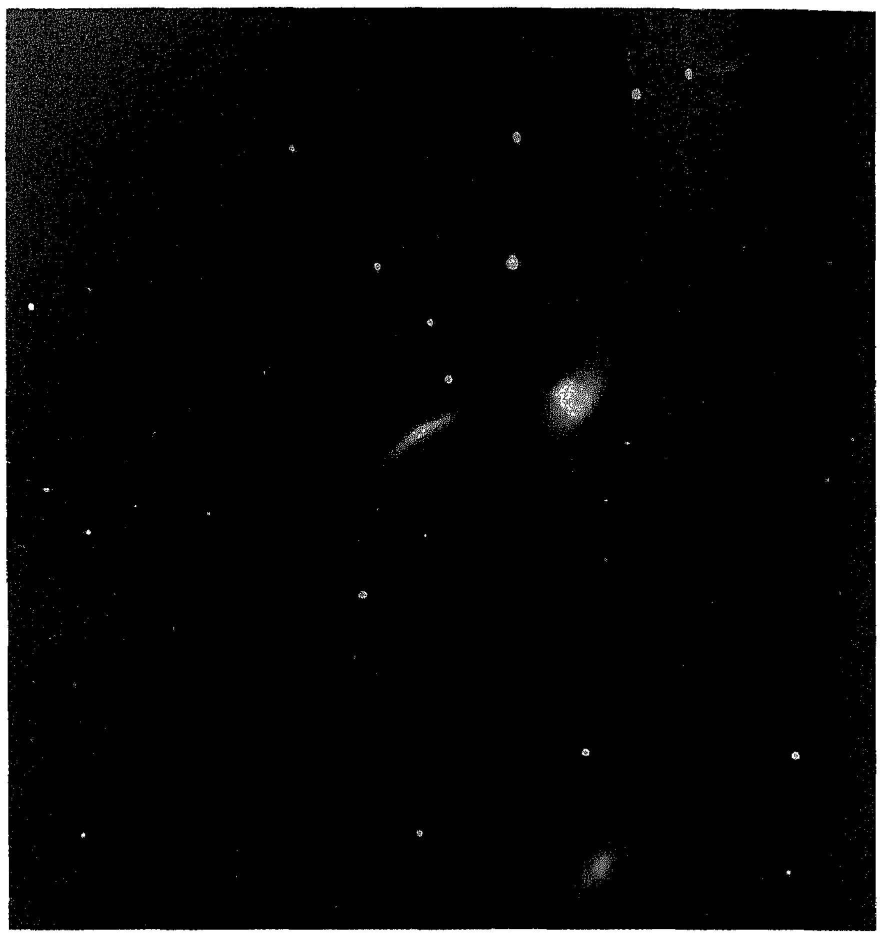
The Whirlpool galaxy M51/NGC 5194 in BVR. (234 cm photograph)



The infrared luminous spiral galaxy NGC 3521 in BVR. (234 cm photograph)



A BVR composite image of the infrared luminous spiral NGC 7817. (234 cm photograph)



The interacting galaxy NGC 2798 in BVR. (234 cm photograph).

which was commissioned during 1974. With slight modifications this coudé echelle spectrograph is still very much in use today. The helium line profiles obtained at a reciprocal dispersion of 4.8 Å/mm allowed a comparison between theoretically computed LTE and non-LTE profiles and showed that the latter fitted the observations better. It also led Rajamohan to a determination of the helium abundance in the member stars of the association[6]. The rotational velocity data were utilized by Rajamohan to produce an important paper on stellar rotation on the zero-age main sequence[7].

In 1973–74 Bappu designed a conventional coudé spectrograph with two cameras of focal lengths 61 cm and 285 cm respectively. The camera with the longer focal length produced spectra at a reciprocal dispersion of 2.8 Å mm^{-1} in the blue. A one-metre telescope is a small one to have a coudé spectrograph on and only the very brightest stars could be observed with it. An image intensifier tube was often used in conjunction with the photographic plate to improve the signal. Bappu had a special interest in obtaining with it spectra of the southern supergiant αCar (Canopus). He was motivated by an earlier observation by Brian Warner where Warner had discovered an emission reversal in the Ca II K absorption line of this star and found that the width of the emission did not quite fit into the width – absolute magnitude relation known as the Wilson–Bappu effect. The spectra obtained at the coudé spectrograph hardly showed any detectable emission. Bappu pursued the programme with characteristic zeal but could never complete it. After his death his colleagues at IIA obtained more spectra of Canopus some of which showed a hint of emission. The last scientific paper of Vainu Bappu describing these efforts was published posthumously in 1984 with joint authorship of two of his younger colleagues[8]. The spectrograph was remarkably stable though. Once a 1N plate was exposed for two successive nights, with the plate properly covered during the intervening day. The exposed spectrum showed no lateral shift of the lines. The coudé spectrograph fell into disuse after the first few years. Since the late eighties, charge coupled devices (CCD) replaced the photographic plate. All spectrographs at VBO currently use CCDs. The dark room in the 40" building, the building that houses the Zeiss telescope, has ceased to be the hub of activity it used to be earlier. Its state of disuse today compares with that of the old coudé spectrograph. It is a pity that the younger generation of astronomers will never know the pleasure and pain of using photographic plates – preflashing or hypersensitizing them, cutting and loading them, exposing them to the right level and then developing them – a chain of activities that often bordered on the artistic. It left the successful observer with a sense of pride and satisfaction which CCDs of today can hardly ever produce.

Two important studies were made within the first decade of the observatory's existence using photographic plates – the first, photographic study of the central regions of Sersic–Pastoriza galaxies by Prabhu[9] and the second, a study of some southern globular clusters, most prominently ω Centauri, by Scaria[10]. Prabhu's was the first truly extragalactic study done at IIA although Bappu had initiated earlier a programme of ultralow dispersion spectroscopy which was used successfully to survey stars in the Large Magellanic Cloud. The programme started by Prabhu is continuing even today with CCD imaging devices replacing the photographic plates. Scaria's study involved equidensitometry of ω Cen, 47 Tuc and other clusters on photographs obtained in different wavelength bands. On ω Centauri he did photoelectric aperture photometry along the major and minor axes of the cluster. Using these he studied the change of ellipticity from the centre to the outer region of the cluster. Scaria was a skilled photographer and well versed in various specialized techniques. He took great pains in producing high-quality photographs of astronomical objects with the telescopes in Kavalur. These now form a permanent collection in our observatory. He coauthored with Bappu the important paper on ω Centauri published in *JAA*[11]. Scaria designed the first prime focus camera of the Vainu Bappu Telescope and the best early photographs taken with this telescope are due to him. His untimely passing away in 1992 robbed IIA of one of its most skilled observers.

Another programme that has been pursued with perseverance and with good results is the photometry and Hα spectroscopy of spotted stars – the RS Canum Venaticorum variables. These binary systems show light variations which are attributed to spot activity on the surfaces of their chromospherically active members, the scale of activity being much greater than in the Sun. The photometry of a selected sample of these objects was started at the 38 cm reflector in 1977 and has been continuing ever since. The small size of the telescope and the dated nature of the recording device were not serious handicaps since the sample was bright enough. The vacuum tube-based amplifier was replaced by a solid state astronomical amplifier in January 1987 and it has been in regular use since then. The photometry obtained over the years has helped building up a database on a selected group of RS CVn variables. The data have been subjected to extensive modelling with the help of computer programs developed by the observers themselves and used effectively to interpret many characteristics of these systems[12–17]. The international recognition of the series of studies has come by way of the Russian group assigning variable star designations to three of the objects based on the photometry done at VBO and by the citation of the work on UX Ari by Trimble in the invited review *Astrophysics in 1996* (ref. 18).

The photoelectric spectrum scanner designed by Bappu was put into operation in 1975. It was used for observations of Comet West soon after[19]. It was also used by N. Kameswara Rao for one of his early programmes when he arrived in IIA. He studied with it broad spectral features due to CH and NH molecules in a special group of G and K giants known as the weak G band stars. The results from this study confirmed the operation of the CNO cycle and first dredge-up in these stars[20]. The scanner was later used for the spectrophotometry of Comet Halley[21]. It was further modified into a PC-based spectrum scanner in 1988 but was decommissioned soon thereafter.

The main thrust of observational activity in IIA has, of course, been in the area of spectroscopy. This may partly be due to the preference of the individual who founded the institution; after all Bappu's everlasting reputation is based on spectroscopic work on late-type stars that led to the discovery of the relation between the luminosity and the Ca II K emission-line width and which practically started the quantitative work on stellar chromospheres. Bappu tried his best to equip the 102 cm telescope with spectrographs of various resolutions. This tradition was continued after him. A Boller and Chivens spectrograph obtained from the Anglo Australian Observatory was put into operation at the Cassegrain focus of VBT in 1989. A Universal Astronomical Grating Spectrograph (UAGS) was purchased from Zeiss and put into operation at the Cassegrain focus of the 102 cm telescope in 1986. All these spectrographs are low to medium resolution instruments. The only high resolution instrument currently in use is the old coude echelle spectrograph at the 102 cm telescope. Although it is not the most efficient spectrograph from the point of view of design, it has been put to effective use by the astronomers. At its current level of performance it can obtain good quality spectra in the red of up to about the fifth magnitude. The lack of a high resolution instrument at VBT has forced the observers to use spectroscopic facilities at other major observatories of the world where this facility exists. This has resulted in high quality work as well as several international collaborations.

An early piece of work with the coudé echelle spectrograph was a study of the chromospheric Hα line in late G and early K supergiants. The blue asymmetry of the Hα profile was attributed to the occurrence of chromospheric expansion of these stars eventually leading to massloss. This photographic study was later superseded by CCD spectroscopy. The observations were matched with elaborate transfer calculations to obtain mass loss rates in these stars[22,23]. A more recent study completed with the same spectrograph is a survey of the infrared Ca II triplet lines in a large sample of dwarfs, subgiants, giants and supergiants[24]. The triplet lines are a potentially powerful tool for the study of late-type stellar populations in galaxies because of their sensitivity to the stellar atmospheric parameters, in particular the luminosity and metallicity. The high-resolution work complements the work done elsewhere at lower resolution and will hopefully enable a more accurate analysis of the galaxy populations. As a spin-off of this study it has been found that the central depths of these lines are an excellent diagnostic of chromospheric activity also. The coudé echelle spectrograph has also been in regular use for studies of Be stars and Be X-ray binaries. A variety of problems concerning line profile variations and phase changes of these stars have been investigated with the help of these spectra. Another early spectroscopic study was concerned with the chemical composition of classical Cepheids and related chemical inhomogeneities of the Galactic disc. The [Fe/H] index of nearly two dozen Cepheids was derived. The places of formation of the Cepheids were determined by numerically integrating their orbits backwards in time under the influence of the axisymmetric and spiral-like gravitational field of the Galaxy. The techniques of synthetic spectra were used to obtain chemical composition of the Cepheids.[25] A sophisticated spectroscopic reduction software called RESPECT was developed by Prabhu and his collaborators[26] and has been widely used by the astronomers in IIA.

Spectroscopy of novae was one of the programmes pursued at Kodaikanal Observatory and this tradition was continued in Kavalur. Nova Cygni was observed in 1975. NQ Vul was also observed soon after discovery. After a period of quiescence, the activity in this area picked up once more in the late eighties and has been continuing since. Several classical and recurrent novae have been monitored from VBO during outburst and a few during quiescence. Spectroscopic differences and similarities between individual novae in outburst have been studied and the physical parameters of the ejected shell estimated. From such studies presence of a white dwarf in the recurrent nova RS Oph has been indicated. Spectroscopic monitoring of T CrB over a long baseline in time has shown secular as well as orbital phase dependent variation in the strengths of the emission lines. Using the images of the shell of GK Per, the proper motion of the individual knots has been measured and the velocity deceleration derived[27–28]. Supernovae have also received the attention of IIA observers. Of the ten supernovae observed so far, SN 1987A was followed in great detail using the 102 cm and 75 cm reflectors despite its low elevation in the southern sky. Observations were started within 48 hours of the discovery. All the observers with scheduled nights agreed to pitch in with the observations the first two hours of every evening when the supernova was accessible to the telescopes. Authorship of the paper that was published soon after testifies to the cooperative nature of the effort[29]. The work received its due recognition. In a report on 1987A published in the November 1987 issue of *Sky and Telescope*, the VBO data figured prominently. Several other supernovae were observed sparsely close to the maximum light. Results on SN 1993J are already in print[30]. The continuous upgradation of facilities through new instrument acquisitions and related developments have resulted in substantial improvements in the capabilities during the period of these observations.

Observational studies of evolved stars, in particular studies related to their evolutionary aspects, have been a favourite of the astronomers in IIA and the work done at VBO and the work by the astronomers of IIA in this area has received critical acclaim and international recognition. The particular areas that have received sustained attention are hydrogen-deficient stars, RV Tau variables, post AGB supergiants, proto planetary nebulae, and planetary nebulae and their nuclei. Work on hydrogen-deficient stars was started by Kameswara Rao and gathered momentum through his initiative. He organized a IAU Colloquium on 'Hydrogen deficient stars and related objects' in Mysore in November 1985 where several leading experts in the field gathered and deliberated on the observations and evolutionary aspects of these stars. Since then an active group in IIA has been working on a variety of problems related to the objects. Photometry and polarimetry of a number of these stars were done at VBO. Several R Cr B variables have been followed in their deep minima and also during the recovery phase. Recently this group has completed a comprehensive analysis of the surface abundances in warm Galactic R Cr B variables using high-resolution data obtained at CTIO, Chile and McDonald Observatory, USA. They use the techniques of synthetic spectra in conjunction with Model Atmospheres of these stars[31] In a collaborative programme with the Astronomical Observatory of the University of Uppsala, led by the well known theorist Bengt Gustafsson, they have developed new hydrogen-deficient line-blanketed Model Atmospheres specifically for the purpose. A thesis on RV Tauri stars was completed in 1990 (ref. 32). Broadband multiwavelength polarimetric observations of several carbon-rich RV Tauri stars were obtained at VBO. The observed amplitude of linear polarization of 14% in the U band in AR Pup is the highest so far seen in any late type star. The polarimetric data were combined with photometric data of the same stars to study the nature of the variations in polarization, its wavelength dependence, etc. Abundance analysis of the carbon-rich RV Tauri star IW Car showed that its photospheric abundances are similar to the depleted abundances observed in the $-15\ \mathrm{km\ s^{-1}}$ cloud component of ISM in the line of sight to ζ Ophiuchi[33].

Various types of post-asymptotic giant branch (AGB) stars are also studied. These include: high galactic latitude post-AGB supergiants, carbon-rich post-AGB stars with 21 micron emission feature, rapidly evolving hot post-AGB stars and post-AGB stars in old clusters, globular clusters and in the Galactic bulge. A Ph D thesis on post-AGB objects and proto planetary nebulae was completed during the Silver Jubilee year[34]. Many of the stars in this group were first recognized distinctly from the analysis of IRAS data. The stars are highly evolved and supposedly journeying to the stellar graveyard of white dwarfs. Years ago in any graduate course on *Stellar Evolution* one would learn all the intricacies of main sequence and post-main sequence evolutionary phases but the knowledge would become increasingly scanty for the low and intermediate mass stars as one approached the second red giant or asymptotic giant branch phases. The story was picked up again at the planetary nebula phase. There remained this gap between the second red giant phase and the pre-white-dwarf/planetary-nebula phase. During the last few years objects have been discovered that chart the evolution through this phase and many of our colleagues have contributed significantly in this area. In some cases evolution in real time has been observed. The star SAO 244567 has shown changes in its optical spectrum that indicates it has become a planetary nebula during the short period of 25 years that IIA has been in existence[35]. LS II + 34° 26 is another case where a star is suspected to be rapidly evolving into the PN phase[36]. A thesis was completed on a class of planetary nebulae that have WC 11 type stars as their nuclei. A detailed photoionization model of M4-18, a member of this class, was constructed and the data obtained at VBO complemented by the data on this object from IUE and IRAS were analysed with its help[37]. This work has led to the interesting possibility that very small grains (dimension ~ 10 Å) exist in the nebula to cause its excess near IR radiation. In general, spectroscopy of extended objects has not been pursued as vigorously as the spectroscopy of stars. A proposal was made some years ago to construct a Faint Object Spectrograph for the VBT to augment this situation but it was dropped later for lack of funding. A collaborative programme on Fabry–Perot spectroscopy of planetary nebulae carried out at the 102 cm telescope produced some interesting results.

A star-and-sky chopping polarimeter was designed and built in IIA in the late eighties by Jain and it has been used at VBO ever since to make polarimetric measurements in a variety of young and evolved objects[38–41].

With the sole exception of the photographic study of Sersic–Pastoriza galaxies that was mentioned earlier, bulk of the extragalactic work in IIA has been done after CCD imaging became available at the prime focus of VBT and the Cassegrain focus of the 102 cm telescope. The study of star formation in Giant Extragalactic H II Regions formed the doctoral thesis of Y. Divakara Mayya[42]. He used the technique of CCD photometry on a selected sample of galaxies and interpreted the data with the help of evolutionary population synthesis models. Mayya found that there was differential extinction between the embedded cluster stars and the surrounding nebulosities in the Giant H II Region complexes, the radiation from the cluster being only partially attenuated. He also found that these regions contained both hot OB stars and evolved red supergiants. Work along these lines is continuing. Some Sersic–Pastoriza galaxies have been imaged for a study of their nuclear starforming regions. VRHα imaging of several early-type galaxies, selected primarily on the basis of their X-ray emission, was used to measure nebular emission from their central regions. The presence of ionized gas, dust rings, lanes, etc. indicates that the galaxies under investigation have had accretion of material. IIA participated in the International AGN Watch by monitoring spectroscopically and photometrically the nucleus of the Seyfert galaxy NGC 3783 (ref. 43). The combined data showed considerable variability of the optical continuum and Hβ emission with light curves resembling the ultraviolet light curve whereas the near-infrared light curve of the nucleus appeared independent. Some IIA astronomers have utilized the EXOSAT database to study the X-ray spectra of a variety of active galaxies. Several interesting results have emerged from their analysis. Ongoing programmes on the Vainu Bappu Telescope include monitoring of blazars, morphological studies of luminous elliptical galaxies, optical imaging of gamma-ray burst fields, study of stellar populations and many others.

Future

Observational astronomy in IIA has come a long way since the first spectra were taken using the Zeiss telescope. When the 234 cm telescope was proposed, Vainu Bappu had in mind three particular areas of study: (i) an investigation of the spiral structure of the Galaxy, particularly the relatively unexplored portions of it visible from the southern hemisphere, (ii) study of stellar chromospheres principally by the methods of stellar spectroscopy, and (iii) study of the morphological aspects of external galaxies and study of their stellar populations. The telescope was built with these goals in mind. Have these goals been achieved? While the telescope has been shown to function to its designed accuracy, the astronomy produced by it so far has fallen short of the expectations principally due to a lack of proper backend instruments. A high-resolution spectrograph is yet to materialize. The Boller and Chivens spectrograph has not been very efficient. Stellar chromospheric studies have not been possible with the VBT. A new computer-controlled medium-resolution spectrograph has very recently been acquired for VBT and put into operation. The first results obtained with it are already in print[44]. By the late eighties when the telescope started regular observations, interest in the spiral structure of the Galaxy had generally waned – this was a worldwide phenomenon. Only one study in this subject has been completed in IIA but the data used were obtained mainly at Australian telescopes[45]. Morphological studies of galaxies, on the other hand, gained more and more in popularity and VBT has been used in this area quite effectively. Some of the smaller telescopes have continued to produce good work and stellar chromospheres are studied with these in a variety of ways using the resources that are available. International collaborations and the use of facilities elsewhere permitted the astronomers to pursue their goals and the amount of high quality work from IIA has been on the increase in greater than linear proportion to the number of active astronomers.

Astronomy has also changed in many ways and the perceptions of the sixties and seventies are no longer very relevant today. In this era of globalization and of accessibility to data through network and information transfer, an astronomer is able to collect data from anywhere in the world sitting at his/her desk. A lot of data from spacebased facilities becomes available in the public domain after a stipulated period of time and these can be used to produce quality science. The needs of an astronomer have thus become somewhat different and so has his use.

The skies in Kavalur have not been very encouraging either. The number of clear photometric nights is rather small in a year and the total number of observing hours per year is about two-thirds of a world-class astronomical site. Kavalur is hit by two monsoons and hardly any observation is possible at VBO between the months of May and December. VBO is also located at a low altitude by the standards of major observatories and it is hardly sufficient for any kind of infrared work, an area of astronomy that is becoming more and more important and popular. The astronomers in IIA have felt the need of a large telescope in a better site where uninterrupted observations will be possible. With the commissioning of a large number of large telescopes in the southern hemisphere, the reason for having an observatory in peninsular India, to capitalize on the observation of the southern skies, is no longer applicable. With all this in mind, IIA is currently pooling in its resources to set up an observatory in the wilds of Ladakh close to the Tibetan border, where the skies are clear for a larger fraction of the year and where infrared astronomy should be possible, as the region is known to be amongst the driest in the world. The current plans are to put a 2-m telescope there during the next couple of years. The new observatory in Hanle will not diminish the importance of VBO in any way. It will complement the efforts at VBO to have better spectral and temporal coverage of celestial phenomena. The harsh weather conditions there will require that the bulk of the observations are carried out in a remote mode and commands from the observer to the telescope and the acquired data from the telescope to the observer are transferred rapidly via a satellite link. If traditional astronomers are already finding observing with the VBT lacking the thrill and romance of earlier times they are bound to be even more disappointed with the planned mode of operation in the new observatory. It may never happen again that the first spectrum of a strange object is being taken while the astronomer sits guiding at the prime focus cage with the strains of Beethoven's Ninth Symphony filling the background. We are on the threshold of a new era.

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