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My encounter with astronomy: later years

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The installation of the 40-inch telescope at Kavalur signifies a major step in the development of astronomical observational facilities in India. The investment in this single instrument exceeded the total cumulative investment on the two century old Madras Observatory and its successor at Kodaikanal. Although not of the largest aperture existing in India at that time, this telescope was very modern and of excellent operational characteristics, making it highly suitable for researches in observational astronomy. This was the first time that a proper research telescope for stellar studies was made available to the scientists of IIA.

The Zeiss engineers arrived at Kavalur by the end of January. Some special arrangements for their stay had to be made, there being no suitable hotels near Kavalur. The Indian agents, M/s Govardhandas Desai requested us to spare two rooms, built in the tower, for their use. We agreed. They arranged for a Goanese cook from Bombay and a small hut was built close to the 40-inch tower where he used to pursue his cullinary skills. From the aroma coming from the hut, we guessed that the Germans were getting tasty food, perhaps tastier than what they could get at home. The hut still exists and is now known as the "German Kitchen", but at present it is used only as a small godown.

One of the perks extended to the German team was a week-end trip away from Kavalur every fortnight: I think they used to roam about in Madras or Bangalore during these trips. At the end of one such trip we noticed a cassette player, perhaps picked up at the Burma bazaar. That used to be their major source of entertainment; we guessed that in East Germany these were rare luxuries.

The team consisted of four persons, Artus was the leader, He knew all about telescopes; all optical adjustments used to be done by him. Schwarz and Sandner were, the latter being the most friendly person in the team. His English was limited but still he attempted to converse with us. Gabler was the Electrical Engineer; he was friendly with two persons: Muralee and Mani, otherwise, he hardly conversed with anybody.

Gabriel and Mani were the two young boys from our group attached to the team, but the Germans were almost totally self reliant. For installation we had to install a heavy A-frame, which

was done by hiring a group of mechanics who were experts in heavy installation work, from Madras. We wondered at their skill, particularly that of their leader Abu Baqr who took the heavy components up to the fourth floor without a scratch on the frame or the building. He himself hardly used the staircase but preferred to climb up by the ropes dangling from above; his agility and dexterity was to be seen to be believed. After the telescope installation was over, he was again employed for dismantling and taking the A-frame down. This was a more difficult task as there was hardly any room on the observation floor with the delicate telescope occupying bulk of the space in the middle, but the way the whole operation was carried out left all of us wonder-struck.

The installation operations began in early February. Some of the Galileo side panels were removed to facilitate transportation. Boxes were opened, parts examined and then loaded on a trolley to be carted to the 40-inch building. For heavy boxes we had to install another A-frame and a couple of chain pulley blocks inside Galileo. On one such occasion the lifting tackle failed and the box landed with a thud; fortunately the equipment suffered no damage.

Although care was taken to fumigate the boxes periodically during storage, we could not prevent small rodents entering the boxes. On opening one such unit we discovered a colony of mice who had nibbled through the insulations of internal electrical wiring. The damage was superficial, but the German engineers were upset. Muralee re-wired the unit with fresh cables and the equipment was as good as new.

On another occasion, an extensive damage occurred during installation. The heavy chain-pulley block, which was kept at the edge of the hatch, slipped and fell on the telescope tube while it was in the process of being lifted. There was a big dent and Schwarz threw tantrums, because he believed that local workers would not be able to repair it properly. We assured him that it will be properly repaired; we got in touch with an autogarage in Madras which specialized in tinkering jobs. A team from this garage repaired the telescope tube perfectly. The Germans saw it after they came back from one of the their week-end trips and could not locate the repaired spot. There were no more complaints from them.

While the telescope was taking shape, the electrical engineer Gabler and Muralee were marking the conductors for interconnection. The switch cabinet was installed and the thousand-odd pairs of conductors were hooked to the right terminals.

By the end of April, the installation was nearly over. We had a peep at the focal plane and saw the bright spots we knew to be due to faint stars. Being used to imperfect drives of telescopes we had used so far, the stability of the drive impressed us the most. We could centre any star on the cross-hairs and the image stayed on for minutes without any guiding.

The Germans left Kavalur by about the middle of May and the telescope was handed over to us. The first scientists on the telescope were Bappu, Scaria and myself; other prolific users like Parthasarathy and Rajamohan came somewhat later. the excellent quality of the telescope was fully utilized by Scaria by collecting a large number of photographs of celestial objects.

Within a month of the installation, an opportunity for testing the quality of the telescope came in. On 7th June 1972, Ganymede, Jupiter's largest satellite occulted a star and the track of visibility passed over Kavalur. We had conducted another occultation observation in the previous year and had felt that higher time resolution should be attempted. This time we had a proper telescope and some modifications in the recording system were also made. In connection with the International Mars programme, Lowell observatory had sent an automatic camera which, at the end of an exposure, also photographed a clockface. We set up a similar arrangement as in 1971, but speeded up the Cathode Ray Oscillograph trace and introduced $0^s.1$ time pips. Thus, we could record the occultation light curve with a time resolution of $0^s.1$. The record indicated a sudden drop at the beginning and a recovery at the end of the event, from which an upper limit of the density of the Ganymede atmosphere could be made. Our data was combined with those recorded at Lembang, Java, Darwin and Australia, by two U.S. teams and a joint paper was published. This was the first published scientific result from the forty-inch telescope.

But we were still not satisfied with the fast recording arrangement; at that time we were planning to start lunar occultation observations in the visible band, which would need recording with resolution higher than a millisecond. We hit upon a new idea of using audio tape recorders, and that gave usable results. Our first lunar occultation record was taken using this equipment in December 1975.

A still major change was being contemplated in the observational set up. The new India-made minicomputer TDC-12 was in the market and Bappu wanted to introduced it in the observational setup. We planned several programmes in photometry and spectrophotometry and requested the ECIL to develop the necessary software. In the meantime the computer system was purchased and installed in the forty inch bulding. Pending development and supply of the software, the computer was being used for off-line computations.

The ECIL engineers took some time before producing the necessary software. They were well versed in computer techniques, but did not fully understand the physics behind the technique of photon counting. They prepared a software for controlling the grating movements in the spectrum scanner and storing photon counts in separate bins and installed it on the Kavalur computer. They wanted to test it out by connecting the scanner on the telescope in day time, but without cooling the photomultiplier, which they did not consider necessary. As expected all the bins were saturated; they were at a loss to decide on the next step.

I remember the day very clearly. It was a sunday and I was at home in Bangalore and ready to have lunch with some old friends of mine. My phone rang, and it was a call from Dr. Bappu at Kavalur. He told me to rush to the Bangalore city Railway station and catch the Brindavan Express; Mohd. Batcha, Bappu's personal secretary would be waiting there for me with a ticket. I had to leave my friends at home and just barely managed to catch the train. The observatory jeep was waiting for me at Jolarpettai and I reached the observatory just before dusk. With my long experience in photon-counting techniques it did not take me long to understand the problem. The software was O.K, only it was necessary to considerably reduce the dark counts. We charged the photomultiplier box with dry ice, and within an hour the system was working perfectly. Bappu immediately took charge of the instrument and started observations. I held a midnight tutorial

class in the library below, explaining elements of the pulse counting techniques to the ECIL engineer and our night assistants. A couple of hours later we went up and found Dr. Bappu extremely happy. The instrument was working beautifully; we could see the building up of stellar spectra on the oscilloscope screen as the observations continued. We walked out on the catwalk, and Dr. Bappu told me there that this night would be known to posterity as the beginning of a new chapter in our efforts to modernize stellar observations.

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In 1976, there was a move for the organization of a set of co-ordinated observations of a rare event. It had been found out from ephemerides calculations that a ninth magnitude star will be occulted by the planet Uranus on the night of 10th March 1977. This was an unique opportunity for measuring physical parameters of the distant planet and its atmosphere. Prof. Tom Gehrels of Lunar & Planetary Laboratory of the University of Arizona sought our collaboration in this effort and we decided to spare our one-metre telescope for the joint observations. Elaborate plans for the observations were made; additional optics was designed and fabricated by the Arizona team for fitting their special photometer to our telescope. But the collaboration did not materialize; the USA team called off their visit about ten days before the event.

It happened like this. The original prediction of the event was made by G.E. Taylor of Herstmonceaux, U.K based on the star position from astrometric plates. In January 1977, Uranus was supposed to pass very close to the star on its direct motion and then reverse and occult the star on 10th March, in its retrograde path. A few astrographic plates were taken during their close proximity and from these measurements it was discovered that the shadow of Uranus will miss India by about 2000 km! There was an error of 1".24 in declination of the star and Uranus was also out by 0".20 in the opposite direction so that the total error was 1".44 and as a result of which at the time of occultation, the northern limit of the shadow will pass much farther south. There were hardly any chances of errors in the 1977 plates. The Arizona team decided to abandon India and go to Mauritius instead.

So we were left with a one-metre telescope and hardly any chance of observing the occultation. We had a quick consultation with Dr. Bappu and decided to go through the observation. We tested the photometric signals from the star and the planet separately and selected the optimum combination of the filter and the photomultiplier. The event was a comparatively slow one, and there was no need to use the fast recorder. We chose the conventional amplifier and the potentiometric chart recorder. With the observing equipment ready we started the observation on the one metre telescope around midnight of 10-11 March, 1977.

I, very well, remember the night. The sky was clear with a trace of ground haze, which could be clearly seen in the moon light. The seeing was excellent and the greenish image of Uranus could be seen in the eight inch guide telescope. I chose the task of guiding, and Kuppuswamy was near the chart recorder, occasionally marking time and other relevant information. Uranus was steadily approaching the star and I was hoping against hope that the star would be occulted by an edge of the planet. The conjunction was expected around 02:30, but about forty minutes earlier Kuppuswamy cried out saying that the signal has dropped. On the guide telescope, I could see the

planet clearly, but for a few seconds the star winked, and again shone clearly afterwards; the pen on the chart indicated that the signal was back; to the original level.

That was the occultation of the star by an unknown ring around Uranus; actually this event led to the discovery of the ring system around Uranus. We did not know about the existence of such a system and were trying to reason out the cause of the drop. We knew the position where the star winked, but that was far away from the satellite Miranda, which in any case was on the opposite side of the planet at that moment. Was it, then, another unknown satellite? That night all indications appeared to point towards that possibility.

I did not realize at that time that I was perhaps the only person in the world to witness this occultation with my own eyes. The other successful teams were the Cornell University team of Kuiper Airborne observatory flying over the southern Indian ocean and the Lowell Observatory team from Perth, western Australia. The Kuiper team noticed the drop on oscilloscope traces, while the Perth observers noticing the drop on their chart decided to interrupt the observations by lowering the photometer microscope. The same thing happened to the observers at Nainital; they could not record the drop due to the epsilon ring and found out the truth only a few days later. But the worst luck was in store for the Arizona team in Mauritius; they could not even open the telescope dome because of rain!

In any case as I kept on observing I could clearly see that we will not be able to see the occultation by the planet body from Kavalur; so half an hour after the closest approach we stopped our observations. That was one act I was to repent later, for had we continued we would have got the occultations by the other side of the ring, and perhaps could have been the first to announce the discovery. As it happened both the Cornell team and our group sent telegrams announcing the discovery of a new satellite. A day later Jim Elliot of the Cornell team found a few other shorter occultations on the record, and noticed the symmetry of the events. His observations were further supported by the reports from Kavalur and Lowell observatory when he surmised that all observations point to a ring system around Uranus.

Our record was thoroughly examined in Bangalore and we found direct evidence of a few shallow dips which we speculated to be the diffuse matter in between the rings. This claim was contested as no other records could detect these. We requested Nainital observatory for their record and an analysis showed the same features as noticed by us. These two were, incidentally, the largest aperture telescopes used in these observations. The results, presented in Montreal, were also received with scepticism. I insisted that the records from Kuiper Airborne Observatory, which used a slightly smaller telescope, would definitely show this dip as it was very prominent in both Kavalur and Nainital records. When I privately discussed with Jim Elliot after my presentation and advised him to look for these shallow depressions, he admitted that Kuiper records were affected by moon light reflected from the wings of the aircraft, and it was not practicable to look for very shallow depressions there. Elliot published a monogram on Uranian Rings, shortly after this, which did not include any mention of the suspected diffuse rings.

However in 1986, Voyager II sent some close pictures of the Uranian Rings which showed the existence of such broad diffuse rings. I saw a paper by a scientist from U.K. who analysed the

Voyager II tapes and triumphantly claimed the discovery of diffuse rings. I promptly sent him the reprint of our paper, by that time almost a decade old, which did not find any mention in his paper. In spite of a reminder, there was no response from the author.

Besides the diffuse rings, we found on the records, several sharp spikes which we interpreted as more thin rings in the extended Uranian ring system. On re-examinaiton of his March 1977 record Elliot had found five rings including a broad one which both of us initially thought to be a new satellite. We had promptly published details of these additional spikes and later explained them as additional thin rings, a view which was opposed by a section of the international scientific community. But a few months later, in April 1978, utilising another occultation event of a much fainter star by the Uranian Rings, at the 4-metre telescope at Cerro Tololo, Elliot et al. claimed the discovery of four more rings and promptly gave them new names; all of them were found to be the same as indicated in our 1977 paper. A fresh paper giving these details was sent to Nature but it was rejected due to hostile comments of an unknown referee. Prof.Kopal who was passing through Bangalore at that time, saw our paper and the records, and promptly arranged to publish it in the next issue of the Moon and the Planets. The matter rested there. None of the later papers on the subject referred to our observations and inferences. During the XVII IAU General Assembly at Montreal, I presented a short report which I have already mentioned. Although a few scientists expressed their interest, nobody attempted to correct the prevalent ideas about the ring system or the history of observations.

By the middle of the seventies we had deeply entered into the project of making a large optical telescope; I have already described the project in detail elsewhere and shall desist from repeating my interesting experiences connected with the project. The incident which shook me most during the execution of the project was the totally unexpected passing away of Dr. Bappu; not only did I lose my friend, philosopher and guide, but found myself saddled with the responsibility of seeing through the task of completing this complex project. I felt like a sailor who has lost his captain in a stormy sea. Although, I was involved in the control and electronics part of the project right from the beginning, several other issues, particularly the arrangement of finances and persuasion of the higher ups in the Government, were absolutely baffling. The powers that be had no idea of the project. They imagined that this was an insignificantly small job, and often expressed so. Our pleas for necessary funds were more often than not brushed aside. The fact that the telescope could finally be completed was solely due to the encouragement, the help and the guidance from Prof. M.G.K. Menon, the then Chairman of the Governing Council of IIA.

Another unfinished task, which Bappu left, was the organisation of IAU's 19th General Assembly in India. Originally we thought of holding the meeting in Bangalore: but closer investigations revealed that the infra-structural support needed would be lacking here. So, ultimately, New Delhi was chosen as the venue; but the problem of organisation and finances came to the fore. The Indian National Science Academy, which is the adhering organisation to the IAU, did not have the means to support such a large meeting. Here again Prof. Menon came to the rescue. He persuaded A.P. Mitra, Director, National Physical Laboratory, to take charge of the local problems, and S.Varadarajan, Secretary, DST to release the necessary funds. There was an enormous volume of organisational work which the Indian Academy of Sciences team in Bangalore volunteered to take up; the roles played by G. Srinivasan, V. Radhakrishnan and Anna

Mani in this context were admirable; I hope some day Prof. Srinivasan would write down his experience of this mammoth endeavour.

As judged from opinions expressed by participants, the New Delhi meeting was a grand success. The accommodation, transport, food, cultural programs - everything was to the liking of the delegates, and the meetings unfolded so many happenings in contemporary astronomy. We were all happy that Bappu's dream of the first ever IAU General Assembly in Asia went through smoothly.

In the meanwhile, I was saddled with the Directorship of IIA. I found myself solving hundreds of small problems connected with the administration. My personal scientific activities slowly tapered off. The only link, I could maintain, was through the theses work of my students, some of them continuing their projects which they started under Bappu's guidance. Some of my collaborations with other institutions in the country and abroad, however, went on.

I would like to narrate a few important incidents of this period. The task of occultation observations was taken over by Vasundhara from me and she discovered a very peculiar circumplanetary feature in the magnetosphere of Saturn. But the paper encountered stiff opposition from referees and had to be revised extensively before it was accepted for publication in Nature. The feature is so unique that many still refuse to accept it in spite of the observational proof being loud and clear. The group plans to obtain further observational proofs if and when new opportunities in the form of favourable occultations arise.

A few brilliant young electronics engineers worked with me in our efforts to modernize the observing equipment; they are Chandramohan, Sundareswaran, Santhanam and Sadasivan to name a few, all of them have since left the Institute and at present are occupying top positions in the Industry. Sundareswaran was instrumental in the development of fast recorders; it was he who introduced the first imaging CCD in our laboratories. The task was taken over by Santhanam, who designed and fabricated the backend instruments for CCD imaging equipment; it was his instrument which was first put on the Vainu Bappu Telescope. He also designed and fabricated electronics for recording pulsar light curves, for a collaborative observational project with TIFR, Bombay. Later a few very enterprising young men joined, who finally located greener pastures abroad; among them I may mention Raghu, Venkatesan and Venugopal, all of them contributed to the many developments in observational equipment. The persons continuing at present are Muralee, Ramamurthy and Chinnappan who have been joined by other young people.

Among my students, Sunetra, Babu, Shylaja and Ashok Pati had started with Bappu and I only helped them complete their thesis projects. Venkatesh had completed his thesis on observational techniques before others and moved abroad. Bala took up my unfinished job of making vector magnetic field measurements, and Vasundhara completed her thesis on solar system bodies. Rajamohan who had completed his thesis under Bappu, fulfilled my long standing wish of discovering a new asteroid from India; we proudly named it after Ramanujan, the mathematical genius of our times.

If I am asked to sum up my experiences over all these years, I would like to say that I do not have any reason for regrets. The face of Astronomy in India, when I started work in this field was totally different from the one we view now, and the present picture is definitely encouraging. Only feeling I miss today is the spirit of friendliness. When our community was small we used to rejoice at every small achievement by any group in the country; now-a-days the individual groups appear to be more important than science. The main reason, perhaps, is the dwindling meagre flow of funds for research satisfying the creative talents of our scientific groups; frustrated groups no longer openly rejoice new ventures or achievements, perhaps with a feeling that such expressions may alter the courses of fund flow. There had been cases of spreading deliberate lies and canards about new achievements, results and ventures, which leave a bitter taste among the wonderful fruits of our endeavours.