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A window to the sk

Dr. J. C. Bhattacharyya, Director of the Indian Institute of Astrophysics, Bangalore, spe

ALTHOUGH scientists of the highest calibre have adorned the Indian scene, instrumentation work, in general, was neglected by our researchers. This occasioned the remark by the eminent astronomer Harlow Shapley that, while India has produced the most brilliant minds in astrophysics, her observational facilities are practically nil.

In astrophysics at least, the situation should change with the commissioning of the new 2.34 m. telescope at Kavalur in the next few weeks. Professor J. C. Bhattacharyya, Director of the Indian Institute of Astrophysics, Bangalore, discusses this new, powerful tool for researchers in an exclusive interview.

Dr. Bhattacharyya is also a co-discoverer of the rings of the planet Uranus, a major discovery for which a section of the western scientific community was unwilling to give credit.

The idea that other planets, like Saturn, could also have a ring system was not altogether new. In fact, scientists like Bibhas Dey of the Planetary Science Institute, Houston (US), had urged the need for searching for ring systems around the outer planets, but their views were brushed aside by other scientists who claimed, on a priori *grounds, that other planets* **could not** *have ring systems.*

They were proved wrong on the night of March 10-11, 1977, when Uranus occulted a rather faint star, SAO 158687. An occultation is an obscuration of one heavenly body by another, a rather rare astronomical event, like a total solar eclipse, which while lasting only a few moments, yields more information than years of observation.

India was considered to be the best location for the observation of that particular occultation. Dr. Bhattachayya's team planned the observation from the 40-inch telescope at Kavalur.

The closest approach of Uranus to the star was expected at 21 hours Universal Time (02.30 IST). The team centered Uranus on the diaphragm of the telescope at 01.00 hours and started continuous recording by 01.30 hours. This was a rather early start, but it was expected that the occultation would be a very shallow one, and for detection of the "dip" in the photoelectrical recording, the performance and stability of the whole recording system should be well determined.

The trace of the record was level, with the usual "noise" (due to extraneous sources) superimposed on it. After about 20 minutes of recording, a young man, Kuppuswamy, noticed the recorder pen dip to a new position. Looking through the eight-inch guide telescope, Dr. Bhattacharyya saw the disc of Uranus, but the star had disappeared. It was missing for nine seconds of time, after which it reappeared suddenly. Visually, this was the only event detected, and indeed it was the only visual observation of the phenomenon anywhere in the world. But, on the photoelectric record, several other sharp drops or "spikes" appeared, which could not have been seen visually. After considering all possibilities, right from a hovering bird to a stray asteroid, the only logical explanation was that one of the known satellites of Uranus had come between the star and the telescope's field.

Soon after sunrise, the Kavalur team drove to Bangalore, where they, along with Dr. M. K. Vainu Bappu, the institute's then director, examined the strip-chart. They confirmed that there was a shallow dip in the photoelectric record just when Uranus and the star were closest, and that the nine-second occultation could not have been due to any of the known satellites of Uranus. However, it could be due to a hitherto unknown satellite of Uranus. A telegram was sent to the Central Bureau of the International Astronomical Union at Boston on the evening of March 11, announcing the finding.

Even as the Kavalur team was observing the occultation, a Cornell University (US) team led by Dr. Elliot was taking observations from a NASA airborne observatory flying over the southern Indian Ocean at 40,000 feet so that they would be unhindered by clouds. They observed the occultation and attributed the sharp dip in the recording to "small occulting bodies, possibly in orbit around Uranus". A third team, from Lowell Observatory (US), led by Dr. Robert Millis, observed the occultation from Perth in Australia. Millis observed the sudden diminution in starlight and stopped his recording for a minute or so for checking; he thus missed two minor events which followed.

A few days later, when Elliot examined reports of the three records, he saw that the times of the pre-occultation and post-occultation events were mirror images of each other. He drew the logical conclusion that the large and small features in the record are due to numerous occulting bodies, all orbiting round the planet in narrow, concentric belts. In other words, there is a ring system round Uranus.

Scientists at the Indian Institute of Astrophysics, however, felt that the shallow dip in their records of the occultation called for a further explanation. The zone causing the light extinction was at least 5,000 miles from the planet's surface and even a giant planet like Uranus could not have such a vast atmosphere. A detailed analysis of the light curve later indicated 19 additional rings, besides the five rings found earlier.

Excerpts from the interview:

Could you say something about the genesis of the 2.34 m. telescope?

In 1945 the Committee for Post-war Development in Astronomy, set up by the Government of India and headed by the late Professor M. N. Saha, recommended, among other things, the acquisition of a 100-inch size telescope, for the country. Later it was found that a 100-inch telescope would be very expensive.

In 1950 or so, a 100-inch telescope would have cost about a crore of rupees. That much money was not to be found, and the government wanted mainly to fund projects which would bring immediate results.

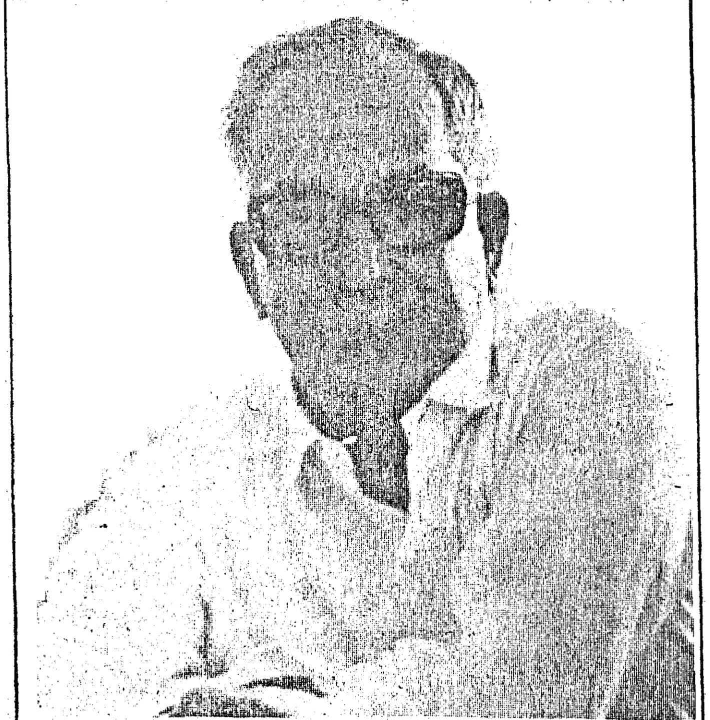
Later, Dr. Bappu felt we should go in for a 100-inch, without which our country would not be able to take a leading role in science. The cost could easily have been Rs. 4-5 crore. The governing body of this institute felt that we could go in for it only if it could be totally manufactured here. Ultimately a Canadian firm teamed up with the Tatas as Tatas-Dilworth-Secord-Meagher and Associates and offered to help in designing and fabricating the telescope in the country.

The telescope is a 122-tonne moving mechanism which has to be moved with better precision than clockwork. In one second of time stars move 15 seconds of arc, owing to the Earth's rotation. The pointing accuracy of the telescope has to be better than one second of arc. An absolutely detailed design of the mount was required, with every screw and bolt specified. For, at different positions there would be different flexures due to the weight of the whole thing. To rule out the resultant errors, which would hamper the accuracy of operation the flexures would have to be compensated, partly by mechanical design and partly, as in modern telescopes, by computer feedback.

Preliminary work was started in 1977 and the mechanical mount work taken up in late 1979 or early 1980. By July 1984 the mount was fully fabricated at Walchandnagar. After that, the whole thing was dismantled and taken to Kavalur, where it is being installed.

The giant horseshoe has been reassembled, the yoke and moving parts and mirror have been installed. The electrical drive system, the consoles and the controls are being installed. So the telescope as such is in the final stage of completion. The testing will take another three months and we will be able to take photographs by the middle of this year.

A new type of solid state detector array has come into use in astronomy. These CCD (charge-coupled devices) arrays when operated by powerful computer system can produce much deeper and sharper images. We have also developed software so that the new images wil



Dr. J. C. Bhattacharyya: reaching for new horizons y

ks to Pravin Kumar

bring out a much deeper picture than normally available.

To what distance can it see?

As far as any other telescope, depending upon the background. When the background becomes brighter than the telescope's detention limit, you can't see much however big the telescope may be. One way of eliminating the interfering background, which is a composite of manmade scattered light, natural air-glow and faint diffuse cosmic background, is to go out into space. Another way of observing from the ground is to use photoelectric detection instead of photography; we can thus scan the image, making the necessary subtraction by computer to get a clear image. This is what we are going to do.

Why was this particular design selected?

Any design is a compromise. We chose basically the Mount Palomar 200-inch telescope design. There are differences: there the latitude is 32° N, we are at 12-1/2° N and thus our polar axis is more horizontal. The design was chosen taking into account the precision of manufacture and the observational convenience at this particular latitude.

Why was Kavalur chosen?

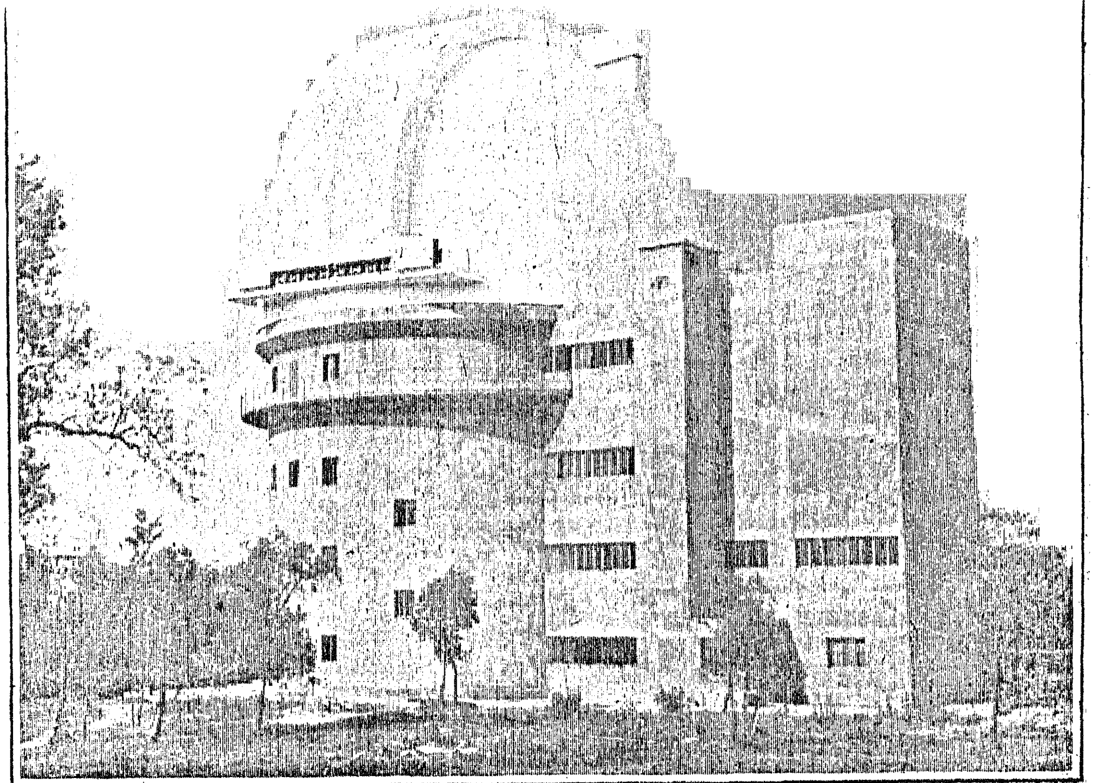
Kavalur was chosen by a site survey team in 1962. In the late 40 s, for historical and sentimental reasons it was felt that the observatory should be at Ujjain. But the team sent out by Kodaikanal Observatory to study the observing conditions found that in that region there is too much dust, which could cause too many operational problems for a modern telescope. Dr. Bappu, too, pointed out that current astronomical research is concentrated in the southern skies – the centre of the Milky Way (that is, our galaxy), the Magellanic Clouds, etc which cannot be accessed from central and northern India. You have to be as close to the equator as possible. The survey, which was done right from Cape Comorin upwards, found that Kavalur has perhaps the best observing conditions.

What would be the total expenditure?

A rough estimate would be Rs. 6 crore, which includes about Rs. 80 lakh for the computer; the cost of the building and ancillary facilities which had to be created. Big telescopes are extremely expensive to run, which is why people share the expenses. Rather than struggle with bad weather, it is better to place the telescope in a good location: You can thus get more observations for the same money.

What are the problems of constructing astronomical telescopes?

They are among the most sophisticated scientific instruments.



The new telescope at Kavalur: boon for astronomists

Even the slightest vibration or the smallest speck of dust on the bearing surface can affect the pointing accuracy. Thus, if the telescope is pointing towards one of a pair of nearby stars, a small speck of dust can cause it to jump from one star to the other. The mirror is described as "a 2.34 metre mirror with an accuracy of (lambda)/20"

What is the weight of the mirror?

It was five tonnes, to begin with. But after the central hole was cut out and considerable material scooped out, it has become about four tonnes. All sorts of modern techniques have been employed. For instance, the whole telescope floats on a film of oil pumped by a hydraulic system (this has been imported from Germany). Ball or roller bearings could not be used, because even a slight difference in the ball bearings will affect the pointing accuracy. The control is by a computer system. You can't use gear for scaling the movements, because there will be a backlash and errors will come in, so we had to use a specially made optical shaft encoder. This has a photographic glass plate inside with a system of very thin marks. Each mark represents an accuracy of one second of arc. That information is read off and there is computer feedback, which very precisely controls the movements of the telescope.

What is the program for the new telescope?

Immediately – deep sky photography, for testing how deep the telescope can go. In textbooks, instead of having photographs with credit lines reading "Courtesy: Mount Palomar and Mount Wilson Observatories", we can have Indian photographs. During this phase we will be doing finer adjustments for optimum operation. Then we will have programmes of scientific observation from faint solar system objects to the faraway external galaxies.

In your opinion, will there be excellent conditions for observing Halley's comet?

Yes, because comet Halley will be coming in March, when observing conditions are very good. According to present indications the best observing conditions will be at Mauna Kea (Hawaii), which is at an altitude of 15,000 feet. Next comes Chile, where there are three large telescopes at La Silla and Cerro Tololo. La Silla has the telescope of the European Southern Observatory (ESO) and at Cerro Tololo the Americans have set up a similar four-metre telescope.

The higher you go, the better, because the moisture content in the atmosphere is low and infra-red observations are possible. From last year we have established a 20-inch telescope at Leh, for trial purposes. However, though the moisture is low there, its latitude (33°N) is a limitation.

What are the theories regarding the origin of the solar system?

That's a difficult question. There are several theories. My own feeling is that what we are seeing is not the original solar system or the first generation solar system. It might have got disrupted more than once. The proof is in the asteroids (the minor bodies in the solar system). An asteroid is not solid in structure. In cross-section it appears to be a sort of conglomeration of different pieces, as if it had been forced together into a solid body, then broken up and again solidified by coalescence.

The estimated age of the solar system (4.5 billion years) is probably correct, but it requires only 10-30 million years for the system to grow and get disrupted again.

What is your opinion about the status of astronomical studies in India? Are there any constraints?

Harlow Shapley, the eminent astronomer, once said: "India is a paradox. She has produced the most brilliant astrophysicists, like Saha and Professor Chandrasekhar, but its observational facility is practically nil." The largest telescopes at that time (1947) were the 15-inch at Nizam's University and the 20-inch at Kodaikanal, which was then not fully operational. Things have changed a lot since then. There are three telescopes – two 40-inch ones, at Kavalur and Nainital, and a 48-inch at Rangapur, near Hyderabad. The new 93-inch at Kavalur is going to be a powerful tool for researchers. For infra-red studies a new 48-inch telescope is coming up at Mount Abu. In the radio domain, there is the radio-telescope at Ootacamund – a really substantial Indian achievement. The Raman Research Institute, Bangalore, has installed a millimetre wavelength radio-telescope. The Giant Metre Wavelength Radio-telescope, which the Indian scientific community is planning to build, will give Indian astronomical research a powerful boost.