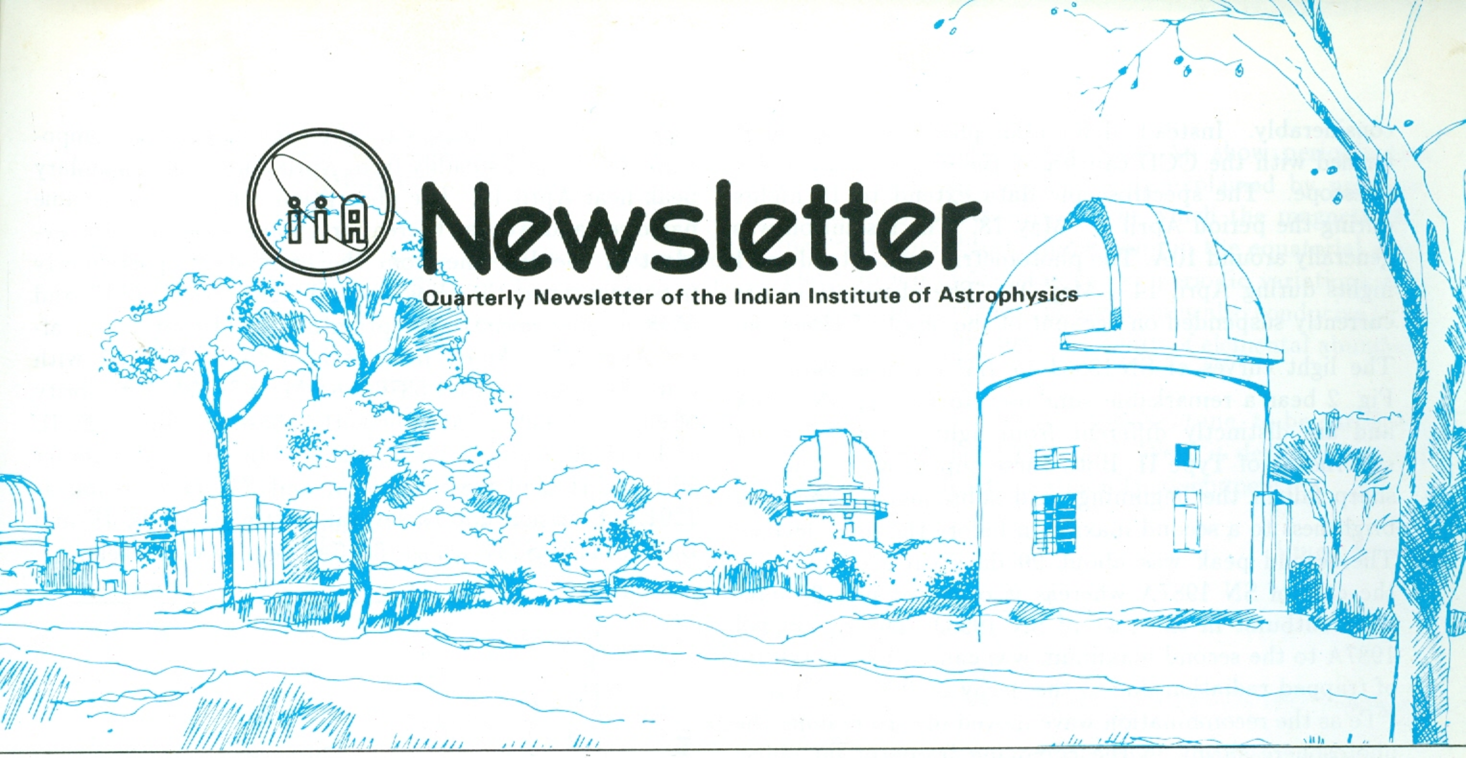

Newsletter

Quarterly Newsletter of the Indian Institute of Astrophysics

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Supernova 1993J in M 81

Fig. 1. Colour picture of SN 1993J produced by combining BVR images of the region obtained at the prime focus of the 2.3m VBT on 1993 April 15. North is at left and east to the top. The brightest star is SN 1993J with a 14th magnitude foreground star to its southeast.

At least once in each decade a supernova explodes at a distance near enough for us to follow the outburst in some detail. Each such event brings out something unexpected. While shaking up our belief that the supernovae can be classified into a small number of types with well-behaved members, such detailed observations help us in improving our knowledge on the phenomenon underlying the explosion. This knowledge may eventually help us in reducing the parameters related to the outburst to a small number.

Six years after the outburst of supernova 1987A in the Large Magellanic Cloud, an opportunity of observing another supernova in some detail arose with the discovery of SN 1993J in the nearby spiral galaxy M 81 (NGC 3031) on 1993 March 28 by an amateur astronomer from Spain, F. García (1993: IAU Circular No. 5731). SN 1991T, 1991AA and 1992A observed in lesser detail from VBO in the intervening period were all of Type I (T. P. Prabhu & G. C. Anupama 1991: IIA Newsletter 6, 17). The brightest of these, SN 1991T, did not show the characteristic absorption at 6150 Å before maximum. SN 1993J started off as Type II, but there are indications that it may turn into a Type Ib soon and may hence be classified as Type IIb (K. Nomoto et al. 1993, preprint). Though it is considerably fainter than SN 1987A, relatively more favourable location (32° above horizon compared to < 10° for the latter), and availability of CCD detectors during the intervening years, made the observations considerably exciting.

CCD spectra were recorded whenever UAG spectrograph was scheduled on 1-m reflector. Some observations were made with the Boller & Chivens Spectrograph on the 2.3-m Vainu Bappu Telescope during the early days, but were discontinued since wide slit spectrophotometry was not yet possible and also since some misalignment was noticed in the spectrograph which reduced the efficiency considerably. Instead, differential photometry was performed with the CCD camera at the prime focus of this telescope. The spectroscopic data extend to 16 nights during the period April 1 - May 18. The resolution was generally around 10Å. The photometric data extend to 11 nights during April 14 - May 23. The observations are currently suspended on account of the onset of Monsoon.

The light curves of SN 1993J in *BVR* bands shown in Fig. 2 bear a remarkable similarity to that of SN 1987A and are distinctly different from light curves of other supernovae of Type II. Both these supernovae showed a sharp fall in the beginning, and subsequent increase in brightness to a second maximum before the final decline. The second peak was about 90 days since outburst in the case of SN 1987A whereas it occurred just 25 days after outburst in the case of SN 1993J. The rise of SN 1987A to the second maximum was caused by the release of trapped radiation due to the decay of ^{56}Ni $\rightarrow$ ^{56}Co $\rightarrow$ ^{56}Fe as the recombination wave moved inward making the photosphere shrink in the comoving frame of reference; the same scenario is likely to hold good for SN 1993J. On the other hand, the absolute magnitude of the secondary peak of SN 1993J was $M_B = -16.3$, which is about 2 magnitudes brighter than that of SN 1987A and compares well with the primary peak of typical Type II events. SN 1993J was thus not underluminous compared to typical Type II supernovae.

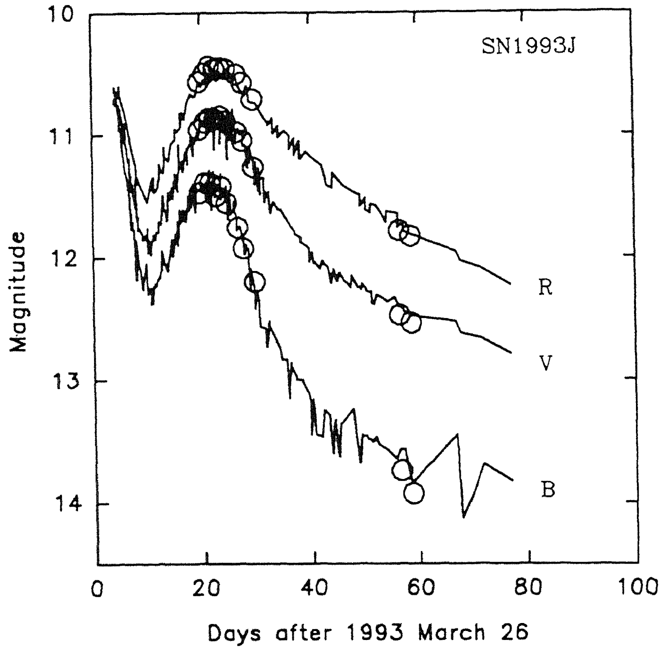


Fig. 2. *BVR* light curves of SN 1993J. The photometric data available in the IAU Circulars and e-mail network are shown by continuous line. The VBT observations are marked by open circles.

SN 1993J resembled type II supernovae spectroscopically. Unlike the well-studied type II supernovae, the Balmer lines in SN 1993J became sharply double-peaked a few weeks after maximum. Some ofthe spectra are shown in Fig. 3. Emission lines with P-Cygni absorption components brightened steadily from April 3 until the secondary peak near April 18. The absorption components became narrower and weaker thereafter. Some structure was evident in the Hα line from the early days; particularly persistent were the dips around 6283, 6477, 6517 and 6548 Å. The central absorption deepened continously after April 18. Apart from Balmer lines, Na I D with contribution from He I 5876, and Mg I 5876Å, a majority of emission lines during the early phase are due to Fe II. O I 7774Å appears during the middle of May together with Ca II triplet 8498-8662Å, and [Ca II] emission at 7291Å. Emission due to several multiplets of [Fe II] and Ba II 6141Å, Sc II 6245Å, 6310Å are also very likely.

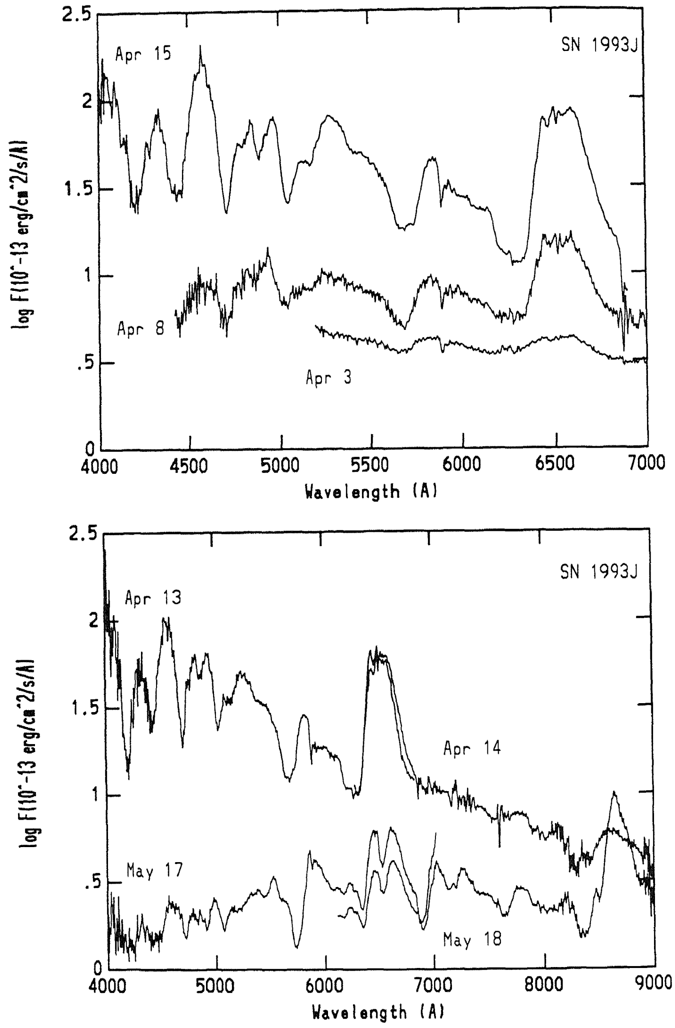


Fig. 3. The evolution of the spectrum of SN 1993J between April 3 and May 18.

The expansion velocities measured from the dips of P-Cygni absorption components are plotted in Fig. 4. The Hα line shows higher velocities since it is formed in the outer layers of the ejecta where the velocities are higher. The lines due to Fe II originate near the photosphere and hence give more reliable photospheric velocities. Hβ, Hγ

and He I 5876Å line fall in between. The sharp drop in the velocities of He I line indicate that it has become weaker than Na I D after day 25. We have assumed the line to be due to Na I D after this date. However, it would appear that the feature is a blend of both these lines with Na I D increasing in relative strength continuously.

A blackbody fit to the observed continuum can be used to derive the total continuum luminosity, the effective temperature and angular radius of the photosphere. The fits show that the bolometric luminosity rose from 0.7×10^{42} erg s^{-1} near the minimum in the light curve on April 3 to 2×10^{42} erg s^{-1} at the secondary peak at April 18 and declined again to 0.7×10^{42} erg s^{-1} by May 18, assuming a distance of 3.55 Mpc to the supernova and no interstellar absorption. The effective temperature declined very slowly from 6500 K to 6200 K until the secondary maximum and fell sharply to a nearly constant value of 3700 K in May. The photospheric radius increased from 0.7×10^{-10} radian to $\sim 2 \times 10^{-10}$ radian between April 3 and May 18 (see also A. Ray, K. P. Singh & F. K. Sutaria 1993, JAA 14, in press).

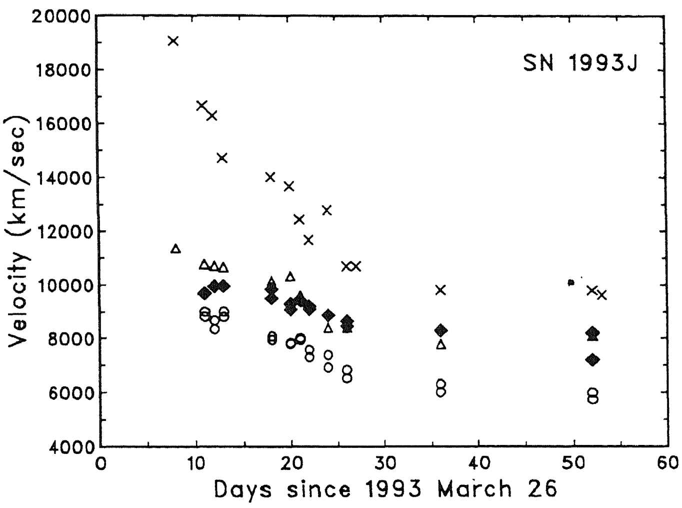


Fig. 4. The evolution of expansion velocities inferred from the P-Cygni dips of lines, Hα (crosses), Hβ and Hγ (filled triangles), He I 5876Å and Na I D (open triangles), and Fe II 5018Å, Fe II + Mg I 5176Å (open circles).

The absorption velocity gives a direct estimate of the rate of change of photospheric radius in absolute units. When compared with the rate of change of photospheric angular radius estimated from blackbody fits, and using the Baade–Wesselink method, the distance to the supernova can be estimated. The distance to M 81 is known fairly accurately and hence the application of the method will be useful in increasing our confidence in the technique. Counting days from March 26, the probable date of explosion, the observed velocities (in km s^{-1}) between days 11 and 26 can be approximated by a polynomial

$$V_{exp}(t_d) = 9319 + 18.43 t_d - 4.668 t_d^2.$$

The angular radius of the photosphere should then vary as

$$\theta = \theta_0 + D^{-1} \int V_{exp}(t) \mathrm{d}t.$$

A least-squares fit to $\theta(t_d)$ and $\int V(t)\mathrm{d}t$ is shown in Fig. 5. The distance derived from the slope in Fig. 5 is 3.6 ± 0.6 Mpc where the error is largely due to errors in spectrophotometry.

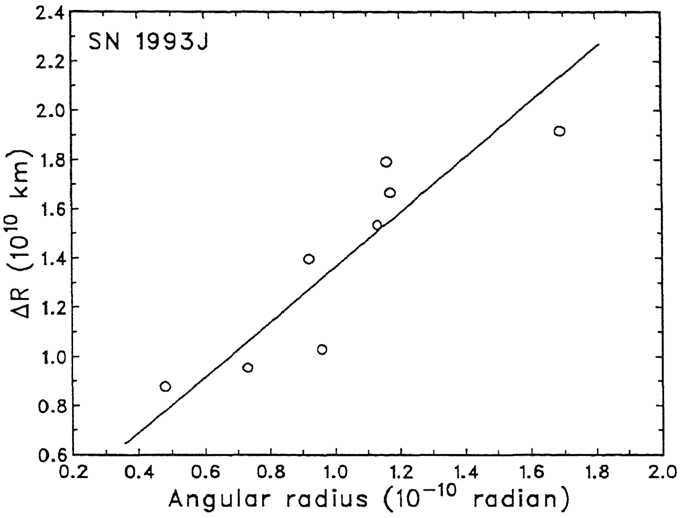


Fig. 5. The relative increase in the radius of the photosphere inferred from expansion velocities (see text), plotted against the angular radius derived from blackbody fits to the continuum. The straight line representing the least-square bisector indicates a distance of 3.6 Mpc to the supernova.

The observations at VBO had to be terminated due to bad weather while the more fortunate will contine to watch the event with great interest.

Several observers obtained the observations reported here, and/or contributed a part of the observing time at 1-m and 2.3-m telescopes at VBO: K. K. Ghosh, S. K. Jain, R. Krishnamurthy, Y. D. Mayya, M. V. Mekkaden, G. Pande, A. K. Pati, M. Parthasarathy, T. P. Prabhu, N. K. Rao, A. V. Raveendran, B. E. Reddy, R. Sagar, A. Subramaniam, R. Surendiranath, and also K. P. Singh (TIFR), Gopal-Krishna (NCRA), G. C. Anupama and A. K. Kembhavi (IUCAA). All the night assistants at both these telescopes provided considerable help, and at times made the observations by themselves.

T. P. Prabhu

Photometric Observations of the Cataclysmic Variable PG 1012-029

PG 1012-029 is a high excitation, eclipsing cataclysmic variable (CV). It belongs to the group of 22 new CVs discovered by the Palomar Green survey (Green et al. 1982: PASP 94, 560) because of their large UV excess. CVs are binaries consisting of a white dwarf primary and a cool Roche-lobe filling secondary. Gas flows from the secondary at the inner Lagrangian point and forms an accretion disc around the primary. The two major components of luminosity present in the disc are the body of the disc, where energy is liberated by gas falling into the gravitational potential of the white dwarf and a 'hot spot' formed where the transferred mass impacts the disc and gives up some of its kinetic energy as heat. The inhomogeneous stream of transferred material that impacts the outer edge of the accretion disc at the hot spot results in stochastic flickerings observed in the light curves of CVs. Because the optical and ultraviolet luminosities of these systems are typically dominated by the accretion disc component, eclipse of the accretion disc by the companion star provides a measure of the disc size and spatial structure, the gas flow dynamics and an estimate of the mass of the white dwarf primary in the system. Eclipsing systems also provide a probe of the origin and physical location of the stochastic light variations in the system.

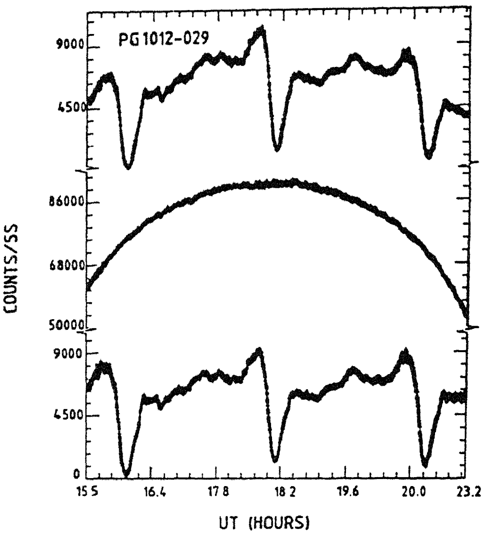


Fig. 1. Light curve of PG 1012-029 on 1992 February 18.

PG 1012-029 was observed on 1992 February 18 using the Vainu Bappu Telescope at Kavalur. The star was observed with the ISRO two star photometer attached to the Cassegrain focus and a PC-based data acquisition system. Measurements were made in white light with 5s integration. The light curve obtained during a long and continuous run lasting 7.7 hours is shown in Fig. 1. The top panel shows the sky subtracted but uncorrected light curve of PG 1012-029. The middle panel shows the light curve of a nearby field star observed in the second channel. The steady second channel indicates clear sky conditions; the smooth variation in the light curve is due to atmospheric extinction. The bottom panel shows the extinction corrected light curve (i.e., the ratio of the top two light curves) of the programme star.

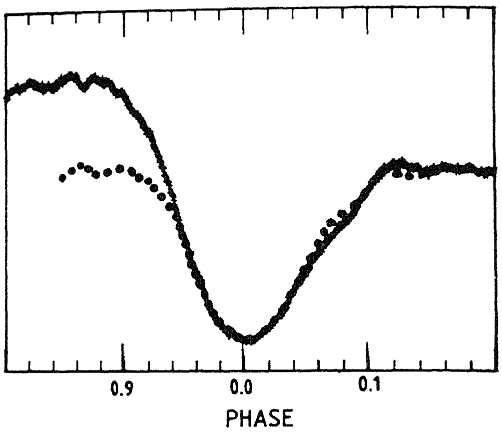
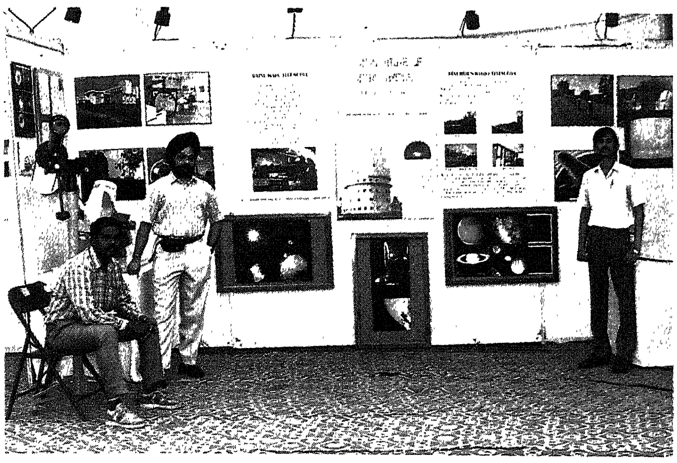


Fig. 2. Comparison of averaged eclipse light curves of PG 1012-029. The continuous curve represents the mean of the three eclipses of our data. Dots represent the mean eclipse light curve from Penning et al. 1984. Y axis is in arbitrary units.

PG 1012-029 undergoes eclipses once every 3h 14m 59s with an eclipse depth of 1.9 magnitudes. The present eclipse light curves show a prominent pre-eclipse hump compared to the earlier published eclipse light curves as shown in Fig. 2. Pre-eclipse hump arises as a geometrical effect due to the hot spot leading the line of centres of the two stars before the eclipse minima. This hump was not clearly visible in the earlier observations (Penning et al. 1984: ApJ 276, 233). Therefore the hot spot in this system may be unstable. Our light curve also shows large flickers with amplitudes larger than 15 per cent and lasting for about 30 minutes. Flickerings seen all along the light curve and even during the eclipse indicate that they originate both in the accretion disc and the hotspot. The orbital period derived by us by combining our data with those available in the literature did not show any significant change over eight years. The data outside the eclipse were subjected to a discrete Fourier transform analysis to search for the presence of coherent short periods in the system. No persistent periodic signals were found in the power spectrum. Therefore all the short duration light variations in the system are due to flickerings which are stochastic in nature. Preliminary results of our analysis were presented at the eighth European workshop on white dwarf stars held at Leicester, UK during July 20–25, 1992.

B. N. Ashoka, S. Seetha, T. M. K Marar
& J. C. Bhattacharyya



The institute praticipated in the science and technology exhibition of the Department of Science & Technology at Panaji, concurring with the 80th session of the Indian Science Congress at National Institute of Oceanography, Dona Paola, Goa, 1993 January 2–3.

* * *

Jagdev Singh has been nominated as the Indian representative on the permanent working group on solar, terrestrial and astrophysical research of the Scientific Committee on Antarctic Research (SCAR). He has also been appointed a member of the working group on eclipses, International Astronomical Union.

* * *

The governing council of the institute was reconstituted for a period of three years effective 1992 October 22. Prof. B. V. Sreekantan of TIFR and currently the Srinivasa Ramanujan Professor of INSA is the new chairman of the governing council.

* * *

The institute had several distinguished visitors. Foremost among them was Professor S. Chandrasekhar, Nobel Laureate, of the University of Chicago, USA, who visited the institute on 1993 January 11 and gave a talk on 'Nonradial oscillations of stars as a problem in the scattering of gravitational waves'.

* * *

The executive committee of the International Astronomical Union (IAU) met in Bangalore at the Raman Research Institute in September 1992. Members of the EC visited IIA, Bangalore and the Vainu Bappu Observatory, Kavalur on 12 September 1992.

* * *

The Institute has signed a Memorandum of Understanding for mutual collaborative research in astronomy and astrophysics with the Uttar Pradesh State Observatory, Naini Tal and also with Osmania University, Hyderabad.

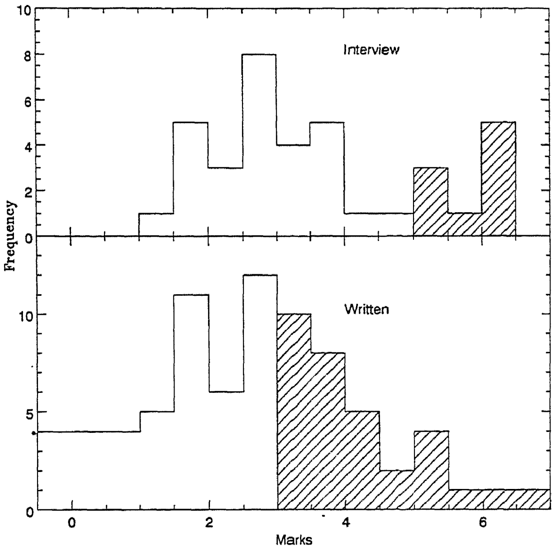
* * *

Specular polishing of a set of panels for the VHRR Cooler of the satellite INSAT II A was completed in the Photonics Laboratories. Another set of six panels for the INSAT II B spacecraft was completed and handed over to ISRO by Professor B. V. Sreekantan in a simple ceremony on 22 March 1993.

The research fellowship programme

All the research fellows of 1992–93 batch have completed the course work of the Joint Astronomy Programme as well as a short-term project. In addition, they have also attended 23 special seminars given by the academic staff of IIA on topics of their research interest.

Histogram of marks obtained (out of ten) in written and interview.



The advertisements for the 1993–94 research fellowship programme were sent out in March 1993. A total of 410 applications were received and 164 were called — based on their academic record — for a written test. Seventy-eight of these appeared for the test held on June 20. The top 37 candidates from these (shaded area in the lower panel of figure) were called for interviews conducted by two committees during June 21–24. Eight outstanding candidates (shaded area in the top panel of figure) have been offered the Junior Research Fellowship.

IIA Bicentennial Lecture

The seventh IIA bicentennial lecture on 'Studies of Cataract and Transparency of the lens' was delivered on 22 January 1993 by Prof. D. Balasubrahmanian, Centre for Cellular and Molecular Biology, Hyderabad.

The eye lens does not metabolize. In this sense, this is the true measure of age of an individual. Until the early stages of childhood, the lens is perfectly transparent and, hence, enables a child to 'see' in the ultraviolet region of the spectrum which an adult eye cannot respond to. This is due to accumulation of non-soluble molecules in the adult eyes which act as scattering centres and lead to incidence of cataract in old age, pointed out Prof. Balasubramanian.

There are about 50 million blind people in the world, half of them estimated to be in the Third World countries; and cataract is the major source of blindness. Cataract is not a disease per se but a manifestation of the process of ageing which results in the loss of transparency of the lens. There is, presently, no cure of cataract except for the surgical methods whereby the opaque lens is removed and replaced with a clean glass-ball or, in more expensive operations, by a lens.

Prof. Balasubramanian elaborated on the extensive work done by his colleagues and himself over the past several years which has led to an understanding of the chemistry of formation and deposition of non-soluble materials in the eye-lens. Apart from biochemical reasons, factors such as geographical, dietary and living conditions influence cataracterization. For example, higher level of sunlight is found to be associated with higher rate of incidence of cataract. tropical climate is worse than temperate as far as cataract is concerned. A study conducted in the laboratories of Prof. Balasubramanian, of eye-lenses collected from different parts where UV-A/B* radiation intensity varies, shows that UV-B radiation is primarily responsible for the damage. An undernourished diet leads to increase in the production of insolubles whereas elements like Zn and Cu, vitamins like B, C and E, and nutrients like carotene (found, e.g., in yellowish carrots) help to prevent the incidence of cataract. Higher intake of calcium however, increases the risk factor.

Studies show there is a connection between smoke, smoking and cataract. In case of smoking, systemic absorption mode is more likely than topical incidence mode. Continuous exposure to, for example, firewood smoke also leads to damage of the lens, and the damage is enhanced in ambient visible light.

What steps should one take to delay the onset of cataract? Avoid staying in bright sunlight for long without protective sun-glasses, increase the intake of green leafy vegetables, like spinach, and ripe yellow vegetables and fruits, like carrots, papaya and mango in the diet and of course abstain from smoking, recommends Prof. Balasubramanian.

Earlier, the lecture series was introduced by Prof. Rajesh Kochhar. Prof. Ramanath Cowsik, Director, welcomed the chief guest and proposed the vote of thanks.

S.K. Jain

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*Clinical biologists define two bands in the Ultraviolet (UV) region, namely UV-A and UV-B, which extend from 320-380 nm and 280-320 nm, respectively. The action spectra for DNA show a peak at 297 nm and hence the importance of UV-B in assessing its harmful effects.

Utilization of VBT Time

Observing time for the 2.34-m Vainu Bappu Telescope was over-subscribed by a factor of three during January – June 1993. Thirty-three scientific proposals were allotted observing time. The telescope was used for observations on 79 nights in the Prime-focus mode and on 85 nights in the Cassegrain mode. The remaining 17 nights were used for telescope maintenance.

In addition to the national observers, two groups from abroad — one from USA and the other from Korea — used the telescope. The prime focus was used primarily for CCD imaging while the following instruments were used at the Cassegrain focus.

Instrument	total nights	% of time
B & C Spetrograph	53	62
PRL Polarimeter	11	13
PRL Imaging FPS	8	9
RRI RS Interferometer	5	6
ISRO 2-star photometer	4	5
PRL IR photometer	4	5

The telescope will be down for maintenance during 1993 August 21 – September 30.

The deadlines for receiving proposals for the allotment of observing time on the 2.34-m Vainu Bappu Telescope are:

Deadline	**Quarter**
15 August 1993	**October – December 1993**
15 November 1993	**January – March 1994**
15 February 1994	**April – June 1994**
15 May 1994	**July – September 1994**

Unearthing of the Magnetic Field of Uranus and Neptune

Uranus and Neptune are poles apart from the planets Mercury, Earth, Jupiter and Saturn. The geometric poles of Uranus and Neptune lie in the equatorial plane of the other planets. This peculiar position can result if these planets suffered an off-centre collision with something of their own size during the advanced stages of their formation.

Measurements of the magnetic fields of the inner planets reveal a near alignment of their magnetic and rotation axes. This is in conformity with the dynamos that are believed to be operating in the planetary cores. In the construction of a dynamo model, one needs to identify a mean and a residual part of the velocity and magnetic fields. The behaviour of the mean magnetic field is then investigated for a prescribed mean flow combined with an averaged effect of the complex residual fields. Planetary magnetic fields can be accounted for by the so called nearly symmetric dynamo where the mean fields are those parts of the total field which are symmetric with respect to a given axis. The axisymmetric motion consisting of differential rotation and the meridional circulation together with some non-axisymmetric motion provide for the magnetic field of the planets.

But this was before Voyager 2 set its eyes on Uranus and Neptune. The magnetic axes of these planets are observed to be inclined respectively at 60° and 50° to their rotation axes. This brought navigational surprises. Voyager 2, which had planned to cross the zones associated with the magnetic polar regions found itself in the distended magnetosphere of Neptune. This makes Neptune three times unique because no other planet including the earth has been wooed this way. The large inclination of the axes, in addition, is accompanied by its off-centre displacement by a third of the planetary radius. Before the Neptune encounter, the inclination of the magnetic axis of Uranus was ascribed either to the accident of birth (remember the collision) or to the habitual reversal of the planetary magnetic fields. Catching two planets midway the reversal seems improbable, though not impossible. The inclined and the off-centre dipole fields are also characteristic of stars, where subsurface convection zone is believed to be the seat of the dynamo instead of the core as envisaged in the conventional planetary dynamo models. A class of dynamos that can operate in a highly turbulent convection zone survive on statistically averaged flows which need not be axisymmetric. Thus small-scale fluctuating and non-mirror- symmetric fields can arrange to maintain a mean magnetic field. The turbulent nature of the convection zone could also accomodate regions of extremely inhomogeneous electrical conductivity, leading to the formation of filamentary field. Measurements of magnetic fields of stars of spectral type Ap show periodic temporal variations. This is being explained by proposing a non-axisymmetric rotator in which the magnetic field may correspond to a dipole lying in the equatorial plane. The rotation of the star causes periodic variations in its magnetic field. This configuration is also conducive to the existence and the time variability of elemental abundance anomalies.

Is the odd couple, Uranus and Neptune, to be enrolled in the class of oblique rotators? Well, it depends how well they do in their time variability assignment.

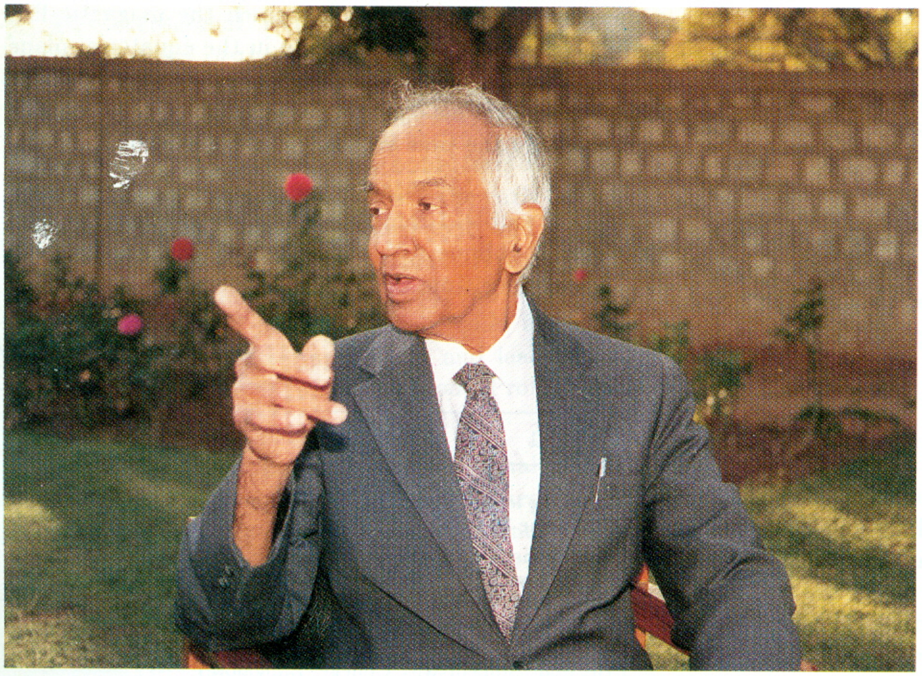
Vinod Krishan

Colloquia

The following lectures were given at IIA between 1992 November 21 and 1993 June 30.

1. Phase transitions in the early universe, and the ultrahigh energy cosmic rays (P. Bhattacharjee, IIA)
2. A new investigation of microbursts at metre-decametre wavelengths (K. R. Subramanian, IIA)
3. Homeopathy: a modern medical science (B.D. Patel, Former Principal, Homeopathy College, Bangalore)
4. On the origin of Li, Be and B in the early galaxy (D. L. Lambert, Univ. Texas, USA)
5. Isotopic fractionation of carbon monoxide in diffuse interstellar clouds(D. L. Lambert, Univ. Texas, USA)
6. Ages and abundances of globular clusters (R.D. Cannon, AAO, Australia)
7. Experimental studies of gravitation and feebler forces (R. Cowsik, IIA)
8. Galactic distribution functions (W. Saslaw, Univ. Virginia, USA)
9. High angular resolution observations of the Sun (F. Kneer, Göttingen Observatory, Germany)
10. Recent results in helio and astrosiesmology (J. Christensen-Dalsgaard, Institute of Astronomy, Univ. Aarhus, Denmark)
11. Non linear Σ models and cosmology (S. V. Cheron, Moscow state univ., Russia)
12. A model for beta decay strength and application to astrophysics (K. Kar, Saha Institute of Nuclear Physics, Calcutta)
13. Multiplicity corrected mass function of stars in the solar neighbourhood (Sarabani Basu, TIFR, Bombay)
14. SAO 244567: a post-AGB star which has turned into a planetary nebula within the last 40 years (M. Parthasarathy, IIA)
15. Generation of spatial structures in star-forming systems (V.I. Korchagyn, Rostok Univ., Russia)
16. Accretion by magnetic stars: theory and observation (Pranab Ghosh, TIFR, Bombay)
17. The heating of the quiet solar chromosphere (R. Kariyappa, IIA)
18. Pulsating characteristics of peculiar dwarf cepheids (C. Kim, Chonbuk National Univ., Korea)
19. Strong Newtonian interactions of the three- and N-body systems (J. Anosova, PRL, Ahmedabad)
20. Quark-gluon Plasma (Jan-e Alam, Variable energy cyclotron centre, Calcutta)
21. Large-scale structure of the universe and the adhesion model (Varun Sahni, IUCAA, Pune)
22. Signatures of CP violation in astrophysics and cosmology (S. N. Nayak, Inst. of Physics, Bhubaneswar)
23. Infrared emission from early-type stars (B.S. Shylaja, PRL, Ahmedabad)
24. Beyond stars and galaxies — Do we live in a false vacuum? (C. W. Misner, Univ. Maryland, USA)

Subrahmanyan Chandrasekhar



The Governing Council of the Indian Institute of Astrophysics has conferred the second Honorary Fellowship of the Institute on Professor S. Chandrasekhar.

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