

## My encounter with astronomy

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Prof. T. Naveneetha Rao, Vice-Chancellor, Osmania University, Prof. J. V. Narlikar, Prof. J. C. Bhattacharyya and friends, I am thankful to Prof. M. B. K. Sharma, Dr G. C. Kilambi, all other colleagues at the Centre of Advanced Study in Astronomy and former students for organizing this workshop and tonight's pleasant function. I am also grateful to all those who have participated in the workshop with their contributions and other well wishers who attended it. It is indeed highly satisfying to have such warm recognition at the end of one's service career. I am overwhelmed by their affection. I am asked to narrate my experience which I call my encounter with astronomy.

1. I first came face to face with astronomy as a boy when my father pointed out to me the *Saptarshis* (the Great Bear), *Dhruva* (the Polaris) and the 27 *Nakshatras* (lunar mansions) which have been in use in India for thousands of years from the Vedic times. It is these *Nakshatras* and not the right ascensions of stars which still help me to orient myself in the sky.

After this initial introduction there was a complete loss of contact with astronomy during my whole educational career right up to taking my M.Sc. degree in physics from Agra University in 1951, thanks to the astronomy-abhorrent curriculum of the Indian education system. The situation was so bad that I did not appreciate the significance of Saha's ionization equation which is discussed in the book 'Heat and Thermodynamics' written by Saha & Srivastava. I am sorry to say that this lacuna still persists in our physics education.

In Madhya Bharat (now in Madhya Pradesh), where I was born in 1928 and where I spent the first 24 years of my life, it was the practice to take a lecturer's job after M.Sc. and settle down in life. I also started as a junior lecturer at Holkar College, Indore; but I was keen to do research for which there were no facilities in Madhya Bharat. So I applied to three places. First I wanted to join TIFR, Bombay to do research in theoretical physics. In those days Dr Bhabha himself used to interview candidates for theoretical physics. There were four candidates. The first two candidates came out of the room within 15 minutes only. I was the third; I could hold out for 45 minutes which was encouraging. However, I did not succeed, because the fourth candidate, who was from Bombay, knew quite well what Dr Bhabha would have liked him to know.

The Physical Research Laboratory, Ahmedabad, then known as Cosmic Ray Laboratory, had also advertised for a research fellowship of Rs 75 per month, and they wanted specialization in wireless, *i.e.* electronics. Although I had specialized in spectroscopy I applied for the same. I do not remember whether I got the call for the interview. But in the mean time there was an advertisement from Kodaikanal

Observatory offering a senior research fellowship of Rs 200 per month I applied for it and was called for interview. Learning from my earlier experience at TIFR, I prepared well and was selected. Dr R. Anantkrishnan, Assistant Director, was the person who interviewed me. So he is really responsible for bringing me into the field of astronomy. Consequently I resigned my lecturer's job and joined Kodaikanal Observatory in May 1952; this was the starting point of my astronomical career.

2. At Kodaikanal Dr A. K. Das, the Director, gave me the problem of measuring the Balmer discontinuity in the solar spectrum for verifying the earlier work of Cannavaglia and Chalonge. With my zero knowledge of astronomy I did not have the faintest idea of Balmer discontinuity and the measurement of absolute energy distribution in the solar spectrum that it entailed. So I had to read original papers for which I tried to get a smattering knowledge of French and German, because English was then not the predominant language of science that it is today. In this way I could read the relevant papers published in *Zeitschrift für Astrophysik*, *Annales des Astrophysique* and *Compte Rendu*. My fellow research scholar Dr A. S. Ramanathan and myself started reading the book on *Astrophysics* written by L. H. Aller and we tried to solve all the problems at the end of each chapter. During our conversations we always admired the work of Prof. S. Chandrasekhar and wondered how he could fill the whole issues of the *Astrophysical Journal* with his papers containing equations running over several pages. In addition, I read Milne's article in *Handbuch der Astrophysics*, eight volumes of the Harvard series on astronomy, and popular books by Eddington and Hoyle. At night, the clear winter skies gave me an opportunity to get acquainted with constellations with the help of Norton's star atlas. But all this effort was more like an unguided missile which does not hit the target.

Towards the end of 1952 there was an accident. The Hydrogen tube, then costing Rs 2000, which was to be used as a standard for comparison with the solar spectrum, broke due to mishandling. I reported the matter to Dr Das who appreciated my forthrightness, but later ventilated his anger on the administrative staff. I was also shaken and went through a period of depression. I got over it by making a trip to Madurai and by enjoying the picturesque beauty of Kodaikanal. Any way Dr Das soon gave me another problem, viz., that of measuring the difference of temperature between the pole and equator of the sun by Woolley's method of calcium ionization. I was able to complete the work just in time when Dr Das, who had been a student of Prof F. J. M. Stratton, was asked to contribute an article for the commemorative volume on Prof. Stratton's 75th birthday. The paper appeared in the first twin volumes of *Vistas in Astronomy* and I got the privilege of signing on its inside cover.

I was aware that the small work in the *Vistas* cannot by itself form a Ph.D. thesis. So I requested my friend Dr A. S. Ramanathan to allow me to use his excellent spectra of sunspots for studying their curve of growth. The paper appeared under our joint authorship in *Astrophysical Journal*. However, I feel that the quality of the paper could have been improved considerably if I had had a proper training in the theory of stellar atmospheres.

By this time my appetite for astronomy had increased to such an extent that I wanted to go abroad for further study. I corresponded with three universities at Göttingen, Chicago—Prof. S. Chandrasekhar's University, and Berkeley. I got positive replies from Göttingen and Berkeley, but I decided to go to Berkeley due to my

familiarity with English and on account of an encouraging letter from Prof. Otto Struve who also recommended my name to Prof. F. J. M. Stratton for an IAU grant of \$ 500.00. The immediate financial problem was solved by a travel grant from the US Educational Foundation in India and a loan scholarship from Tata Endowment Trust of Bombay. Finally I set sail from Bombay by SS Stratheden in August 1954 and, after a five day stop-over in London, reached New York by SS Elizabeth and then on to Berkeley by train. I was surprised and quite happy on finding William Shane to receive me at the Berkeley railway station. And it was a pleasure to share the office in the Astronomy Department with him and George Presten for the next two years.

3. In Berkeley I was exposed to the whole vista of astronomy all at once, which dazzled me so much that I was not able to perceive the difference between older and immediate excitements. It has convinced me that one should have a formal training in astronomy as early as possible for becoming a good astronomer. I got systematic instruction in basic astrophysics and statistical astronomy from Prof. H. F. Weaver, theoretical astrophysics from Prof. L. G. Henyey, celestial mechanics and numerical methods from Prof. L. Cunningham, and astronomical spectroscopy from Prof. J. G. Phillipps. In addition I could attend the courses and seminars of visiting professors : R. Wildt on thermodynamics of radiation and planetary physics, W. C. McCrea on stellar evolution and cosmology, and V. Kourganoff on radiative transfer. But I could not take advantage of the course on radio astronomy by Prof. R. N. Bracewell as I was then staying at Lick Observatory. The weekly seminar on every Friday brought one up to date on current research.

I got training in spectroscopic observations from Dr W. P. Bidelman who initiated me into all the intricacies of making finding charts, pointing the telescope to the desired object, putting the Mills spectrograph on the 36-inch refractor, and the photographic procedures followed at the Observatory. He particularly impressed upon me the importance of the eye-ear-nose test before closing the dome. I think it was Dr Kron who showed me the use of the 20-inch Tauchmann telescope which I used extensively for observing AO Cas. All this experience helped me in deciding my thesis topic and it stood me in good stead after returning to India.

In my first year at Berkeley I was short of funds. I was able to support myself partly by staying in a cooperative house where every student had to put in five hours of work per week as part of the living expenses. I think it is a good way of instilling the dignity of labour which can be practised in our student hostels. I also worked for Prof. Struve who gave me remuneration for measuring his plates of Nu Eridani. This work later appeared in *Astrophysical Journal* under our joint authorship.

My problem was solved after the first semester examination in February 1955. The first was an oral examination given by Prof. Henyey on physical foundations of astrophysics. The order of the students was alphabetical, so I had to be the first. But it so happened that the others who followed me could not do as well as I had done, most probably on account of my background in physics; so the order of students was reversed in the second semester. Anyway this impressed Prof. Henyey and I was offered the Lick Observatory fellowship for 1955-56 which I was able to hold for another two years. Although I have narrated this incident which helped me in solving my financial problem it should be mentioned that most of my class fellows of that batch have proved to be better astronomers than myself.

At the end of the second year I had to decide about my line of research for Ph D. First I thought of choosing a theoretical topic, because a theoretician is considered superior in India. But after a little thought I deliberately decided to concentrate on observations, because I felt that the tradition of making astronomical observations is rather weak in India. I also argued that theoretical work can be done any time with paper and pencil. The choice of binary stars was of course made because of the attraction of working with Prof. Struve. It was also my desire to continue my work in India. So in addition to spectroscopy I got myself trained in UBV photometry of binary stars, because it was obvious that with the small and medium size telescopes that would be available in India this would be a fruitful field of study for some time to come. It so happened that I could not pursue it for nearly ten years after my return due to the delays in the 48-inch telescope project.

In the third year, I had an hectic schedule. I was taking a few courses at Berkeley and I used to get two full nights on the 36-inch refractor of Lick Observatory on Friday and Saturday every fortnight. After attending the 9-10 a.m. class of Prof. Henyey on stellar structure on Friday morning I used to take a bus from Berkeley to Oakland and then from Oakland to San Jose. At San Jose I had to catch the mailman who would drive up to Mount Hamilton with mail at about noon. If I missed him I took a bus up to the foot of the hill and hitchhiked from there to the top, this was possible because Friday used to be visitors' day at Lick Observatory. Immediately after arrival I proceeded to put the Mills spectrograph on the telescope and load the plates. After dinner at 5.30 p.m. the observing session would start at 6 p.m. and continue till 6 a.m. Then followed the routine of putting the standard marks and developing the plates. I would go to sleep for about 3 hours and get up for lunch. The preparation and observing schedule were repeated on Saturday. On Sunday, after lunch I would start my journey back to Berkeley by the mail van to San Jose and from there by bus to Oakland and Berkeley. It would be 8 or 9 p.m. when I arrived quite exhausted. Next day I would again be present for Prof. Henyey's class at 9 a.m., where I had to make special effort to keep awake during the whole hour. In spite of this strenuous schedule I enjoyed my observing sessions with the midnight lunch and western classical music on the radio put on the observing floor. In June 1957, I shifted to Mount Hamilton for a one-year stay at Lick Observatory.

I would like to recall one typical incident of this period. One night when I was reversing the telescope there was a noise like clanking of chains in the basement. After completing the reversal I went down the spiral staircase near the pier to check the cause of the noise. But I did not notice any mishap, so I returned to the observing floor and proceeded to continue my observations. Then I heard the laughter of David Williams and Charles Worley who entered from the side door. They told me that they were trying to test whether I would be scared by the ghost of James Lick who is known to be buried under the pier.

I appeared for the final viva voce examination on my thesis on early type binaries in October 1958 and received my degree at the next convocation in February 1959. I stayed one more year at Berkeley as Junior Astronomer when I observed with the 20-inch telescope of Leuchner Observatory and used the Berkeley computer for studying the stability of the straight line solutions in the restricted problem of three bodies. I consider my stay of five years at Berkeley as one of the most enjoyable and fruitful periods of my life. In addition to the stimulating academic atmosphere, company of good friends and

salubrious climate I had also the opportunity of seeing the Californian mountains and deserts on hiking trips with Bill Livingston and Roger Lynds.

1958-59, when I completed my Ph.D., was perhaps the best time to enter into an astronomical career in the USA because there was an increase in the flow of funds and expansion of opportunities on account of the accelerated space programme. The immigration authorities even offered to give me a green card. Prof. Struve was asking me to go and work with Prof. A. Sletteback at the North Western University. However, I had decided to return to India and work here to develop the long neglected astronomical culture. I had two offers: one from Kodaikanal Observatory and the other from Osmania University which had planned to acquire a new 48-inch telescope. I first took up the Kodaikanal offer because it was more attractive from a financial point of view. But I was soon disillusioned, because I was missing the academic atmosphere of a university to which I was accustomed at Berkeley. So I resigned and took a Reader's position at Osmania University in a lower scale of pay. I also got married soon thereafter.

4. I would like to divide my tenure at Osmania University into four periods, first of these covering the years 1960 to 1964. I joined the university in January 1960 and immediately plunged into two activities. One was the site survey for the location of the new 48-inch Fecker telescope and the other was the formulation of the syllabus for the M.Sc. course in astronomy which was the first of its kind in India.

The site survey covered an area of about 40 km radius around the city of Hyderabad. It was perhaps the first systematic survey for an astronomical site in the country. It involved observations of seeing, cloud cover, transparency and wind conditions. Although the methods used were rather elementary they gave the best site near the Rangapur village within the specified area. It is now known as the Japal-Rangapur Observatory. Together with Nizamiah Observatory and Astronomy Department it became part of the Centre of Advanced Study in Astronomy. (CASA) in 1966.

I have always enjoyed teaching, hence the starting of the M.Sc. course was a welcome challenge which I relished to the fullest extent. In my approach I have always emphasized on broad based training in all branches of astronomy instead of concentrating on one or two topics that are of interest to the teachers. Due to a shortage of staff in the beginning, at one time I was teaching as many as 36 hours per week. The notes prepared during teaching have helped me in writing a comprehensive text book in recent times.

I have experienced two very trying periods during my service at Osmania University. One was between 1961 and 1963 when there was no permanent Director for Nizamiah Observatory after the death of Dr Das in February 1961. I was asked to carry on an Incharge Director and Head of Astronomy Department without adequate recognition of my position and without authority to take any decisions. Every thing was being handled by remote control by outside persons who corresponded with the university authorities who in turn would send it to me for comments and drafting of replies. Thus I was only a go-between, more like a traffic policeman. Without going into details I would only say that it was the best example how an important project should not be run. Anyway I worked hard and did my best to push the 48-inch telescope project to the maximum extent. It involved final selection of the site, acquisition of land, laying of road and power line to the observatory site, preparation of the building plans etc., with the support of Prof. N. V. Subbarao, the Principal of Science College. When the Director, Prof. R. V.

Karandikar finally arrived in June 1963, I worked with him closely for three months and brought him up to date with all the developments before taking a well earned respite as a Post Doctoral Fellow at David Dunlap Observatory in October 1963.

I would like to narrate one episode from this period which made me bear all the inconveniences of the situation with some degree of confidence. Prof. S. Chandrasekhar visited Osmania University and Nizamiah Observatory in 1962. When he arrived in Hyderabad I got the impression that he was already briefed against me by someone. But when he visited Nizamiah Observatory I discussed with him my research problem which was an extension of his own earlier work on the Schuster problem for a moving atmosphere. And then, on his questioning, I explained to him what I had been doing for the Observatory under the prevailing circumstances and how I was eager to hand over the responsibility to the permanent director when he arrived. Later he visited the new Rangapur site and gave his opinion that it was as good a site as he had seen at other observatories. All this created a favourable impression on him and at the time of departure he expressed in a friendly way that he hoped he was not interfering in the affairs of the Observatory.

Another significant thing that occurred in this period was that I was called upon by Dr S. D. Sinhal to serve on the Advisory Committee of the U.P. State Observatory, Naini Tal. It brought me into contact with northern astronomers, thus making me acquainted with the problems of all the astronomers in the country. This proved to be a boon later while initiating the formation of the Astronomical Society of India. Plans for acquiring the one metre telescope of the U.P. State Observatory were also finalized at that time.

My stay of one year at David Dunlop Observatory was quite fruitful. In addition to making observations with the 74-inch telescope I was able to complete the work on moving stellar atmospheres which I had discussed with Prof. Chandrasekhar at Hyderabad. And he was delighted to publish it in the *Astrophysical Journal*. I was also able to contribute an article in the Struve memorial volume brought out by Prof. M. Hack. But the Canadian fellowship was meagre and my wife and I had to live there rather uncomfortably. So I was happy to return to Hyderabad in November 1969 and take up the Professorship offered to me by the Vice-chancellor Dr D. S. Reddy.

5. The second period of my tenure covers the years 1965 to 1973. After returning from Canada, I took the initiative in laying the north-south line on the site of the telescope. But soon I found that I was a persona non grata as far as Japal-Rangapur Observatory was concerned. So I concentrated on my teaching duties. There was very little that I could do by way of observations. Actually I had joined Osmania University due to the attraction of the 48-inch telescope. Prof. Struve always used to say that it is nice to work with a new telescope. But the installation of the 48-inch telescope was getting delayed year after year and there was frustration on that account. The last straw on the camel's back came in the form of a big theft in my University quarters in October 1966 when my wife lost all her jewellery and I had to resign to the loss of my two gold medals awarded by the Ajmer Board for getting the first rank in the high school and intermediate examinations. I was, therefore, keen to go abroad, this time to earn some money. So I applied and got the senior Post-Doctoral Resident Associateship of NASA at Jet Propulsion Laboratory in Pasadena, California which I joined in October 1967. On the way I attended the 13th IAU meeting at Prague, for the first time.

At JPL the main activity centred around the development of payloads for lunar and planetary missions. Fundamental research in astronomy was of peripheral importance. Also the whole atmosphere was quite different from that of a University or research institute. In spite of these drawbacks I was able to do enough work which enabled me to get an extension of my assignment up to March 1970. This work was mainly on the theory of scattering in inhomogeneous and imperfect Rayleigh scattering atmospheres done in collaboration with Dr A. Fymat. This line of research was later continued at CASA with my student R. K. Bhatia. During this period I got many pinpricks from the Registrar of Osmania University forcing me to vacate my quarters rather unceremoniously. I was so disgusted that I wanted to leave Osmania University and take up work at some other place. I applied to the IITs, Governments of Maharashtra and Madhya Pradesh and also to TIFR. Prof. M. G. K. Menon wrote to me that he was impressed by my work at JPL, but he would consider me for a post at TIFR only if otherwise I would stay abroad on a permanent basis. Anyway I returned to Osmania University in April 1970.

The 48-inch telescope was then installed, but it was not yet used for observations. So Prof. Sarma, Prof. Sanwal and myself started making regular trips. After alignment of the polar axis, photometric observations of binary stars were started in March 1971. However the dry spell of 1972 brought the work to a stand still for one year. But this lull was used to do the spade work for ushering in the Astronomical Society of India and also for preparing the NCST (National Council of Science and Technology) report on astronomy and astrophysics as convenor of the subcommittee appointed for that purpose. This report formed the basis for the development of astronomy at several places during the fifth plan, such as the 93-inch Vainu Bappu telescope of IIA and the millimetre wave telescope of RRI. I also got the opportunity to look after the organization of the symposium on spectroscopic studies of astrophysical interest in August 1972; this was the first conference which brought all astronomers of the country together.

6. The third period covers the years from 1973 to 1981. In 1973 Prof. Karandikar desired for relief from the responsibility of directorship and I was asked to take over as the director of observatory and head of the Astronomy Department. My first task was to put the 48-inch telescope in working order. In this task I got full cooperation from the scientific and technical staff including among others Sri S. Ishwar, the observatory engineer. We often camped at Rangapur for several days and saw to it that all the major defects of the telescope and the dome were rectified. In this way the total number of observing hours were doubled in 1973-74 season and tripled in 1974-75 season. Since then the telescope is being used on all clear nights resulting in three to four observational papers per year.

In the beginning we concentrated on photometric observations of binary stars which are being continued till today. On account of this dedicated use of the telescope we were able to obtain full UBV light curves of about three dozen stars which established the observatory as a centre for the study of eclipsing binary stars. Later, the Meinel spectrograph was also put to use. The rotation of the field by the third mirror of the Nasmyth arrangement was compensated by turning the whole spectrograph in its flange so as to align the slit in the east-west direction for trailing the star image. We did not try to put the Baker corrector system because it would have disturbed the ongoing

programmes. The Baker corrector was finally used during the apparition of Halley's comet in 1985-86 when it gave some good photographs of the comet.

Two conferences were held at CASA during this period. A seminar on 'Infrared and millimeter range astronomy' was held along with the first meeting of the Astronomical Society of India in February 1974. The proceedings of this seminar were consulted by Prof. D. Lal while initiating the programme of infrared astronomy at Physical Research Laboratory in Ahmedabad. The other was a round table discussion on training requirements of Astronomers held in December 1978. Its proceedings still form the standard reference on this subject.

In 1980 we had the opportunity of hosting a large delegation of U.S. astronomers at JRO for observing the total solar eclipse of 16 February 1980. It was perhaps the first time when the path of totality of a solar eclipse passed over an established observatory, and astronomers wanted to make the best use of the opportunity. It was at this time that we shifted the 8-inch astrograph of Nizamiah Observatory to JRO. It came very handy later for photographing Halley's comet in 1985-86.

During this period I was able to guide 4 Ph.D. and 4 M.Phil. students for their degrees. The topics of their research covered the fields of binary stars (by A. G. Kulkarni and T. Panchatsaram), line formation in planetary atmospheres (by R. K. Bhatia) and coronal observations during the total solar eclipse (by Anthony Raju).

In 1978 the UGC appointed a committee consisting of late Dr M. K. Vainu Bappu, Dr S. D. Sinvhal and Dr N. A. Narasimhan to look into the working of the Centre of Advanced Study in Astronomy. They recommended that Nizamiah and Japal-Rangapur Observatories be separated from the Astronomy Department and the Observatory be made an autonomous institute within the Osmania University with sufficient powers to the Director. But the University did not take this recommendation seriously. In fact they started a campaign to oust us from the Nizamiah Observatory premises. This was the second trying period in my university service, and I was happy when the university implemented its policy of rotation of Heads of Departments and asked me to hand over charge to the next incumbent in 1981.

7. This brings me to the fourth and last period of my service. Personally I feel that the principle of mechanical rotation of Heads of Departments has worked against the healthy growth of University departments. It is particularly unsuited for the Director of an observatory where continuity is essential as I found when I took over again as Director for the third time in 1986. In addition to this eventuality the CASA suffered after 1980, because the UGC stopped supporting it after 15 years according to its accepted policy. However, they later tried to rectify the situation by proposing to make the JRO a National Centre for Astronomy for all Indian Universities. It was during the Platinum Jubilee Celebrations of Nizamiah Observatory held in 1983 that Prof. Rais Ahmed, Vice-Chairman of the UGC announced their decision to form the National Centre. But several factors have made this goal almost an unachievable dream as far as the staff of CASA are concerned. So, at present they have to depend upon sanction of research projects by national funding agencies like ISRO, DST, CSIR etc. Such projects by its staff have enabled CASA to acquire a few peripheral facilities like a couple of computers, a photon counting system and an Echelle spectrograph. But the routine observational work is suffering in the absence of assured recurring financial support in one form or another. Anyway this is now a problem for the next Director to solve. I am glad to report that UGC has recently extended support to CASA for the next five years.



I retired in June 1988. Of the six research scholars who were working with me at that time two have already obtained their degrees and the remaining four are well under way. Their work mainly covers the fields of binary stars and stellar atmospheres, which is the title of the present workshop. I have also got myself interested in ancient Indian astronomy and I hope to write soon an essay on the evolution of Vedic calendars.

8. Epilogue: Looking back I am satisfied that I have worked continuously to the best of my ability for the advancement of astronomy in India. But I am unhappy that the culture of astronomy has not spread in the Indian university system to the desired extent. However, recent developments like establishment of IUCAA and GMRT, and the increased interest of senior astronomers in manpower training augers well for future development. As far as my future is concerned I hope to continue working in astronomy as long as I can and as long as I am allowed to do so.

I again thank you all for your kindness