Newsletter
Quarterly Newsletter of the Indian Institute of Astrophysics

Volume 5 Number 4 October 1990

Dust Envelopes around RV Tauri Stars

RV Tauri stars are rare, variable yellow supergiants which constitute an interesting and rather poorly understood class of pulsators. The principal characteristics of these objects are: (i) spectral types lie in the range F–K, (ii) light curves exhibit alternate deep and shallow minima which may interchange occasionally, and (iii) periods between two consecutive deep minima lie in the range 30–150 days. There are suggestions, both from theoretical and observational studies, that RV Tauri stars are low mass objects undergoing post-asymptotic giant branch evolution, representing a crucial phase in the evolution towards white dwarfs.

Three spectroscopic subgroups of RV Tauri stars are recognized, group A, B and C. But for the appearance of TiO bands during deep minima, all group A objects have spectral features corresponding to types G or K, whereas those belonging to group B and C show large discrepancies between spectral types based on Ca II lines and that based on hydrogen lines. Presence of strong CN bands between secondary and primary light maxima differentiate group B stars from group C stars. Objects of group A are considered to be oxygen-rich and those of group B carbon-rich.

RV Tauri stars have been known to possess infrared radiation far in excess of their blackbody continuum, indicating the presence of cool and extended dust envelopes around them. The study of dust envelopes are important because it provides valuable information not only on the mass loss from these objects but also on the nature of interstellar grains because of their probable origin in circumstellar envelopes. The main observational tools for the study of dust envelopes are multiwavelength infrared photometry and polarimetry. The present work was begun with the goal of understanding the formation and properties of dust envelopes around carbon-rich RV Tauri stars.

17 RV Tauri stars, which constitute about 20% of all known members, were detected by the Infra-Red Astronomy Satellite (IRAS) at 12, 25 and 60 μm passbands. An analysis shows that the IRAS fluxes are consistent with the density in the envelope $\rho(r) \propto r^{-2}$, where r is the radial distance. Such a dependence for the density suggests that, most probably, the mass loss in RV Tauri stars is radiation-pressure driven. In the IRAS two-colour diagram, a plot of [25] − [60] colour against [12] − [25] colour, RV Tauri stars are found to populate cooler temperature regions ($T < 600$ K), distinctly different from those occupied by the oxygen and carbon Miras. The carbon-rich and oxygen-rich objects are well-separated in the IRAS two-colour diagram, with the former having systematically cooler dust envelopes.

Broadband multiwavelength (*UBVRI*) polarimetric observations were obtained for 4 carbon-rich RV Tauri stars—AR Pup, RU Cen, AC Her and SX Cen. The polarimetric behaviour of AR Pup is found to be exceptional in several respects. The observed amplitude of linear polarization in U band is $\sim 14\%$, the highest so far observed in any late type star. The wavelength dependence of polarization exhibits a wide range of shapes, and the shape of the $P(\lambda)$ curve apparently depends on the level of polarization itself, such that, as the level of polarization increases the curve becomes steeper towards ultraviolet. The polarimetric data when combined with simultaneous photometry indicates that the observed large time-dependent variations, both in the amount and wavelength dependence of polarization, are cyclic and related to the light variation; the polarization increases rapidly close to the epochs of light minima, during the ascending branch of the light curve (Fig. 1).

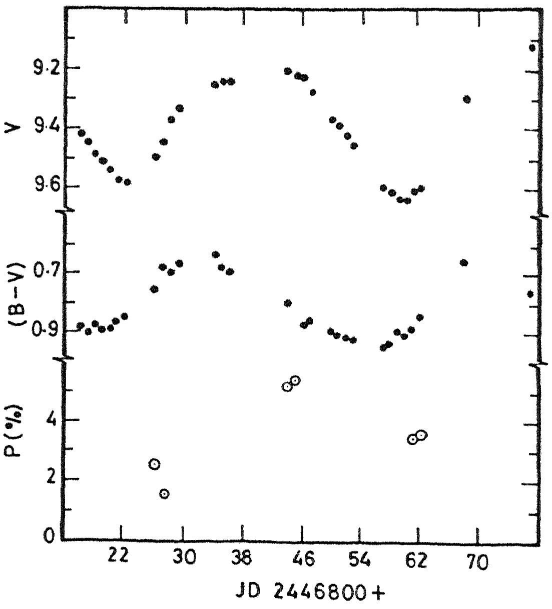


Figure 1. Plots of *V*, (*B*− *V*) and *P*% in *V* band of AR Pup against the corresponding Julian days of observation. Note that polarization was low close to the light minimum.

The most significant result of the polarimetry, which would constrain the possible polarization models for AR Pup, is the finding that the observations in *UBVR* bands obtained during February–March 1986 lie on separate near-straight lines in the (*Q*, *U*) plane (Fig. 2). Such a regular behaviour in the polarization and position angle appears to be a result of some very systematic changes in the several parameters that determine the level, direction and wavelength dependence of polarization produced.

Other carbon-rich RV Tauri stars show a near-flat wavelength dependence of polarization in the 0.35–0.90 μm region, and hence circumstellar grain scattering appears to be the main mechanism responsible for the continuum polarization. In the (*Q*, *U*) plane, the RV Tauri stars, in general, show a regular variation during the light cycle, implying a very regular variation in the geometry involved. This suggests that the variations in polarization observed in RV Tauri stars during the light cycle are rather caused by changes in asymmetries associated with the pulsation of the star than due to changes in an asymmetric dust envelope around it.

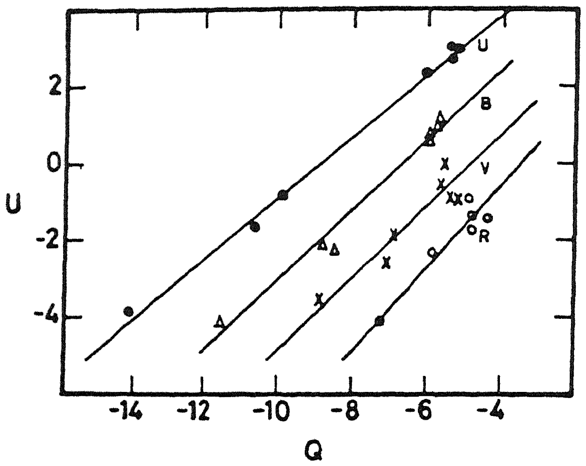


Figure 2. The path of polarization of AR Pup observed during February–March 1986 in the (*Q*, *U*) plane. Note that the first set of observations during that period fall nearly in the middle of each line.

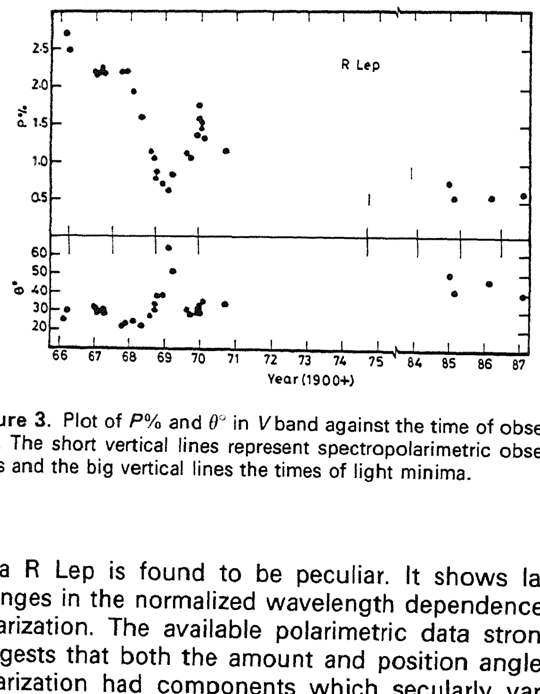


Figure 3. Plot of *P*% and θ° in *V* band against the time of observation. The short vertical lines represent spectropolarimetric observations and the big vertical lines the times of light minima.

BVRI polarimetric observations of a sample of red carbon stars belonging to different variability types—VX And, UU Aur, T Cae, Y CVn, U Hya, Y Hya, R Lep, RY Mon, W Ori, Y Per, RT Pup and X Vel—were also obtained along with the carbon-rich RV Tauri stars for a comparative study of the wavelength dependence. Of these objects, the polarimetric behaviour of the carbon Mira R Lep is found to be peculiar. It shows large changes in the normalized wavelength dependence of polarization. The available polarimetric data strongly suggests that both the amount and position angle of polarization had components which secularly varied since their first measurements in 1966 (Fig. 3). Circumstantial evidences suggest a possible connection between the largest polarization observed in 1966 and the faintest ever observed light maximum of 1959–60.

Numerical computations of polarization produced by dust envelopes using Mie theory under single scattering approximation show that the changes in the net polarization produced by an envelope due to changes in the size of the star as a result of radial pulsation is not significant. However, in objects that show polarization variation coupled with the pulsation, other effects such as changes in the number and size of the scattering grains may be occurring as a result of changes in the temperature during the pulsation cycle.

On average, carbon stars show a flatter wavelength dependence of polarization than oxygen-rich objects. The mean polarimetric behaviour of red oxygen-rich stars is found to be more consistent with the scattering by grains of dirty silicates than by pure silicates. It is also found that the mean polarimetric behaviour of red carbon stars is inconsistent with the scattering by graphite grains, suggesting the existence of carbon grains in the envelopes around them in some other form. The present computations clearly indicate that circumstellar grain scattering produces not only significant changes in the normalized wavelength dependence of polarization but also polarization changes across spectral features if the illuminating star has a non-uniform surface brightness distribution.

Related publications

Polarimetric observations of the RV Tauri star AR Puppis.
Raveendran, A. V., Kameswara Rao, N., 1988, *Astr. Astrophys.*, **192**, 259.

Polarimetric study of the RV Tauri star AC Herculis.
Raveendran, A. V., Kameswara Rao, N., Anandaram, M. N., 1989, *Bull. astr. Soc. India*, **17**, 95.

Long-term polarimetric behaviour of the carbon Mira R Leporis.
Raveendran, A. V., Kameswara Rao, N., 1989, *Astr. Astrophys.*, **215**, 63.

Dust envelopes around RV Tauri stars.
Raveendran, A. V., 1989, *Mon. Not. R. astr. Soc.*, **238**, 945.

Polarimetric and photometric study of the RV Tauri star AR Puppis.
Raveendran, A. V., Kameswara Rao, N., Anandaram, M. N., 1989, *Mon. Not. R. astr. Soc.*, **240**, 823.

An investigation of polarization produced by circumstellar dust envelopes.
Raveendran, A. V., 1990, *Astr. Astrophys.* (in press).

BVRI polarimetry of carbon stars.
Raveendran, A. V., 1990, *Astr. Astrophys.* (in press).

A. V. Raveendran

(Synopsis of a thesis titled *Studies of Pulsating Carbon Stars* for which the Bangalore University has awarded its Ph.D. degree.)

Development of Active Optics System for Optimizing Optical Performance of a Large Telescope

The ultimate performance of a large telescope is set by the limit imposed by the diffraction effects. The diameter of the Airy disc in radians can be defined by the classical formula

$$d_\alpha = 2.44 \frac{\lambda}{D},$$

where D is the diameter of the main mirror. In practice, with large ground based telescopes diffraction has been of no significance because atmospheric turbulance (seeing)

$$d_b = 2.44 \frac{\lambda}{r_0},$$

where r_0 is Fried's parameter, has set a limit at least an order of magnitude greater. Although better seeing is claimed for some modern sites, the accepted value of d_b for most of the ground-based observatories has been $\geqslant 0.3$ arcsec. For apertures larger than the Fried's parameter d_b is effectively independent of the aperture D. For the best site in the world the Fried's parameter rarely exceeds 30 cm and therefore the best quality image for any ground-based large telescope can be expected to be ~ 0.3 arcsec, and may vary up to 0.5 arcsec. This limit dictates the optical specification in terms of optical quality of individual components and incombination (primary and secondary mirrors in case of Cassegrain system). Besides the inherent optical quality of the surfaces, a large number of technical factors prevent most telescopes from achieving the specifications for more than a small fraction of their practical observing time. Table 1 provides the factors causing degradation of the image quality in telescopes and their corresponding bandpasses.

Table 1. Factors causing degradation of the image quality in telescopes.

No.	Sources of error	Bandpass (Hz)
1.	Optical design	dc
2.	Optical manufacture	dc
3.	Theoretical errors of mirror supports and structure (focus, centring)	dc
4.	Maintenance errors of the structure and mirror supports	10^{-5}
5.	Thermal distortions:	
	Mirrors	10^{-6}
	Structure	10^{-3}
6.	Mechanical distortion of mirrors (warping)	10^{-6}
7.	Thermal effects on ambient air	10^{-3}
8.	Mirror deformation from wind gusts	10^{-1}
9.	Atmospheric turbulence	2×10^{-2}
10.	Trading errors	5

The first six factors bringing degradation to the image quality, have low bandpass and can be corrected at periodic intervals of time, because of the slow nature of the changes. This is the problem addressed by *active optics* system. The remaining four factors (7–9) are high-frequency effects and require very fast corrections. A system for such corrections is known as adaptive optics.

The active optics correction

The basic concept for the active and adaptive optics correction is the same but they differ in actual method of correction quite significantly. A typical method of correction in principle is shown in Fig. 1. In active optics, none of the error sources in its bandpass have field limitation: the effects are essentially constant over the

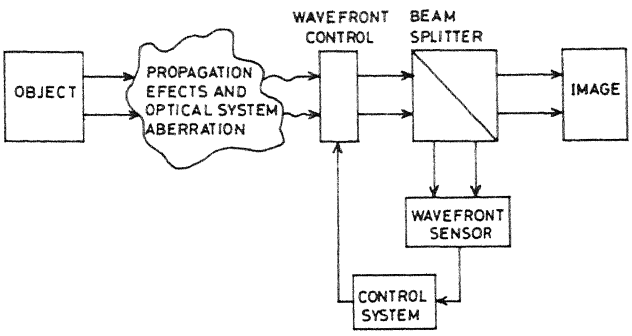


Figure 1. Principle of active and adaptive optics correction.

field. The logical point in the system for applying the correction is therefore the pupil. If the entrance pupil is used, the full field of the telescope is automatically corrected.

Conventionally, the entrance pupil is placed at the primary mirror, which provides a most efficient use of the main expensive element i.e. primary mirror. Some telescopes, with strong emphasis on infrared observation, place the pupil at the secondary. If the pupil is at the primary and the active correction is performed there, the beam moves over the secondary according to the point in the field observed. However for the small fields we have in practice with large telescopes, this shift of the beam is negligible for the low spatial frequency terms corrected. Therefore active correction may be done either at the primary or at the secondary mirror, or at both elements, whichever is logistically more convenient. Technically it has been found that it is easier to perform corrections at the primary. These concepts are being adopted for present-day new technology telescopes. 3.58 m ESO NTT is an example of successful application of these concepts.

We have been working on the development of an active optics system for optimizing the optical quality of thin optical elements for our future large telescope projects. One 27-inch spherical mirror is being prepared for such experimentation.

In active optics system, aberrated wavefront from optical elements require fast evaluation and correction. We have developed a new method for sensing and evaluating the wavefront using two crossed Babinet compensator polarization interferometer and adopting Fourier methods. The efficacy of the method has already been proved by testing an 18-inch paraboloid in the laboratory using a monochromatic light source. The details of the method were presented in the SPIE Conference on Interferometry 1989.[1]

The method is being extended for multiwavelength applications for its use in telescopes with star as a source of light.

Reference

1. Wavefront sensing and evaluation using two crossed Babinet Compensators, Saxena, A. K., Lancelot, J. P. (1989) *Proce. SPIE* Vol. 1121.

A. K. Saxena

A new twelve band photometer for observations in the near infrared and in the visual bands

A new photometer for near simultaneous measurements in the *JHKLM*, in the *UBVRI* bands and in the H_α has been designed and fabricated with the help of the Institute's workshops. It is expected to be ready after trials for regular observations at Kavalur in the coming winter months.

The photometer has four main parts. (i) Optics for separating the infrared and visual beams, (ii) Infrared detector; (iii) Visual detector and (iv) Other accessories.

Optics for separating the infrared and visual beams: The layout of the *UBVRI*-H_α-*JHKLM* photometer is shown in Fig. 1. Separation of the infrared and visual beams from the incoming radiation at the Cassegrain focus is done by the cold mirror (made by Ealing Optics Co.) which efficiently transmits ($\approx 85\%$) in the infrared in the range 0.8μ to 2.5μ and reflects ($\approx 95\%$) light in the range 0.4μ to 0.7μ. This makes simultaneous observations possible in the limited region of *BVR*-H_α-*JHK* bands. For those who desire to cover the *U* and *I* bands also we have provided a flat mirror (Fig. 1) which would replace the cold mirror and reflect all the radiation into the visual photometer and none into the infrared photometer. After completing the observations in the *UBVRI*-H_α bands, this flat mirror can be flipped to its rest position (shown by the dotted lines in Fig. 1) thus allowing the incoming radiation to reach the infrared detector after reflection from the chopper mirror. In this mode near simultaneous observations can be made through all the filters.

Infrared detector: The liquid nitrogen cooled devar supplied by the Infrared Laboratories, Tucson, has an

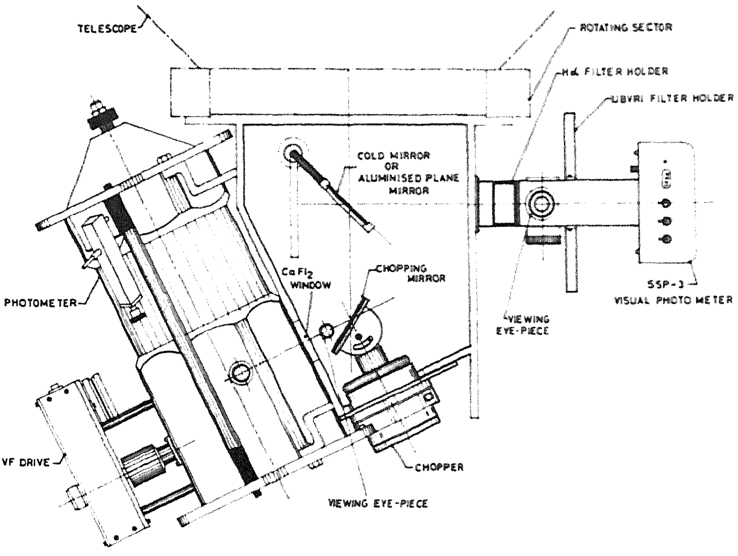


Figure 1. A twelve band photometer.

InSb detector mounted on a cold deck at 77 °K and 5 filters fixed on a slide that isolate the J(1.2μ), H (1.63μ), K(2.25μ), L(3.75μ) and M (4.7μ) bands of the Johnson system. The photometer has also a circular variable filter (CVF) which can do a low resolution scan in the spectral band 1.4–4.6μ. There are five circular apertures with diameter of 0.5 mm, 1.0 mm, 1.5 mm, 2.0 mm and 3.0 mm. We have designed the imaging system inside the IR photometer for an f/13 beam and so this photometer can be used at the Cassegrain focus of either the 1 m or the 2.3 m telescope at Kavalur. On the 1 m telescope these 5 apertures would represent the angular sizes of 7.7, 15.5, 23.2, 31.0 and 46.5 arcsec respectively, whereas at the Cassegrain focus of the 2.34 telescope, they would represent angular sizes of 3, 6, 9, 12 and 18 arcsec respectively. A focal plane chopper operated at the 15 Hz modulates the incoming signal from the Cassegrain system. The detected output of the lock-in-amplifier can be recorded on a strip chart recorder, or stored in the digitised form in an IBM-PC. Both the aperture and filter controls are operated manually. The infrared photometer is mounted on the telescope at an angle of 26° with respect to the optical axis of the telescope. This tilted mounting prevents the spilling of the liquid nitrogen out of the devar even while observing objects close to the horizon.

Visual photometer: The visual part of the system is a SSP-3 photometer made by Optec. Inc. USA. This uncooled photometer has a solid state silicon pin photodiode detector and is ultrasensitive over a wide range from 0.3μ to 1.1 μ. The photometer has only one aperture 1 mm diameter which corresponds to 15 arcsec at the Cassegrain focus of the 1 m telescope and 6 arcsec at the Cassegrain focus of the 2.34 m telescope. The six position filter holder of the photometer carries 5 Schott filters to isolate the standard Johnson *UBVRI* bands in the visual region and the sixth position is blank. The filter slide is controlled by a stepper motor and is operated through the IBM-PC. This PC also stores the data from the photometer. The output from the photometer can also be read through a window on one of its sides. The photometer can reach 9^m in the *U* band and 12^m in the *V* band at the Cassegrain focus of the 1 m reflector with 100 sec. integration. Two H_α filters, one with a pass band of 50 A and the other with a passband of 160 A can be mounted close to the SSP-3 photometer on a separate slide as shown in Fig. 1. When the object is fainter than 12^m in the *V* band, there is also a provision to replace the SSP-3 photometer with a more sensitive and conventional dry ice cooled *UBVRI* photometer with a RCA 9558 photo-multiplier tube in its place. Provision is also made to mount the Fabry lens and a 5 band filter holder of the photometer at the appropriate places.

Other accessories: One wide angle eye-piece is provided to help identify the source. In addition, separate microscope eye-pieces are also provided for the IR and the visual photometers (Fig. 1). One disadvantage in the IR photometer is that unlike in the visual photometer there is no access to the aperture for proper centring of the star image against the aperture. The centring is done by maximizing the output signal in one of the IR bands and for this position the star is centred on the visual photometer. Once this is done, the position of the image on the visual photometer eye-piece can be used as the reference for guiding the star on the IR photometer as well. The wide angle eye-piece has also a provision for offset facility. An integration unit has been added to the IR photometer for observations of fainter objects. Description of this unit will be presented in a subsequent note.

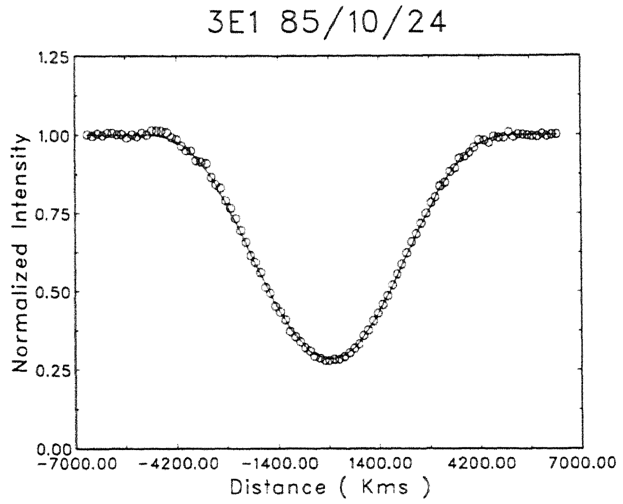
We hope that many observers would welcome this photometer. Mr. B. R. Madhava Rao and Mr. K. Kanakaraj helped us in the fabrication of the photometer.

K. K. Scaria, R. M. Nair & K. R. Sivaraman

Mutual Phenomena of Jovian Satellites

The equatorial plane of Jupiter is seen edge-on twice during its orbital period of 11.6 years. During a few months around this time, the Galilean satellites frequently eclipse (occult) each other when any two of them are aligned with the Sun (Earth).

Observations of the mutual events provide means of observing positions of the satellites with an accuracy at least two orders of magnitude better than the photographic or eclipse (behind the planet) observations. A series of precisely timed events observed over a few decades has the potential of detecting secular changes in Io's orbital elements arising from tidal interactions.



Observed (O) and fitted (continuous line) light curves of 3E1 event on 1985 October 24 observed from VBO.

The mutual events during 1973, 1979 and 1985–86 were extensively observed all over the world. The next mutual eclipse season will commence around end of 1990 and will continue till middle of 1991. The forthcoming eclipse season is of great significance as much interest now centres on improving the satellite ephemerides to assist in guiding the Galileo spacecrafts during extreme close approaches. Mutual phenomena that are observable from most parts of India are given in Table 1. The first column gives the UT date. Second through fifth columns give the timings of the begining of the penumbral phase, begining of the umbral phase, end of the umbral phase, and end of the penumbral phase for eclipses. For occultations, the third and fourth columns give beginning and end times. The sixth column identifies the event type: e.g. 203 or 2E3 means Europa occulting or eclipsing Ganymede either partially (P), totally (T), or annularly (A). The seventh column gives an indication of light loss (DL); for occultations only, DL is normalized to the combined light of both satellites V1 and V2 (columns eight and nine). The tenth column (DIST) provides the distance in Jovian radii from the planet's centre at mid-event.

R. Vasundhara

Table 1. Mutual events observable from most parts of India.*

DATE(UT)	BEG PU	BEG U/O	END U/O	END PU	EVENT	DL	V1	V2	DIST
90/12/18		18 32.9	18 47.9		203 A	0.23	5.55	4.93	9.4
90/12/25	18 53.2			19 04.5	2E3 P	0.03	5.52	4.89	10.7
90/12/25		21 58.7	22 15.7		203 A	0.23	5.52	4.89	9.4
90/12/28		19 19.9	20 22.5		201 P	0.03	5.50	5.29	4.2
91/01/01	22 45.3	22 49.3	22 57.3	23 01.3	2E3 P	0.13	5.49	4.86	10.5
91/01/08		13 36.8	13 52.1		201 P	0.12	5.46	5.26	5.7
91/01/10		15 48.1	15 58.4		402 P	0.62	6.01	5.46	8.8
91/01/15	15 18.7	15 20.7	15 36.4	15 38.4	2E1 A	0.69	5.45	5.24	5.7
91/01/15		16 13.4	16 25.7		201 P	0.15	5.45	5.24	5.8
91/01/18		17 08.1	17 46.1		201 P	0.39	5.44	5.23	2.0
91/01/22	18 14.7	18 16.4	18 27.7	18 29.4	2E1 A	0.71	5.44	5.23	5.9
91/01/22		18 37.2	18 48.2		201 P	0.20	5.44	5.23	5.9
91/01/23	13 31.4	13 39.4	14 35.0	14 43.0	2E3 P	0.29	5.44	4.81	8.2
91/01/23		15 20.9	18 13.9		203 A	0.23	5.44	4.81	6.9
91/01/23	19 49.7	20 14.2	20 25.9	20 50.4	2E3 P	0.03	5.44	4.82	5.2
91/01/29		20 54.5	21 04.5		201 P	0.26	5.44	5.23	5.9
91/01/29	20 56.2	20 57.7	21 07.0	21 08.5	2E1 A	0.68	5.44	5.23	5.9
91/02/05		23 07.9	23 17.3		201 P	0.33	5.44	5.24	5.9
91/02/05	23 30.3	23 31.6	23 39.3	23 40.6	2E1 A	0.69	5.44	5.24	5.9
91/02/16		14 24.6	14 32.9		201 A	0.40	5.47	5.26	5.8
91/02/16	15 13.2	15 14.4	15 21.1	15 22.2	2E1 A	0.69	5.47	5.26	5.6
91/02/23		16 34.5	16 42.2		201 P	0.38	5.49	5.29	5.7
91/02/23	17 38.0	17 39.2	17 45.2	17 46.3	2E1 A	0.68	5.49	5.29	5.5
91/03/01	16 12.1	16 21.3	16 36.0	16 45.1	4E2 P	0.79	6.07	5.52	9.0
91/03/02		18 44.5	18 51.5		201 P	0.31	5.52	5.32	5.7
91/03/09		20 54.6	21 00.9		201 P	0.24	5.56	5.35	5.5
91/03/18	19 37.7			19 47.4	4E2 T	0.36	6.17	5.62	6.7
91/03/20	13 51.7	13 53.0	13 57.4	13 58.7	2E1 A	0.52	5.62	5.42	4.6
91/03/27		14 23.7	14 28.0		201 P	0.09	5.67	5.46	5.2
91/03/27	16 10.5	16 11.7	16 15.7	16 16.8	2E1 P	0.46	5.67	5.46	4.3
91/04/03		16 37.1	16 40.8		201 P	0.05	5.72	5.51	5.1
91/04/03	18 28.3	18 29.6	18 33.0	18 34.3	2E1 P	0.38	5.72	5.51	4.0
91/04/04	13 53.3			15 28.6	4E1 P	0.21	6.28	5.52	4.6
91/04/13	16 04.9			16 11.2	1E4 P	0.07	5.58	6.36	6.8
91/04/23	14 52.3			14 57.0	3E1 P	0.04	5.22	5.65	3.3
91/04/28	14 26.6			14 30.6	2E1 P	0.08	5.89	5.68	3.1
91/04/30	15 30.6			15 42.3	3E4 P	0.18	5.27	6.47	9.0
91/05/07	15 12.3	15 15.8	15 16.8	15 20.3	3E2 P	0.39	5.32	5.95	7.5
91/05/17	14 46.7	14 47.9	14 51.2	14 52.4	1E2 P	0.68	5.80	6.02	2.6
91/06/02	14 10.9	14 13.1	14 17.1	14 19.3	2E3 A	0.32	6.10	5.48	7.0
91/06/20	13 30.7	13 32.8	13 39.8	13 42.0	3E1 P	0.83	5.55	5.98	5.3
91/06/25		14 04.0	14 08.3		102 P	0.09	5.99	6.21	5.0

* Extracted from Aksnes and Franklin (1989): Preprint Series No. 3003, Harvard-Smithsonian Center for Astrophysics.

New Drive System for 1-metre telescope at VBO

You will now find a new solid-state drive system at the 1-m reflector at VBO which was developed in the Institute's electronics laboratory. This system replaces the original valve-based drive system whose maintenance problems kept on increasing due to aging and non-availability of suitable spare components. The new system adopts a digital approach to sine wave synthesis and uses transistor power amplifiers procured from Inland Motors. The amplitude stability in the waveform is obtained from a temperature-compensated reference source and the frequency stability is derived from a crystal oscillator. The system has been working satisfactorily for over a year without any breakdown. A similar system has been fabricated and handed over to U.P. State Observatory, Naini Tal in July 1990.

R. Srinivasan & K. S. Ramamoorthy

newsline

Prof. J. C. Bhattacharyya retired as the Director of the Indian Institute of Astrophysics on attaining the age of superannuation on August 31, 1990. The first decade of his career was spent in the India Meteorological Department doing instrumentation for meteorology. In 1964 he moved over to Kodaikanal. His original contributions to Solar Physics and Planetary environments are well known in the international sphere. He assumed the office of the Director in September 1982. The period under his leadership witnessed the successful accomplishment of many projects, the most notable one being the 234 cm telescope. He was associated with this project right from its start and this gave him the confidence to go forward and complete it on his own in spite of the misfortune which took away Dr Bappu from our midst. He passed through many days of intense anxiety while the project was moving forward step by step. All these vanished in the joy when the star light first entered the telescope. He solved the teething troubles one by one along with a small bunch of devoted workers with him. Without the singleness of purpose, extreme determination and high level of devotion which he possesses, this telescope project could not have been made possible. He thus brought into reality the life ambition of Dr Bappu.

He has accepted the honorary position as a CSIR Emeritus Scientist and will continue his scientific work in IIA with emphasis on Solar System Astronomy. His keen sense of humour, his deep concern for the future of astronomy and especially for the young astronomers as well as his many cultural and humanitarian interests will manifest in far greater measure with more time available to him in the years to come. The members of staff of the Institute wish to express their deep gratitude to him for the creation and development of many facilities in the Institute, which have made this place a congenial home for scientific research.

K. R. Sivaraman

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Following students have joined the Institute for the PhD programme: S. Mahadevan, B. Eswar Reddy, N. Annapurni, D. Banerjee, Uma Gorti, S. K. Sengupta (CSIR-JRF) & Mausumi Dikpati (CSIR-JRF, JAP). Aruna Goswami continues her work on F-G supergiants and Classical Cepheids on a CSIR Post Doctoral Fellowship from July 3, 1990. A. Satyanarayanan has joined as a Visiting Fellow from May 2, 1990 for a year.

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Four physics teachers from Bangalore are visiting the Institute to work as external candidates for PhD degree. They are: (i) N. D. N. Prasad (M. S. Ramaiah College), (ii) T. D. Sreedharan (Mt Carmel College), (iii) C. Chowdappa (Govt P.U. College) and N. Sundar Rajan (Christ College).

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Three teachers (R. Gangadharamurthy, M. F. Ingalgi and Prasannalakshmi) deputed by Government of Karnataka under the Faculty Improvement Programme of the University Grants Commission have reported back to the parent colleges. They are in the final stages of completing their research for the PhD degree.

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Annamma Mathews (Physics Department, Assumption College, Changanacherry) spent three years from June 8, 1987 under the F.I.P for her PhD work. The Institute has since awarded her a fellowship for a year to complete her thesis.

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C. T. Vanajakshi was in the Institute as a visiting Fellow at Kodaikanal from July 13, 1989 to August 31, 1990.

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Prof. Chanchal Uberoi (Department of Applied Mathematics, Indian Institute of Science, Bangalore) spent 6 months (Jan 8–July 8, 1990) at the Institute as a visiting Professor. During her stay she delivered seminars and collaborated with the Institute scientists in the area of solar system studies.

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R. T. Gangadhara attended the meeting on *Variability of Active Galactic Nuclei* at Atlanta, U.S.A., May 2–4, 1990, and presented a paper on *Parametric Decay Instability in 3C 273* coauthored by V. Krishan. Subsequently he spent two weeks for collaborative work with Paul J. Wiita at the Department of Physics and Astronomy, Georgia State University, Atlanta.

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S. S. Hasan attended the *IV Regional Conference on Mathematical Physics* in Tehran, Iran, May 12–17, 1990, and delivered an invited review talk on *Oscillations in Magnetized Structures on the Sun.* He spent four weeks at Queen Mary College, London during June–July collaborating with R. Tavakol.

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K. R. Sivaraman, S. S. Hasan, and K. E. Rangarajan attended the Heidelberg conference on *Mechanisms of Chromospheric and Coronal Heating,* Heidelberg, June 5–8, 1990. Sivaraman delivered an invited talk on the *Bright Points in the Ca II K-Line and their relation to the inner Network Magnetic Structures.* Hasan delivered an invited talk on *Heating in Intense Flux Tubes.* Rangarajan presented a paper titled *Effects of Electron Scattering on Si II 1816 Line in the Solar Chromosphere* coauthored by D. Mohan Rao.

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K. R. Subramanian spent six weeks at Nancay and Meudon observatories, France during May–June 1990 for a collaborative programme on solar observations and data reductions.

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R. C. Kapoor attended the IAU colloquium 128 on the *Magnetospheric structure and Emission Mechanisms of Radio Pulsars,* Lagow Village, Poland, June 17–23, 1990 and presented a paper on the *Effect of Light Bending and Redshift on the Pulsar Beaming: the Case of Shorter Neutron Stars.*

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D. C. V. Mallik attended the *Fifth Asia-Pacific Regional*

IAU Meeting, Sydney, July 16–20, 1990. He presented an invited review on *Planetary Nebulae: Origin and Evolution*. Prior to the meeting he visited the observatories at Siding Spring, and SUSI and AT at Culgoora.

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D. Mohan Rao participated in the NATO Advanced Study Institute School on *Supernovae*, Les Houches, France, July 31–September 1, 1990.

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M. Parthasarathy and Sunetra Giridhar attended the IAU Symp. 145 on *Evolution of Stars: the Photospheric Connection*, Druzba, Bulgaria, August 27–31, 1990. Parthasarathy presented a paper on *Post-AGB stars*. Giridhar presented a paper on *Spectroscopic Studies of F-G Supergiants showing Semi-regular Light Variations*, coauthored by A. Arellano Ferro and Aruna Goswami.

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A. K. Saxena attended the *15th Congress of the International Commission for Optics*, Garmisch, Partenkirchen, Federal Republic of Germany, August 5–10, 1990. He presented a paper on *Large Optical Mirror Making Technology and Facility at Indian Institute of Astrophysics*. He visited Observatoire de Haute-Province (OHP) and Equipe d'optique del I.R.C.O.M, Faculte des Sciences, Lemoges, France, before the Congress and delivered a talk on *Optical Technology at the Indian Institute of Astrophysics* at OHP. After the Congress he visited Physikalisch-Technische Bundesanstall, Braunschweig und Berlin, European Southern Observatory, Garching, and Schott Glaswerke, Mainz, in Federal Republic Germany in connection with certain optical instrumentation programmes and National Large Optical Telescope Project.

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C. Sivaram is on sabbatical leave for one year from September 15, 1990. During this period he will work as visiting Professor at the Institute of Physics and Astronomy, Bologna University; Department of Physics, University of Ferrara; Institute of Nuclear Physics, University of Pavia; and International School of Cosmology and Gravitation, Erice. He will lecture at the "Ettore Majorana" Workshop on the *Problem of the 'Cosmological Constant'*, September 17–20, 1990 and at the 12th Course on *Black-Hole Physics*, Erice-Sicile, May 12–22, 1991.

* * *

B. Datta participated in the NATO Advanced Study Institute, on Neutron Stars, held in Crete, Greece, September 3–14, 1990. He delivered a lecture on the *Neutron Stars: Interior Structure and Rotation*.

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Prof. K. R. Sivaraman has taken over charge of the duties of the Director from August 31, 1990.

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The solar astronomers observing at the solar tower telescope would find the coelostat mirrors are realuminized and the exposure times have considerably come down.

Jagdev Singh & S. P. Bagare

* * *

out of context

No other supernova has shown this development, but no other event has been observed at a corresponding stage in its development.

Supernovae, (1990) Springer-Verlag p. 6.

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Like Toomre, I obtained a remarkably long, narrow tail when the perturber mass was equal to the parent mass.

Astrophys. Space Sci., **17** (1972), 299.

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Editors: T. P. Prabhu & A. K. Pati
Editorial Assistant: Sandra Rajiva
Published by the Editors on behalf of the Director, Indian Institute of Astrophysics, Bangalore 560 034.

Newsletter
Quarterly Newsletter of the Indian Institute of Astrophysics
Vol. 5, No. 4, October 1990

To:

Indian Institute of Astrophysics
Bangalore 560 034.