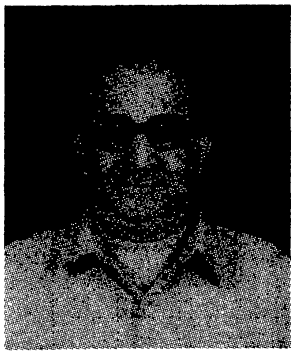
Bull. Astr. Soc.India (1997) **25,** 19-28

Silver Jubilee Article



My encounter with astronomy: early years

J. C. Bhattacharyya

Indian Institute of Astrophysics, Bangalore 560 034, India

To be very frank I never dreamt of becoming an astronomer in my childhood. I wanted to be a scientist, but my knowledge and interest in astronomy was next to nothing; yet circumstances have slowly and surely dragged me into a whirlpool which landed me in the heart of a group whose entire ambition was to rebuild an astronomical institution. That was a dozen years after I started my working life in the laboratories of the Indian Meteorological Department in Delhi and Poona.

In college, we had Parker's Astronomy in our B.Sc., syllabus, and I never liked it. I think I had some mental inability to picture three-dimensional space and spherical geometry, and the only way I could solve problems was by memorizing formulae in spherical trigonometry and applying them blindly. I did not like this practice. I always preferred that form of mathematics which reveals physical pictures at every step; I learnt later that such operations are possible only in very elementary forms of this great art.

So, when I had to choose my line of specialization after graduation, I chose electronics. In those early days of electron-tubes, the subject was totally transparent and to my liking. Building up circuits with desired characteristics was indeed like solving a jig-saw puzzle, very interesting and stimulating. But astronomy was still far away.

After my Master's degree from Calcutta University, I spent almost a year in the Institute of Radio Physics and Electronics pursuing problems in instrumentation and then I joined the Indian Meteorological Department. The Department had embarked on a new programme of electronics instrumentation and I was inducted straight into the programme - opening boxes, studying pamphlets and setting up the equipment. Even the task of installing them at outstations was a part of our duties.

But I was destined to pursue my love for experimental science in a different field. The department had an ionospheric research station at Kodaikanal and the authorities were frantically looking for a scientist who could replace Sri B.N. Bhargava who had been looking after the unit ever since its establishment. But according to the rules of posting in the department he was likely to be posted outside Kodaikanal in due course of time. The group

in Calcutta I came from was noted for their ionospheric research; so within a few months of my joining the Radar laboratory in Delhi, I was called for a tete-a-tete with Dr A.K. Das who had come from Kodaikanal. I was given to understand that the Ionospheric Laboratory was in good hands; Dr Das wanted me to build a Radio Telescope and start observations there. He also suggested that I should spend some time with the Ionospheric and Radio Astronomy research groups in U.K. and join Kodaikanal on my return. This was in 1954.

In November 1957, I found myself in the Radio Research Station at Slough, U. K. Coming from Prof. S.K. Mitra's laboratory, I was very well accepted there and jointly with W.R Piggott and C.M. Minnis worked on some ionospheric problems. One of the problems concerned was with the behaviour of the ionosphere during a solar eclipse; that was my first brush with Astronomy.

Around the same time, I first became aware of some of the developments in the field of Astronomy in India. Dr A.P. Mitra, who was a couple of years senior to me in our Alma Mater, was a pioneer in the development of Riometry in Australia. He had come back home and was keen on setting up a radio dish and receiver for celestial radio sources. In his laboratory I met Govind Swarup, then Secretary to Prof. Krishnan, Chairman Radio Research Committee and he was on his way to Australia. I also knew that Prof. M.N. Saha was trying to build a group in Radio Astronomy. I also heard that a brilliant young man Vainu Bappu had come back home after a triumphant stay in U.S and had built a new observatory at Nainital.

I came back to India in July 1958, but my posting to Kodaikanal came six years later. The main interest of the department was not in astronomy, but in running the meteorological set up. The entire surface observational equipment and some of the balloon borne instruments were built in a departmental workshop in Poona (the new spelling Pune was adopted much later), and I was put in charge of this unit. Apparently I was liked by the general work force and the workshop functioned without any major crises during my tenure. I tried to introduce some of the tricks of modern production technology, which I learnt on the job, as well as in some specialised courses run by the National Productivity Council where I was deputed to attend. In hindsight I feel that my stay in Poona on a manufacturing job for six years was not a total loss to Astronomy. During this period I had attained a deep insight in some basic elements of mechanical Engineering which gave me a tremendous advantage years later during the execution of the large telescope project; the telescope was subsequently named after Vainu Bappu.

Finally in July 1964, I landed in Kodaikanal; that was the first time I visited an astronomical observatory. I was taken around and shown all the experiments and programmes of research; strangely I did not experience any difficulty in understanding them. A few days later I had a long discussion with Dr Vainu Bappu; he suggested that with my long experience in instrumentation, I may try to build a new and sensitive instrument for studies on the sun. What he had in mind was a Babcock type magnetograph for measuring small magnetic fields on the sun. With great foresight he had already obtained the essential components for such an instrument. The job was quite challenging; he also suggested this project can fetch me a Ph.D. Thesis, which I had left unfinished a dozen years ago.

I started on the project without any delay. The magnetograph was required to be fitted to the solar tunnel spectrograph, which at that time was being used by two of Bappu's students: Arvind Bhatnagar and Nirupama in their respective research projects. I had no difficulty in designing a portable attachment in the spectrograph focal plane, which will throw the light from two wings of a selected spectral line on to two photomultipliers. The outputs were amplified by an excellent differential amplifier which had already been imported by Dr. Bappu. I also rigged up a narrow band selective amplifier and a synchronous detector. The electro-optic chopper needed an alternating voltage of about 2000V r.m.s, and I obtained a suitable transformer from the Ionospheric Laboratory for the purpose. My first model utilized the 50 Hz mains, but stray-pickups forced me to move away from the mains frequency and ultimately I had to build a crystal controlled oscillator as a 62.5 Hz source for chopper operation. By December 1964, I could take observations on solar plages, but the prototype instrument had limited maneuverability, and a second unit incorporating several monitoring arrangements was built. This was ready in about a year's time. In those days we had direct access to the machines and technicians, and excellent co-operations from all fellow-scientists could be obtained; this way projects involving construction of new instruments could progress really fast.

Major difficulties we experienced were in inadequate funding. The consolidated grant for the whole department was received by the Director General of Observatories, and he used to distribute this to different units. Most of it used to go to maintain meteorological services, and only the left over amount was available for non-meteorological scientific research. Requests for additional funds were more often than not rejected, no consideration for special type of work being done in Kodaikanal was shown. Moreover the Director of the observatory had very little financial powers; a contingent expenditure of more than Rs. 100/= at a time had to be sanctioned by the headquarters. Civil constructions were particularly difficult to carry; sometimes we had to adopt dubious accounting procedures to cover unavoidable expenses. For example, we needed a covered enclosure for installing a small telescope; according to rules, for any constructions involving an expenditure of more than Rs. 400, we were required to inform CPWD, who would make an estimate, get the sanction of the appropriate authority and then execute the work, a procedure often taking months. But the installation, perhaps, was for observing an unforeseen event, such as a comet or a nova, which was not going to wait. In one such case I remember we had to prepare several estimates, e.g. building North-wall, West-wall, flooring etc. to keep each estimate within the statutory ceiling of Rs.400/=. I have known some officers who did not bother to go through such procedures and simply ignored the requirement, often missing important observations. They used to wait for orders transferring them to other units of the department engaged in routine work; the ultimate loser was the science.

The first step to end such difficulties was taken in 1966. The Central Government appointed a high power Committee (COSR - Committee for Scientific Reorganization) with the eminent scientist Prof. S. Bhagawantam as its chairman. Other members of the committee were Prof. K.R. Ramanathan and Dr. S. Ranganathan, a scientist of the Defence Science Cadre. The committee visited Kodaikanal in January 1967 and studied the working of the observatory. They openly expressed surprise at the existence of artificial hurdles in the form of severely restricted

powers of the Director and lack of career opportunities for scientists with specialization in Astrophysics. The committee submitted a report which recommended some sweeping changes in the organization, as a result of which Kodaikanal Observatory was transformed into an autonomous research Institute in 1971.

During the late sixties, besides working on the design and construction of the Solar Magnetograph, I was involved with several other areas of research and development. Bhargava left Kodaikanal in early 1966; he had nurtured the ionospheric and magnetic section since its inception, and this responsibility now fell on my shoulders. With the help of a few young researchers, I could bring out some results connecting solar radiation and ionization in the earth's upper atmosphere. One paper authored by T.K. Balakrishnan and myself was very well received among the ionospheric scientists.

Bhargava had started a project of measuring Faraday rotation of satellite signals through the Ionosphere. Measurements were being done at 40 and 41 MHz, and the differential effects could be clearly seen. A study was undertaken to measure the variations of total electron content and correlate them with phases of the solar activity cycle, but the emphasis shifted to low frequency radio noise measurements after Dr. Ch.V. Sastry joined the observatory. The Faraday rotation studies were prematurely terminated

Radio astronomical observations were being conducted by a group lead by U.V. Gopala Rao. Solar radio-noise measurements were originally started at Kodaikanal by Das and Bhargava in as far back as 1952, when they set up an interferometer with two Yagi antenna with a spacing of 22 λ, measuring 100 MHz solar noise. Two more systems at 60 MHz and 200 MHz were added later. Besides these, in a collaborative programme between Yale observatory and Kodaikanal, radio noise measurements at 22.2 MHz from Jupiter were being made since 1962. When I joined Kodaikanal all these experiments were going on in full swing. Gopala Rao spent sometime in Australia with Paul Wild's group and after his return started two more projects. The first one was to measure 10 GHz flux from the sun, while the second one aimed to measure spectral characteristics of solar radio bursts. Both the experiments were going full swing when the reorganization of the observatory came through and Gopala Rao opted to stay in the IMD cadres. He was posted in Delhi, and all the solar radio experiments came to a halt. Only Sastry's efforts to build up a low frequency interferometer continued, and some solar and galactic sources could be studied using his instrument. After the formation of the Institute, efforts were made to build a large array around Kalpakkam near Madras, but the project ran into problems. Finally the venue was shifted to Gauribidanur in Karnataka where a low frequency radio telescope was built. Scientists from the Raman Research Institute in Bangalore joined in this endeavour and this low frequency telescope was jointly completed by the two groups.

Bappu was very keen on observing every celestial event. In October 1965, Comet Ikeya-seki appeared in the sky, and ingenious ways of photographing it were applied. I remember Bhargava fixing a camera on a tripod and photographing the comet's reflection on the coelostat mirror of the solar tower telescope. Later a chart camera strapped onto the body of the eight inch telescope gave excellent pictures of the comet.

At Kodaikanal we had two telescopes for night observations; the bigger one, the 20-inch Bhavnagar telescope was fitted with a locally made stellar spectrograph. K.S. Ganesh one of Bappu's students, obtained all his observations of Wolf-Rayet stars with its help. Bappu's other student Rajamohan also started using this telescope. Arvind Bhatnagar, after his PhD, joined the observatory and obtained several spectra of the nova sighted in the constellation of Delphinus, with this telescope.

The other telescope was the 8-inch Madras Equatorial. This nineteenth century, gravity driven telescope which had Bappu's "poor man's photometer" at its focus, was used for stellar photometry. Each one of us in the scientific cadre was allotted a couple of variable stars and a few nights' telescope time every month. The locally built photometer had an uncooled 1P21 photomultiplier and an amplifier, also locally constructed. The recording was done on a Honeywell Brown potentiometric chart recorder. Every night's observations used to be manually scaled and analysed, a far cry from today's pulse counting on an on-line computer. To reduce thermal noise, the photomultiplier used to be cooked in a dark box with EHT on for days together and even on the telescope it was continuously kept on.

The tracking system of both the telescopes were clock driven, power being provided by a heavy weight which had to be periodically raised by a chain pulley operated arrangement by winding a handle. Quite often during the night we would hear an ominous thud and the telescope stalled, the frayed steel cable giving way to the strain. On those occasions we had to pack up for the night as the repair was a day time job. We tried to make the drive system a bit more reliable; synchronous motors replaced the gravity driven clock; some of the long handles meant for remote operations for fine adjustments, gave way to electric motors and hand set switches. Nevertheless, we still had to use our muscle power for additional adjustments off and on.

Not much refinements could be affected in the old frames, but the experience gained in those exercises proved very valuable when we started building other telescopes. By 1966 a new telescope was already built in Kodaikanal workshops. It had a primary mirror of fifteen inches diameter, which was ground and figured in the optical workshop. This telescope was housed in the old Lyot filter dome and was sort of an experimental prototype, where all new instruments developed had their first trials on. The dry-ice cooled photomultiplier boxes used to be tested out here; a spectrum scanner was built locally and had its first trial on this tiny telescope. With additional weights hanging at all sorts of places for balancing it was difficult to recognize it as a telescope. When Kavalur observatory was established, this telescope was sent there and housed in a roll-off shed of nineteenth century vintage.

Photomultipliers used so far for astronomical photometry were of the uncooled type, whose sensitivity and spectral coverage were severely restricted. Bappu and I designed a cold box where low temperatures were achieved by the use of dry-ice. Window fogging was the most annoying problem; so was the heat leakage into the system resulting in dew formation all over

the outer case. This often trickled down to the electrodes, causing a total break down of the photometer operation: We made paper thin stainless steel pipes, but the problem still persisted. Finally the problem was solved by importing special low conducting alloy pipes. The trials continued for more than ten years; then with the relaxation of the foreign exchange restrictions we could import some cold boxes and indigenization efforts were given up. But we still had to use flowing water through flexible pipes on the telescope to keep the cold boxes functioning.

Simultaneously, we started rigging up the photon counting equipment. When cold boxes started giving very low dark counts, the existing counting equipment was fast enough for the task. Most of the electronics like counters and timers could be obtained from the Atomic Energy Establishment and no sub-assembly rigging up was necessary. But the observers held on to the electrometer-amplifier approach for a long time; it was only after the on-line computer TDC-12 went into operation with the forty inch telescope at Kavalur that the new method was finally accepted.

Bappu was very keen on starting infrared observations from Kodaikanal. We had some old lead sulphide detectors and we designed and built a simple IR photometer, but the flux collected from stars through our telescopes was inadequate. A new lead selenide detector was obtained but we could get an output only for the very bright stars. No worthwhile IR Photometer could be built while we were at Kodaikanal. Later when the laboratories were shifted to Bangalore, the efforts were renewed but again we had limited success. In the early eighties, we imported complete IR Photometers to meet the needs of the observers.

By late 1967, the solar magnetometer was ready, but the original plan of obtaining magnetic field distribution over an extended area on the solar surface was postponed. The instrument was very sensitive for measurement of solar magnetic field at any point, but still more sensitive to fine doppler line shifts, and shifts corresponding to about 20 m/sec could easily be detected. Leighton from caltech had discovered the five minute oscillations a few years ago, and Howard had displayed the use of Mount Wilson solar magnetograph for these studies. Bappu suggested that I study the depth variations of these oscillations using the new instrument. Sivaraman had meanwhile joined our group, and he started a detailed study of solar velocity oscillations from series of high dispersion spectra. Both of us completed our studies almost together and our studies threw some new light on the subject. We found periods other than five minutes and had an approximate idea of the depths and sizes of the oscillating cells. Many other groups in different observatories were pursuing similar studies at that time, and a few years later the global oscillations were discovered. The subject of helioseismology was born and became a powerful tool for studies of the solar interior.

Towards the fag end of our association with the India Meteorological Department, an expedition to Mexico for observing the total solar eclipse of March 7, 1970 was approved. The sanctioned funds could cover the expenses of only a two-man team; Bappu and I formed the duo. The recent earlier expeditions from the observatory went to Iraq in 1952, and Ceylon in 1955 and both were failures, all optical observations were hampered by clouds; Bappu was very keen to succeed this time. He had drawn up a very ambitious plan to conduct four different

experiments including the use of a big coronal spectrograph, all to be done by the two of us. He had hoped that we might be able to get additional hands from the National University of Mexico, the local hosts, but as it turned out they themselves were short of hands and could not help us. But we got valuable help from a person in the Indian Embassy in Mexico. The interpreter in the Embassy, Senor Zentella, a very young and enthusiastic individual came forward and helped us in finding a suitable location and setting up of the eclipse camp in a remote village in southern Mexico. On the eclipse day he arrived with the Indian Ambassador Sri B.K. Masand, and took a movie of the eclipse event showing a beautiful diamond ring at the third contact.

The two main experiments went off beautifully. We had rigged up a big long focus coronagraph and obtained five excellent photographs of the solar corona, which in addition to being scientifically valuable, served as a publicity material for the next ten years. The spectrograph experiment yielded a serendipitous result that cool pockets existed in the lower corona. Even the third experiment to measure polarization of the corona gave usable results. In facts the voodoo of eclipse expedition failures which had haunted the observatory teams since Evershed's attempt in 1922, in Australia, was finally broken.

At about the same time the decision of the central Government in accordance with COSR recommendations, was received. The Kodaikanal Observatory together with the newly started Kavalur Observatory was transformed into an autonomous research institution with effect from 1.4.1971. Years later I happened to glance through Dr Bappu's personal diary covering this period. Under this date, there was just one entry in bold letters "Freedom, at last !".

I first heard about Kavalur a few days after I joined Kodaikanal. I was not even sure of its location. Bappu with a team of young assistants had discovered the place and seeing observations with small telescopes were in progress. Bappu had taken an 8mm home movie covering his expedition. We watched this movie at his residence during some of our social evening get togethers.

My first visit to Kavalur was in July 1996. We had a funny experience during this visit. We parked the car at the road side very near the present gate and walked up the hill. Then we climbed down the valley on the south eastern side; it was densely wooded and we lost our tracks in the jungle. Three or four attempts to come out of the labyrinth failed and we were at a loss to decide our next step. Any direction we took along cattle tracks brought us back to the same spot. Fortunately I had a little magnetic compass with me; I had picked up a fancy little keychain in Bangalore only the previous day which had this small compass as a pendant. We once more consulted the map and followed the direction of the compass; in five minutes we came out of the lantana grove. I fully realized why compass is so essential in navigation.

The land was taken over by us within a couple of months after our visit and a detailed survey of the 40 acre site was undertaken. A.P.Jayarajan, assisted by R. Sivashanmugam completed the job. Until this time all seeing observations were made from the nearby forest

rest house; now the first pre-fabricated structure came up; it was named Tycho after the great astronomer of the middle ages who was a pioneer in precise position measurements. The locally made fifteen inch telescope was installed near it, in another pre-fabricated roll-off shed brought from Kodaikanal.

My next visit to Kavalur was two years later; but in the meantime we were kept informed of the developments through photoslides and home movies. The boxes containing the 40-inch telescope had arrived and a huge prefabricated hut had to be built for storing the boxes. We learnt that while the trucks were waiting to deliver the boxes, mechanics from Kodaikanal were busy fixing the roof panels to the steel frame work (side panels were fitted after the boxes were in position). The hut had been christened Galileo, the first user of astronomical telescopes; meanwhile a second twin hut had been built and named Kepler. A team of Zeiss Engineers came to see the storage of the boxes and to draw up a plan for installation. The forty inch tower was still to be built. We went up and visited the site where a hole had been dug for soil testing.

The fifteen inch telescope was being fully utilized. T.K.Balakrishnan was pursuing a photometry observation programme and turning out rolls of charts. I spent the night in Tycho in a makeshift bed and had a not very pleasant experience of mice jumping over me throughout the night.

My next visit to Kavalur was about a year later. The forty inch building was ready and the engineers were having doubts about leveling of the rails before placing the dome. In Mexico we had learnt a method of leveling using a water filled polythene tube, and Bappu suggested that I use the same technique for this task. We checked the level successfully and in the process learnt another point. I had planned to check with an accuracy of fraction of a millimeter, not realising that a very long column of liquid may execute period oscillations, making achievement of such accuracies difficult.

This time I spent the night in one suite in the hutment named Kepler. Although covered by asbestos boards and with rough floors, the accommodation was excellent, mainly due to the efforts of Sivashanmugam. Spotlessly clean linen and bath room made this humble apartment something worth remembering. Less than a year later I spent about a month in the same room with my family when my children had a vacation. The forty inch telescope was under installation.

Shortly afterwards the Indian Institute of Astrophysics was formed and we were freed from most of the artificial obstacles which had hindered our efforts to build up a modern research institution. An immediate effect could be seen in Kavalur. Until then no proper catering or dining service was available, now a spacious hut was built for the purpose. Another hut housing observers rest-rooms was built in a quiet corner of the campus. Bappu started naming them after the celestial nymphs from Indian mythology; the new huts were named as Rohini, Urvasi, Menaka, Tillottama etc; their architecture and construction was much more graceful than that

of the earlier pre-fabricated sheds. Of course, the auditors's team from the Accountant General's office raised technical objections as we did not have a qualified civil Engineer on our rolls; but as the limits on financial transactions were removed, we did not have to build the structures wall by wall as in earlier times.

The first full-fledged scientific expedition to Kavalur was undertaken within a couple of months of the formation of the Institute. The Head Quarters were still at Kodaikanal, and it was decided to observe an occultation event from Kavalur on May 13, 1971 when the planet Jupiter was to occult the bright star β - Scorpii. The fifteen inch telescope was operational but we needed some arrangements for photometry, the conventional potentiometric recorder was too slow for registering fast changes in the light from the occulted star. Our aim was to obtain data revealing the structure and composition of the Jupiter atmosphere.

In parallel with the conventional potentiometric recorder we connected a 4-trace Techtronix Oscilloscope with one channel displaying the light curve and the others showing seconds time beeps. The screen was photographed by a camera; the occultation light curve when analysed gave clear indication of stratifications in the Jupiter atmosphere. It was during this experiment that an urgent need for developing fast recorders for occultation photometry originated.

The Zeiss Engineers arrived in India in October 1971; the tower and the building was almost complete by this time. The switch cabinet room was to be located one floor below the observing floor; elaborate wiring was needed for connecting these two places. A couple of kilometers of multistrand cables were cut to the required lengths, and bundles drawn through the conduits already embedded in walls and floors. The Engineers decided to complete the installation of an identical telescope at Nainital first and then come to Kavalur. Dr Bappu and I moved to Kavalur with our families immediately after the Christmas of 1971. Our aim was to watch every step of the installation and learn as much as possible about the new telescope.

We had a collaboration with the Lowell Observatory at Flagstaff, Arizona, for observing the Planet Mars during its favourable opposition in 1971. They had loaned us a 24-inch Optics of excellent imaging quality and a mount for which was built in our workshop at Kodaikanal. This telescope was housed in another roll - off shed at Kavalur. The observations were over by December, and I had the full use of the telescope for trying out the new pulse counting photometer. During January 1972, I tested my new equipment on known star clusters. I remember that I could use the telescope almost every night; we had as many as 25 clear nights during that month.

For India it was a very eventful period; we had just helped Bangladesh to attain freedom. Prof. Bart J. Bok wrote a letter to Bappu congratulating our leaders for achieving this difficult task. I remember from one of the newly built huts our listening to Shaikh Mujibur Rahman's address on the radio from Delhi. On the last day of the year we heard the shocking news of Vikram Sarabhai's untimely death at Kovalam. He was very close to all of us; he was an ardent well-wisher in our efforts to build up the Institute of Astrophysics; it was indeed a great loss to the entire nation.

For us the whole of January 1972 was a leisurely time. Our cable drawing task was over within a week, a much detailed listing of individual conductors was to wait for the Zeiss Engineers. Muraleedharan Nair was of great help in this work. I remember Dr. Bappu and Sri. Jayarajan sitting on the verandah of Kepler working out the detailed architecture of the dining hall which was later christened as Menaka. Jayarajan collected a sizeable number of butterflies, several varieties of the species could be seen all over the campus. So also were flocks of migrating birds, the colours and patterns of their plumage was a real feast to the beholder.

The campus being situated right in the midst of a forest we had regular visitors from wild life families. Herds of spotted deer could be seen crossing over paths. They are seen even today. A year later, a herd of wild buffaloes came into our campus making everybody a bit scared and hesitant to roam about after dark. In the late eighties we even had a herd of wild elephants, who used to wrench open our taps for drinking water. At that time we were forced to install an electrified fence all around for preventing them from coming in.

The Zeiss Engineers came back to Kavalur by the end of January after completing the installation at Nainital, and with that the second phase of Kavalur activities began. Many memorable events occurred during the installation, commissioning and the observational programmes that followed, but all that will be another long story.