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Spectra of two recent supernovae

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Abstract. Preliminary results on the spectroscopy of two recent supernovae are presented. The spectrograms obtained at a dispersion of 400 Å mm^{-1} in the wavelength range of 4300–8700 Å show that the supernova in NGC 6946 is of type II and that the supernova in NGC 1316 is of type I. The spectroscopic monitoring of the two supernovae is being continued.

Key words : supernovae — spectroscopy — classification

1. Introduction

Two recent supernovae in NGC 6946 and NGC 1316 are being spectroscopically monitored at the Kavalur Observatory. The spectrograms were obtained with an image tube spectrograph mounted at the Cassegrain focus of the 102-cm reflector telescope. A preliminary account of the spectroscopic observations in the wavelength range 4300–8700 Å is reported here.

2. Type II supernova in NGC 6946

The supernova was discovered by Wild on 1980 October 28. Kirshner (1980) and Barbon, Ciatti & Rosino (1980) made spectrophotometric observations during the early phases and classified it as a supernova of type II. Kavalur observations began on December 1. The supernova had faded from 11.0 mag at maximum to 12.5 mag by this time. A spectrum obtained on December 1 around H_α region at a dispersion of 125 Å mm^{-1} shows broad H_α emission with a P Cygni absorption component at -5000 km s^{-1}. Subsequently spectra were recerded at a dispersion of 400 Å mm^{-1} from December 5–17. A microdensitometric tracing of a typical spectrogram is reproduced in Figure 1. The spectrum is typical of type II supernovae 30 days after maximum. The spectrum shows strong P Cygni profiles of H_α and H_β as also Na I D and Mg I b with fainter emission components. The emission peak at 5000 Å is probably due to multiplet 42 of Fe II. The 4670 Å complex is possibly due to the multiplets 37 and 38 of Fe II as suggested by Kirshner *et al.* (1973). The atmospheric OH (6–2) emission at 8300–8500 Å partially fills in the P Cygni

absorption of Ca II 8542–8662 Å while $H\beta$ affects the P Cygni absorption of Fe II 4924, 5018, 5169 Å. The absorption velocities of remaining lines are listed in Table 1. The mean expansion velocity of the envelope of the supernova is 6300 ± 400 km s^{-1}. No correction has been applied for the apparent recessional velocity of the galaxy which is very low (46 km s^{-1} *cf.* de Vaucouleurs, de Vaucouleurs & Corwin 1976).

NGC 6946 has had the largest number of recorded supernovae, the previous ones being 1917a, 1939c, 1948b, and 1968d. A possible supernova in 1969 remains unconfirmed. While the supernovae 1948b and 1968d are classified spectroscopically as type II, the supernova 1939c has been classified as type I on the basis of its light curve (Maza & van den Bergh 1976).

3. Type I supernova in NGC 1316

A supernova was discovered in the peculiar radio galaxy NGC 1316 (Fornax A) by Wischnjewsky on 1980 November 30 at a brightness of 14.0 mag. (Maza 1980). The supernova brightened subsequently to 12.5 mag by December 7. Spectrograms were obtained at the Kavalur Observatory on December 17 and 18 at a dispersion of 400 Å mm^{-1}. A microdensitometric tracing of the spectrogram obtained on December 18 is shown in Figure 1. The continuum is very much bluer than that of the supernova in NGC 6946. Balmer lines are not seen either in emission or in absorption while a strong absorption feature is seen centred on 6175 Å. These characteristics are typical of a type I supernova (Oke & Searle 1974). The wavelengths identified in Figure 1 have been corrected for the heliocentric recessional velocity 1774 km s^{-1} of NGC 1316 (de Vaucouleurs, de Vaucouleurs & Corwin 1976). While the spectrum resembles in general the typical type I spectrum of the first 20 days, there are a few exceptions. The redward shift of 4600 Å feature by 100 Å and the complex feature at 5180–5570 Å are characteristic of the type I spectrum 20–60 days after maximum. The feature around 5000 Å is also typical of this

Table 1. Identified absorption features in the spectra of the two supernovae

λ_{obs} Å	Identification	λ_{lab} Å	Expansion velocity km s^{-1}
Type II SN in NGC 6946			
4755	$H\beta$	4861	6540
5070	Mg I b	5180	6370
5780	Na I D	5893	5750
6420	$H\alpha$	6563	6540
			Average : 6300 ± 375
Type I SN in NGC 1316			
4770–4910	Fe II	4924–5018	7950
5040	Fe II, N II	5169–5180	7740
5570	N II	5679–5710	6550
6175	Si II	6347–6371	8450
			Average : 7675 ± 800

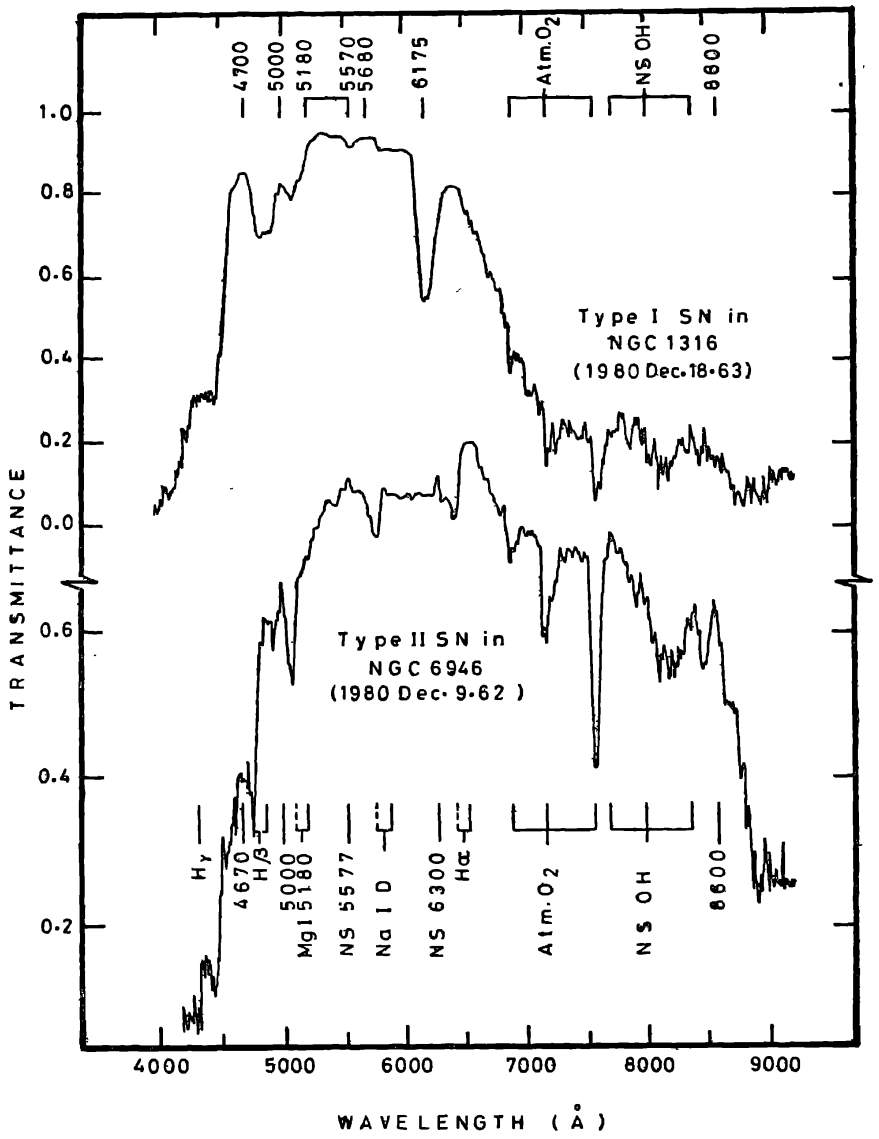

Figure 1. Microdensitometric scans of the spectrograms of the supernovae in NGC 1316 and 6946. Various emission features and the P Cygni absorption components (dotted lines) are identified. *NS* denotes the lines of the airglow spectrum while *Atm.* denotes the atmospheric absorption bands due to O_2.

later phase. However, the emission at 6550 Å which develops at the later stage, has not appeared yet. Also Ca II 8600 Å is very weak.

The identification of spectral lines in the supernovae of type I is more difficult than in the spectra of type II supernovae. We have listed in Table 1 the absorption velocities of the less controversial identifications. The mean expansion velocity of 7675 ± 800 km s^{-1} is larger than that of the type II supernova in NGC 6946.

This is the first supernova recorded in NGC 1316. Its being type I is consistent with the hypothesis that the supernova producing E/SO galaxies are generally peculiar, and that the supernovae they produce are always of type I (Oemler and Tinsley 1979, Kochhar and Prabhu 1981).

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Abstracts of Papers Presented at the Sixth Annual Meeting 1980 November 25-29 at Ahmedabad

Non-linear electromagnetic waves in relativistic plasma

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A finite amplitude linearly polarised electromagnetic wave (pump wave) propagating in a homogeneous relativistic plasma can generate longitudinal electric field components at the second harmonic of the pump wave frequency as well as at zero frequency. The evolution of the pump wave amplitude is described by a non-linear Schrödinger equation. For ultra-relativistic electron and ion temperatures, the envelope solitons are always unstable against modulational instability. For plasmas containing ultra-relativistic electrons and non-relativistic ions, the modulational instability can exist in the temperature range $1 << (K T_e/m_e c^2) < 2m_i/15m_e$. ($K$, T_e, $m_{e(i)}$ and c are the Boltzmann constant, electron temperature, electron (ion) mass and the velocity of light respectively).

Excitation of the auroral kilometric radiation by whistler mode instability

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The intense radio waves observed by satellites to be emanating from the auroral region of terrestrial magnetosphere are strongly correlated with magnetospheric substorms. This auroral kilometric radiation (AKR) has frequencies close to the local electron cyclotron frequency and is dominantly right circularly polarized. Simultaneous AKR and auroral hiss activity have been observed. The free energy of the precipitating electrons during a substorm can drive the whistler mode unstable in this region and this process can be the origin of the simultaneous AKR and auroral hiss activity. The whistler waves are right circularly polarized and are excited in the frequency and wavelength range that agrees with the observations.

Wave interactions in astrophysical plasma

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A highly simplified stability analysis of astrophysical plasma was carried out by Jeans with a view to accounting for the formation of stellar systems. Jeans' linear theory or its various generalizations failed to explain the instability of wavelengths

shorter than those predicted by Jeans' theory. We therefore consider a non-linear theory of stability of magnetized, gravitating plasma. Our analysis of wave-wave interactions shows that instability can be triggered when a wave mode interacts with itself or with other modes that can be excited in the system. In the astrophysical plasma under investigation the linear analysis permits three modes : a fast and a slow magnetoacoustic mode and an Alfvèn mode. It is found that instability can be triggered at a wavelength less than the Jeans' wavelength. The growth rate increases aperiodically at a rate which is proportional to time, t, when a mode interacts with itself. The growth rate becomes faster and varies as t^2 when any two of the three modes have identical frequencies and wave vectors. The system also permits a singular situation when all the three modes in a linear theory degenerate to the same phase speed. This case, when all modes are in resonance, is the most unstable in the sense that the instability can now be triggered at a rate which varies as t^3.

Structural studies in the soft diffuse x-ray background

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The large scale structure of diffuse soft x-ray background in the energy range 0.1–0.4 keV (L-band) and 0.4–1.0 keV (M-band) has been studied over a quarter of the sky, using collimated (5° × 5° FWHM) proportional counters flown on a freely spinning RH-560 rocket. The counters (area about 1000 cm²) were equipped with 1.5 μ polypropylene window and filled with propane gas. The payload was launched from Sriharikota (lat. = 13°.7, long. = 80°.2) on 1979 June 24 and reached an apogee of 332 km. The rocket was allowed to precess with a half cone angle of 30°. X-ray counts recorded along the scan path were lumped in each 5° × 5° sky bin in the galactic coordinate, corresponding to the central axis of the field of view, thus constructing the x-ray brightness maps in the L and M bands. In this experiment we observed the previously unscanned region of the sky bounded by l^{II} = 180° to 270° and b^{II} = 40° to 75°. This region is found to be very bright in the L-band.

X-ray sky monitor experiment onboard Bhaskara

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An x-ray sky monitor was launched on 1979 June 7 on board the second Indian satellite, "*Bhaskara*". The instrument consisted of a 1 cm² area pin-hole placed above a position sensitive proportional counter pointed along the spin axis. The primary objective of this instrument was to study the time variability of x-ray sources

and to detect new transient x-ray objects. The instrument was turned on after about a fortnight of its launch on 1979 January 21 and remained operational till 1979 June 30 when it was switched off by command. The instrument performed satisfactorily during its 'on' state. However, no new transient source was detected during this period in the part of the sky ($\alpha = 265°$ to $50°$, $\delta = +5°$ to $-75°$) scanned by the x-ray sky monitor.

Luminosity variation due to neutrino Angular momentum in stellar collapse

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We examine the luminosity variation due to a decrease in the angular momentum per unit mass caused by neutrino emission during the formation of a neutron star by the collapse of a sufficiently massive stellar core. It is found that the diminution in the luminosity during the process of the collapse varies directly as the fourth power of the angular velocity of the rotating core.

An attempt to understand the observed antiprotons in cosmic radiation

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Production spectrum of secondary antiprotons($\bar{p}$) (in cosmic rays due to the interaction of cosmic ray nuclei with interstellar gas has been calculated by making use of a new and accurate parametrization of the invariant cross-sections available at accelerator energies. Equilibrium spectra of $\bar{p}$ have been determined using various models of cosmic radiation by taking into account ionization, annihilation and inelastic interactions with finite inelasticity. It is shown that the observed $\bar{p}$ are in excess of the calculated flux by more than a factor of four.

Revised closed galaxy model for cosmic ray propagation

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A new galactic model for the propagation of cosmic rays has been proposed recently to account for the observed flux of antiprotons. It is assumed in this model that about 50 per cent of the observed cosmic ray nucleons are of recent origin, while the rest are totally confined in the Galaxy. The recent component ($\sim 10^7$ yr) propagates according to the existing models of cosmic rays, which are invoked to explain the energy dependence of the abundance ratios of secondary to primary nuclei. The equilibrium spectrum of positrons has been calculated on the basis of the new model by taking into account all energy loss processes. The results are found to be in

agreement with the observed flux values. Using the calculated spectrum and the observed charge ratio of e^+/e^-, the total interstellar electron spectrum has been estimated; this is also found to be consistent with the limits set from galactic radio emission. Because of the short mean free path for heavy nuclei, most of the nucleons belonging to the old component are in the form of *p* and *He*; thus > 90 per cent of the observed heavy nuclei of charge $\geqslant 6$ are of recent origin. Therefore, the observed energy dependence of the abundance ratios of secondary to primary nuclei can be explained well by this model. From the observed energy spectra of *p* and *He*, it is argued that 'nested leaky box' model, in which part of the matter traversed by the cosmic rays is near the source regions, is the right choice for the recent component. The new galactic model proposed predicts more *D* and He^3 than the existing ones.

Distribution of infrared sources in the galactic plane

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Though the near-infrared surface brightness distribution of our galaxy shows a gradient in the flux along the galactic plane which is correlated with the 2.6 mm line emission of CO molecules, the infrared brightness derived by counting each individual 2.2 μm infrared source exhibits small scale structure which shows peaks consistently at every $\sim 10°$ interval in the galactic longitude. The small scale structure is found to be correlated with the fine structure of 2.6 mm emission line of CO molecules indicating that the infrared sources are associated with the dense clouds of molecular hydrogen in which stars are being formed. The infrared brightness of the galactic plane which includes radiation emitted from both background and stellar sources is found to be ~ 5 times greater than the flux derived from 2.2 μm sources, suggesting that a significant portion of the infrared flux is contributed by the background radiation, which may be attributed to the emission from gas and dust particles or the obscured infrared sources in the galactic plane.

Near-infrared observations of R Coronae Borealis

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N. Kameswara Rao *Indian Institute of Astrophysics, Bangalore 560 034*

Observations of R Cr B were made on the Kavalur 1-m telescope in the J, H, K and L bands in the near-infrared in 1979 and 1980. Previous infrared observations of R Cr B in the above infrared bands are very few, except in the L band.

During our observing period of one year the change in the magnitudes has been less than 0.1 in all the bands. Comparison with other observations shows that during the past five years R Cr B has brightened marginally in the H, K and L bands but not in the J band. A long term periodicity of about 1100 d has been proposed in the L band by Strecker. Assuming this period our observations fall a little beyond the minimum. No such long range periods have yet been proposed for the J, H and K

variations. On the night of 1980 February 18-19 we found rapid variations in the K band in a continuous 100 min record. Power spectrum analysis gave significant short term periodicities with a dominent 25 min period. Peak to peak variation was 0^m25 with a probable error of 0^m05. We present this as a tentative result which needs further confirmation. It may be pointed out that short term variations (<30 min, 0^m2 variation) in the UBV bands have been reported earlier for XX Cam, a star of R Cr B class.

Photometry of the solar corona of 1980 February 16

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The direct photographs of the corona taken with the double polarigraph, with blue and red filters, are analysed. Isophotes show a north south asymmetry which is correlated with a higher prominence activity in the north. Ellipticities and central shifts for various contours are derived. Radial intensity distributions along the equatorial and polar directions are compared with the van de Hulst curves for maximum corona.

Coronal temperature measured during the total solar eclipse of 1980 February 16

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At the time of totality, we took at Gadag (15° 25′ N, 75° 37′ E)

(i) a coronal interferogram in λ 5303Å, and
(ii) photograph of solar corona in λ 5303 Å through a 10Å band width filter.

The coronal interferogram was taken with a Fabry-Perot etalon having a free-spectral range of 4.68Å and a finesse of 22. The resulting instrumental width was 0.23Å.

Coronal temperatures from corrected line widths are mainly in the range (2–4) × 10^6K. Line width temperature contours show that coronal temperature structure during the solar maximum period is quite complex. However, a notable feature at many azimuths is the tendency of the temperature to reach a local maximum value at $1.11 \pm 0.03\ R_\odot$ from the solar centre. This agrees well with the model calculations of Kuperus [*Space Sci. Rev.*, **9**, 713 (1969)].

From microphotometer tracings of 5303Å photograph log I vs $R/R_\odot$ plots have been made for various azimuths. We have determined the scale height temperatures assuming collisional excitation. The scale height temperatures do not show the large variations seen in line width measurements but marked discontinuities in slope

of log I vs $R/R_\odot$ plots are correlated with gross changes in line width temperatures. Correlations of high line-width temperature points with brightenings in a corresponding x-ray picture or with coronal magnetic structures remain to be studied.

Coronal electron density distribution from white light totality photographs taken through a polaroid

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During totality a series of white light photographs of the corona were obtained with a 3.5-inch f/16 Questar telescope. The photographs were taken on pre-calibrated Kodak Plus X (125 ASA) 35 mm film through a polaroid oriented successively at relative angles 0°, 45°, 90° and 135°. The white corona up to $3R_\odot$ could be studied from these photographs. An extensive program of digital micro-densitometry has been carried out on all photographs with a resolution of 50 μm on the film (or 0.007 $R_\odot$ at the corona). Each frame was divided into 600 × 500 squares giving 300,000 grey levels. A computer analysis to determine the electron density distribution from the data is currently in progress. Some results will be presented.

Coronal temperatures as measured from [Fe x] 6374Å

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Spectra of solar corona during the total solar eclipse of 1980 February 16 were taken in 6374Å [Fe x] line using a high resolution multislit spectrograph. The observed line profiles from 1.1 $R_\odot$ to 1.7 $R_\odot$ give half widths which vary between 0.6Å and 2.4Å. A large number of locations have half-widths around 1.3Å corresponding to a temperature of 4.6×10^6K. If temperatures of the order of 1.5×10^6K are typical of the regions that emit [Fe x] then turbulent velocities of $\simeq$ 30 km s^{-1} need to be invoked for the enhanced line broadening.

Interpretation of H_α emission from solar corona

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At the 1980 February 16 solar eclipse H_α emission has been observed from solar corona. An attempt has been made to interpret this emission in terms of the combined effect of (a) resonance excitation of the residual neutral hydrogen atoms by disk L_β, and (b) electron collisional excitation of coronal neutral hydrogen. During the de-excitation process of the excited hydrogen atoms in the third quantum state about half would decay into the second quantum state giving rise to H_α-photons.

Polarisation of the solar corona of 1980 February 16

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The corona was photographed at the total solar eclipse of 1980 February 16 with a quadruple camera of one metre focal length. Eleven exposures were obtained, each with the four coronal images, exposed through a broad band filter with peak transmission at ~6300Å and polaroids with planes of polarisation 45° apart.

Microwave flux measurements during 1980 February 16 total solar eclipse

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Solar radio fluxes at 2.8, 10, 19.3 and 22.2 GHz were measured at Japal-Rangapur Observatory during the total eclipse of 1980 February 16. Residual fluxes of 23, 3.5 and 3 per cent of the uneclipsed values were observed at 2.8, 10 and 19.3 GHz 2 to 7 min prior to the totality. Using the slopes of the observed eclipse curves, the radial brightness distribution of the eclipsed Sun was derived at the four freqnencies. Limb brightening was observed on the south-west limb of the Sun. Enhancements of radio brightness ranging from 25 to 75 per cent and half power widths of 2 to 4 arc min were observed corresponding to two bright regions seen in H-alpha photographs of the Sun. The brightness distributions indicate regions located around 0.4 $R_\odot$ from the west limb which are cooler than the uniformly bright solar disk.

Radio observations of the solar eclipse of 1980 February 16 at Ootacamund

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The solar eclipse of 1980 February 16 during which 88 per cent of the Sun was eclipsed over Ooty has been observed at 327 MHz using the Ooty radio telescope and at 1630 MHz using a 13.5-m dish. The 12 beam system of the Ooty telescope has enabled us to identify the occultation of features on the Sun at different heliographic latitudes. The occultation of the large sunspot in Hale region 16653 is clearly seen. Evidence is presented for the existence of a feature on the south-west limb, probably a large streamer, which at 327 MHz extends to about 8′ above the limb. The size of the Sun at 327 MHz is also discussed. Using the occultation curve at 1630 MHz we deduce the spectral index of the features seen at 327 MHz.

Observation of 10.4 cm radionoise during the solar eclipse of 1980 February 16

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Using an S-band radar at Madras, measurements of solar radiation flux at a wavelength of 10.4 cm were made. On 1980 February 16, there was rapid drop in signal level in the half hour before the maximum phase and gradual rise after the maximum phase. The radiation flux fell to less than 5 per cent of the normal value at the maximum phase of the eclipse, although the eclipse was not total at Madras. This may be compared with the figure of 7 per cent given for the total eclipse of 1954 June 30.

Solar radiation and air temperature measurement during the solar eclipse of 1980 February 16

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Data for the direct solar radiation on horizontal surface collected at six peninsular stations on 1980 February 15, 16, 17 have been analysed. The percentage fall in the radiation in various phases of the eclipse at each station is evaluated and compared with the theoretical percentage fall in radiation received at the top of the atmosphere. Air temperatures recorded at surface at three stations inside the totality path were analysed. Surface temperatures at some selected stations where the eclipse was partial were also analysed. The maximum fall of temperature occurred just after the maximum phase and was 2.4°C.

Ionospheric effects at Ahmedabad of the total solar eclipse of 1980 February 16

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Ionosonde observations and Faraday rotation measurements were made at Ahmedabad to study the ionospheric effects of the total solar eclipse of 1980 February 16. Data on the eclipse day and on control days, 1980 February 17-19, are presented here in a comparative way. Decreases in the critical frequencies of E, F_1 and F_2 layers *viz.* f_0E, f_0F_1 and f_0F_2 and in the minimum frequency f_{min} detected by the ionosonde and associated with the eclipse were noted. True height analysis of the quarter hourly ionograms shows decreases in the electron densities at various heights, the effects being gradually delayed at higher altitudes. Increase in the height of maximum F_2 layer ionization (h_mF_2) and in the semi-thickness of the F_2 layer (y_m) were noted. A decrease in the total electron content, derived from the recording of Faraday rotation at Ahmedabad, occurred during solar eclipse. No evidence of gravity waves, generated because of the eclipse, and propagating in the ionosphere could be detected from the continuous recording of f_0F_2 or from total electron content.

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Effects of the total solar eclipse of 1980 February 16 on total electron content at low latitudes

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A number of polarimeters to record Faraday rotation at 136 MHz using radio beacon radiated by the Japanese satellite ETS-II were set up at low latitudes to investigate the effects of the total solar eclipse of 1980 February 16. The stations included Rangapur in the totality zone and Ahmedabad, Rajkot and Poona away from the totality. Decreases of about 10 per cent in the total electron content were observed with a delay of about 15–20 minutes. No evidence of eclipse induced gravity waves could be detected from these measurements which is in contradiction to the theoretical predictions of Chimonas and Hines.

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Experiments during the total Solar eclipse of 1980 February 16

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We describe here the experiments conducted by the Association of Bangalore Amateur Astronomers during the solar eclipse. Good quality photographs of solar corona in polarised light were obtained for three directions of polarisation. Experiments for flash spectrum and electron density measurements however failed.

Contact timings of solar eclipse from photographs

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Accurate contact timings can be obtained by photographing the Sun close to the time of contacts. Accurate measurements of the diameter of the Sun and of the distance between the horns of the eclipsed Sun can be used to determine the exact time of contacts. A pair of photographs were selected and the above measurements taken. The diameter of the Sun was obtained from the ephemeris and the scale of the photographs determined. The travel of the Moon between the two photographs is calculated after taking into account its shift due to parallax and refraction. The position of the Moon, and thus the time at contact can be determined by solving a simple geometrical figure.

Evidence for prominent enhancement in solar flare activity on a million year time scale

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The recent careful analyses of sunspot and other data by Eddy have provided definite evidence for abnormal behaviour of the Sun during the 14th and the 16th centuries. Using tree ring C^{14} data, Eddy has postulated several periods of Solar grand maxima and minima during the last seven millenia.

A 'hard-rock' method has been developed in recent years to study the long term variability of solar flare radiation. The method is based on the study of solar flare proton induced radioactivity and heavy nuclei induced solid state damage in extra-terrestrial samples, i.e., moon rocks and soil and meteorites. All solar flare data so far were found to be consistent with a long term solar constancy over periods of 5 Myr. The Eddy 'shock' led us to reexamine the prehistoric and contemporary flare data carefully and we have found definite evidence for large variations in solar flare radiation in the past on a shorter time scale. The simplest hypothesis consistent with our present understanding of flare acceleration processes is that the flare propagation and acceleration characteristics during grand maxima and grand minima are totally different, the flares being more intense and energetic during periods of grand maxima.

Solar flare and solar wind activity at present and in the past

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Studies on specific mineral grain-size fractions of lunar soils and gas-rich meteorites permit a quantitative characterization of the composition and flux of the solar wind using methods developed in our laboratory and elsewhere. The "solar" wind noble gas abundance patterns, both isotopic and elemental, are distinctly different from those of "planetary" components and the clues obtained from these compositional differences are discussed with regard to the evolutionary time scales of our present Sun. The noble gas components in lunar soils and in gas rich meteorites produced by solar flare protons are quantitatively isolated using selective etching of the mineral size separates and stepwise heating decomposition techniques. The average solar flare proton fluxes in the last few million years deduced from the present studies are compared with the contemporatory solar fluxes estimated from satellite measurements. $^{3}He/^{4}He$ and $^{4}He/^{20}Ne$ ratios in lunar samples are sensitive indicators of the temporal changes in solar temperatures. Based on these isotopic data in lunar cores, the low solar nutrino flux observed by Davis is discussed.

A CCD camera for a possible Indian space mission for comet Halley observations

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With the recently acquired capability of launching a spacecraft, a Rohini Satellite Mission for the study of comet Halley has become a distinct possibility. Realising

the potential of CCD camera technology for imaging the comet in ultraviolet, visible and near-infrared bands, we have performed a feasibility study of an experiment incorporating this device in conjunction with suitable optics that can be flown on-board a Rohini spacecraft of 150 kg class. Details of the design of the experiment in terms of sensitivity limits, spatial resolution, contrast considerations etc. and the resulting requirements on the spacecraft along with the problems associated with the use of CCD's in space environment are discussed. Preliminary results from a laboratory model of a CCD camera employing a 244 × 190 element Fairchild CD 211 device are now available.

Lunar occultation of Jupiter at 327 MHz

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Occultation of Jupiter by the Moon on 1980 June 18 was observed at 327 MHz using the Ooty radio telescope. The observations provide one dimensional brightness distribution of Jupiter with resolution of about 10–20 arcsec. The results are compared with other high resolution radio observations. Location of radiation peaks and extent of radio size are discussed.

Model dependence of the rotational temperature of SiO in sunspots

L. M. Punetha, G. C. Joshi and M. C. Pande *Uttar Pradesh State Observatory, Naini Tal 263 129*

To select a model for representing the physical conditions in sunspots in the infrared, we have calculated the rotational temperatures of the fundamental band of SiO. The calculated rotational temperatures at the centre of disk in the four selected models are : (1) 3918 ± 5 (Henous 1969), (2) 3648 ± 4 (Stellmacher & Wiehr 1970), (3) 3675 ± 4 (Kneer 1972) and (4) 3468 ± 4 (Zwaan 1974).

These rotational temperatures may be used in future when the umbral spectrum around 8 μm is available.

Henoux, J.C. (1969) *Astr. Ap.* **2**, 288.
Kneer, K. (1972) *Astr. Ap.* **18**, 32.
Stellmacher, G. & Wiehr, E. (1970) *Astr. Ap.* **7**, 632.
Zwaan, C. (1974) *Solar Phys.* **37**, 99.

A time dependent model for spicule flow

S. S. Hasan and P. Venkatakrishnan *Indian Institute of Astrophysics, Bangalore 560 034*

A time dependent model for the flow of gas in a spicule is studied. In this model the flow occurs in a magnetic flux sheath. Starting from hydrostatic equilibrium, the flux sheath is allowed to collapse normal to itself. The collapse induces a flow of gas along the magnetic field and this flow is identified as a spicule. A variety of sheath geometries and velocity patterns for the normal collapse have been studied. It is seen that a large curvature in the field geometry and a large-initial value for the normal flow are necessary for building up spicule-like velocities. The duration for which a

large velocity of normal flow is required is much shorter than the average life-time of a spicule. It is proposed that the initial rapid collapse occurs during a "pre-spicule" phase and it is the subsequent relaxation of the flow which is observed as a spicule.

Temperature and flux distribution along a solar coronal loop in presence of a source of heating

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Expressions are obtained for temperature and flux distribution for a solar coronal loop in the presence of a Gaussian source of heating in plane parallel and line dipole geometrics under static conditions. These expressions are then used to estimate the aforesaid quantities for the flare loop of 1973 November 26. The formulation is not appropriate near the foot-points of the loop as the temperature gradients and fluxes there are too high. The fluxes in line dipole geometry near the foot-points are much higher than those in plane-parallel geometry because of a large decrease in the area of cross-section of the loop in the former geometry.

Intense microwave bursts observed at 2.8, 10 and 19.3 GHz on 1980 June 4

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Simultaneous microwave GRF type bursts were observed at 2.8 and 19.3 GHz at Ahmedabad and at 10 GHz at Hyderabad on 1980 June 4 in association with M-class x-ray flares starting at 0654, 0751 and 0835 UT. The microwave burst starting at 0817 UT at 19.3 GHz and at 0826 UT at 2.8 GHz was the most intense and was observed at all the three frequencies. The peak of the burst occurred at 0837, 0838 and 0839 UT at 19, 10 and 2.8 GHz respectively, showing the propagation of the generating agency from high to low frequency. Since the mechanism for centimetre radiation is considered to be gyro-synchrotron emission from energetic electrons in strong magnetic fields, the magnetic field, energy of the electrons and angular size of the burst source are estimated for this event taking into account the multi-frequency flux observations made at other places. These are $\sim$900 G, 1.4 MeV and 0.3 arcmin respectively. The brightness temperature works out to be 1.2×10^4K at 19 GHz and 2×10^6K at 2.8 GHz, respresenting plasma heating in association with x-ray transients.

Observations and interpretation of the slowly varying component of solar radio emission at decameter wavelengths

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We have observed the slowly varying component of solar radio emission at a frequency of 34.5 MHz with half power beam widths of 26/40 arcmin in the east-west

and north-south directions. It is found that the observed brightness temperatures vary within 0.3×10^6K and 1.5×10^6K and the average half power widths of the brightness distribution on the Sun is about 3 $R_\odot$. We have not seen the peak of brightness distribution rotating in any regular manner. This is perhaps due to the fact that the entire corona is uniformally raised to the required values of electron density and temperature or else there are several unresolved regions. It should however be pointed out here that the width of any discrete region, if it exists, should be $\gtrsim$ 20 arcmin.

The interplanetary Scintillation observatory at Thaltej, Ahmedabad

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A large radio telescope at a frequency of 103 MHz is in operation at Thaltej near Ahmedabad and is the first of the three telescopes to be developed for the study of the interplanetary medium and structure of compact radio sources. With an aperture of 5000 m², the telescope functions in the form of a correlation interferometer having 32 declination beams formed using Butler matrices. Sine, cosine and scintillometer outputs of the correlation receiver are recorded on a strip chart, the former two being digitized and recorded on magtapes. The sensitivity of the telescope is about 5 Jy. About 100 strongly and weakly scintillating sources have so far been detected. Identical radio telescopes at Rajkot and Surat are being developed and are expected to be operational by the end of 1981. This will then be the most sensitive interplanetary scintillation observatory in the world.

Study of interstellar scattering by interplanetary scintillations

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Interplanetary scintillation survey at 80 MHz by Readhead & Hewish (1974) showed a deficiency of scintillating sources at low galactic latitude which they attributed to interstellar scattering. In this interpretation it is hard to understand the presence of some very compact scintillating sources close to the galactic plane which has led to the suggestion by Rickards & Cronyn (1979) that these sources may be a new class of compact galactic objects (scintars). Since scintillation observations at 327 MHz are not strongly affected by interstellar scattering, a survey of about 500 deg² in the galactic plane ($b_{II} < 10°$; $180° < l_{II} < 235°$ and $30° > \delta > 5°$) was made using the Ooty radio telescope to detect scintillating sources. Results indicate that the statistics of scintillating sources at 327 MHz is not significantly dependent on the galactic latitude in the region studied. This shows that the existence of any new class of scintillating sources is unlikely. Further, all strong sources which scintillate at 327 MHz also scintillate at 80 MHz. It is therefore not clear whether the absence of

scintillating sources reported by Readhead & Hewish (1974) is really due to interstellar scattering or due to their poorer sensitivity in the galactic plane where the background temperature is higher.

Readhead, A. C. S. & Hewish, A. (1974) *Mem. R.A.S.* **78**, 1.
Rickards, J. L. & Cronyn, W. M. (1979) *Ap. J.* **228**, 755.

A study of the supernova remnant

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The supernova remnant IC443 was observed at 34.5 MHz using the Gauribidanur radio telescope with a resolution of 26 arcmin, The radio map of the region was obtained. The brightness distribution appears to be different from that observed at higher frequencies.

Microcomputer system for a digital correlation receiver

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A microcomputer system based on RCA 1802 microprocessor was developed for controlling an "on line Fourier transform processor". This processor is used to obtain the brightness distribution map from different correlation coefficients measured on an antenna array comprising of long east-west element of 1.38 km length and 90 north-south elements extending 0.5 km in the perpendicular line at Gauribidanur. The computer controls an incremental magnetic tape recorder where computed brightness distribution values are stored for further processing and also displays brightness distribution map on a TV monitor. In the OFF line mode, the computer is used to set the initial parameters for the Fourier transform processor like beams to be computed, pre- and post-integration controls and the type of Grading function used for various correlation coefficients. The computer is also used to store the Grading tables and phase correction table necessary to correct the measured correlation coefficients. Delays necessary for various interferometer elements in order to keep the delay decorrelation within reasonable values are also computed and set on the various interferometer channels of the receiver.

Relativistic beaming in the central components of extended radio sources

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Several authors have recently suggested that bright compact quasars arise because of relativistic beaming of radio emission in the forward direction when the collimated beams or jets carrying energy from the nuclei happen to be directed close to our lines

of sight. It is possible that the flux densities of the compact central components, which are often found in extended radio sources and have properties qualitatively similar to those of compact sources, may also depend on source orientation. One should therefore expect sources which are inclined at small angles to the lines of sight to have prominent central components and smaller overall linear sizes due to projection. From a large sample of well observed quasars and radio galaxies we find a significant anti-correlation between the fractional flux density in the central component and the projected linear size, which supports the beaming hypothesis. The relative strength of the central component can be used as a statistical measure of the orientation of the source to infer the velocities of advancement of the outer components of double sources. For the sample of quasars we find that the observed asymmetries are largely independent of orientation, and hence unlikely to be due to relativistic speeds of advancement of the outer components.

Extragalactic radio sources with asymmetric extended structure

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A list has been compiled of about 50 radio sources, most of them identified with quasars that appear to have a one-sided radio structure (referred to in the literature as D2 type) characterized by a single extended component displaced from a compact nuclear component coincident with the optical object. The most important difference between the observed properties of D2 sources and those of normal double quasars is that while the central (nuclear) components of most D2 sources account for more than half the total flux density at high frequencies, those in double quasars rarely contain more than 10 to 20 per cent of the flux density. This difference rules out the possibility that D2 sources are normal doubles in which one outer component is intrinsically much weaker than the other. The observed properties of D2 sources provide support to the hypothesis that their nuclear emission originates in relativistic jets inclined at small angles to the line of sight.

Structure of 3C2 and 3C279 at metre wavelengths

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The paper presents structure of the quasars 3C2 and 3C279 with resolution of a fraction of arcsec at 327 MHz derived from their lunar occultation observations. The results are combined with those of IPS and interferometric observations by others in order to derive models from their fine structure. Both the sources exhibit complex structure and contain multiple compact components at metre wavelengths lying in the vicinity of the QSOs.

Redshift distributions of Extragalactic radio sources and optical identification statistics

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In order to study the cosmological evolution of the radio source population, the basic observational data available at 408 MHz are : (a) the source counts $n(S)$ for

$S > 10$ mJy and (b) luminosity distribution of a complete sample of strong sources with $S > 10$ Jy. Although these two observations impose severe restrictions on the possible evolution schemes, they still lead to several alternatives for the radio luminosity function (RLF). However, the models so inferred predict quite different redshift distributions at various flux densities. Hence the optical identifications of radio sources can be expected to set powerful constraints on an acceptable model. In the light of this, a comparative analysis is presented of the models of RLF deemed successful in the recent lierature based on their very good agreement with the source counts and luminosity distribution mentioned above. The redshift distributions predicted by these models are also examined and compared with the available information on the identification statistics. In particular, it is inferred that one of these models is ruled out even by the limited information available on the optical identification of sources of about 1 Jy, corresponding to a majority of sources in the Ooty and Bologna catalogues.

Massive configuration with constant proper and rest observed densities

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Solutions for cold massive spheres with constant rest mass and proper mass per unit volume have been obtained. It is seen that these solutions are not unphysical like the wellknown Tolman's III solution with constant coordinate mass per unit volume. In both of these solutions density decreases outwards and $dP/d\rho$ is positive definite. The maximum surface and central redshifts for the limiting condition, $dP/d\rho \leqslant 1$ everywhere, have been calculated for both the solutions. Calculations have also been made for the gravitational binding coefficients. Finally, these solutions have been used to construct neutron star models and their mass and size have been calculated.

For a constant proper density configuration the maximum surface and central redshifts are 0.374 and 0.731 while those for constant rest-density are 0.526 and 1.18 respectively. The maximum mass and the corresponding size for a neutron star based on a constant proper-density and rest-density models are 2.88 $M_\odot$, 18.09 km and 3.74 $M_\odot$, 19.46 km respectively.

Condensed structures with arbitrarily large redshifts and total mass

M. C. Durgapal and P. S. Rawat *Department of Physics, Kumaun University, Naini Tal 263 602*

The upper limit for the surface redshift of an extremely relativistic structure is 0.81 and that for central redshift of a pulsationally stable cluster is 0.73. We have proposed a model in which a spherical structure is immersed in a pool of photons constrained to move in circular orbits. This gives an arbitrarily large redshifts for structures stable under radial perturbation. The results are then applied to quasars and it is seen that the proposed model does not suffer from the drawbacks of Hoyle-Fowler

type of models. Further, it is believed that the condensed objects with mass $>$ 4.8 $M_\odot$ are black holes, but the new type of object proposed here can account for an arbitrarily large total mass without actually being a black hole.

Global spiral density waves in disk galaxies

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The origin and amplification of spiral patterns in disk galaxies due to the gravitationally unstable global eigenmodes of oscillations have been studied. A global analysis of dynamic oscillations is necessitated by the facts that the main force acting in self-gravitating systems, gravitational force, is long range and there is no neutralizing effect corresponding to Debye's shielding of a plasma which consists of charged particles of opposite signs. The 'local' analysis, which depends heavily on tightly wound spirals, holds no more for relatively longer modes.

The global analysis studied here is based on the linear modal analysis. The hydrodynamic equations governing the system are transformed linto matrix form and an eigenvalue problem is posed. In comparison with the linear mode analysis of spherical stellar structure, there are a few characteristics which are peculiar to galactic disk systems which rotate differentially in general and the main force balancing the gravitational attraction is not only pressure but also the centrifugal force. In such a rotating system, the eigenfrequencies are complex in general and the corresponding eigenfunctions involve a complex phase which may lead to spiral patterns. The amplification time and the pattern-speeds are uniquely determined for each mode from the eigenvalue. Disks with varying order of central concentrations have been studied. The effect of internal pressure on the eigenmodes has also been studied.

Tidal effects of our galaxy on a globular cluster passing through its nucleus

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The change in the internal energy of a globular cluster as it passes through the nucleus of our Galaxy is studied. The cluster is treated as a polytrope of index $n = 4$. It is found that the cluster can survive up to a distance of 2.5 kpc above the galactic plane if the mass, radius and relative velocity of the cluster are 10^6 $M_\odot$, 0.1 kpc and 530 km s^{-1} respectively.

The post explosion shock propagation in the central region of the galaxy

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Immediate consequences of nuclear explosions on the structure and physical state of the galactic disk are considered. Explosions in the nucleus of a galaxy generate

strong shock waves which, while propagating onwards, heat and condense the gas, forming thin dense ring-like gaseous features behind it. Such rings and dense gaseous complexes have been observed in the central region of the Galaxy. These features have been treated here as the remnants of galactic shocks generated by nuclear explosions. We have estimated the time elapsed since the corresponding explosion, the energy released by explosion and the initial temperature and the velocity of the shock waves thus generated. The cooling of the gas heated by strong shocks has also been considered. The time taken by shock heated gas to cool to its original temperature has been estimated to be of the order of $\sim 10^5$ to 10^6 yr, according as the initial shock temperature is about 9×10^6K or 6.4×10^7K. The rate of emission of energy and the total amount of energy dissipated away in the form of radiation in the cooling process have been calculated for different values of initial shock-temperature and also for different field intensities. The high energy radiation emitted in the cooling process is suggested here as a source for heating of dust grains, which ultimately is radiated in the infrared. Thus a part of the infrared radiation from the central region of the Galaxy may originate ultimately from the cooling of the shock-heated gas there.

The formation of a ring structure during a head-on collision between a disk and a spherical galaxy

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The tidal force effects of a spherical galaxy passing head-on through a disk galaxy have been studied at various regions and for various orientations of the disk galaxy with respect to the direction of relative motion of the two galaxies. The density distribution of the disk galaxy is taken to be $\sigma(r) = \sigma_c\, e^{-4r/R}$, where σ_c is the central density and R the radius of the disk. The density distribution of the spherical galaxy is taken to be that of a polytrope of index $n = 4$. It is found that as we go away from the centre of the disk the tidal distruptive forces first increase, reach a maximum, and then fall off. A direct consequence of this is that the central and the outer parts do not experience much tidal disruptive effects relative to the region in between them which experiences maximum tidal disruptive effects and disrupts. Thus, the central and the outer regions remains intact while the region in between them gets disrupted, resulting in the formation of a ring galaxy with a nucleus embedded in the ring, i.e. a ring galaxy of the RN type.

Tidal distortions of a close fair of galaxies from stellar orbits

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The tidal distortion of a close pair of identical spherical galaxies is studied in detail by computing the orbits of stars in the test galaxy. The mass distribution of the

galaxies is taken to be that of a polytrope of index $n = 4$ and the separation to be equal to the radius of the polytrope in this study. Orbits of 120 representative stars in the test galaxy are computed during a time equal to the orbital period of the pair. From the stellar orbits the changes in the shape and the mass distribution of the galaxies are inferred. Our results indicate that in close binary galaxies the expansion of the outer parts is considerably larger than that of the inner parts. We also find that the test galaxy becomes an oblate spheroid after half a period with the minor axis pointing along the direction perpendicular to the orbital plane, and after a complete period it becomes an triaxial system in which the shortest axis is perpendicular to the orbital plane and the longest axis is in the orbital plane and in the direction of the previous position of the companion.

The nature of V-V 1-7 and its central star HD 62001

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G. P. Gilra *Kapteyn Astronomical Institute, University of Groningen, The Netherlands*

The nebula V-V 1-7 which was clearly present on the blue Palomar Observatory Sky Survey plate is not present on the ESO sky survey plates and on the direct plates obtained with 102-cm telescope at Kavalur. The nebula seems to have disappeared in about 23 yr. The central star of the nebula, HD 62001, is found to be a variable in both radial velocity and light. The ground based and the IUE spectra of the star show that it is an Algol type binary with a period of 0.977 days. There is evidence for mass transfer from the primary A0 star to a cooler secondary.

Scanner observations of the Be Stars ν Gem, κ Ori, β Mon and ω CMa

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The photoelectric spectrophotometric scans of the Be stars ν Gem, κ Ori, β Mon and ω CMa have been analysed with a view to obtaining their stellar parameters. The absolute energy distributions of these stars in the wavelength range $\lambda\lambda$350–750 nm have been given. Their effective temperatures and gravities have been estimated from comparisons with non-LTE model atmospheres. The stare ν Gem and β Mon have been found to have Balmer discontinuities in emission. The excess emission in the region $\lambda\lambda$ 620–750 nm has been observed for β Mon and ω CMa.

A new cepheid variable, HD 200925

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Photoelectric observations of the star HD 200925 in the standard UBV system have been made. The period is determined to be $0^d.267394$. From the period and shape of the light and colour curves, the star HD 200925 appears to be a dwarf cepheid.

The physical parameters are derived from the empirical relations. The mass derived for this star is found to agree well with the value inferred from the evolutionary tracks. The star appears to be a post-main sequence star in the hydrogens hell burning stage of evolution. The spectral class assigned is F2 III.

Study of the galactic cluster NGC 6913

U. C. Joshi, B. B. Sanwal and R. Sagar* *Uttar Pradesh State Observatory, Naini Tal 263 129*

Photoelectric UBV magnitudes and colours have been determined for 106 stars in the galactic cluster NGC 6913. The reddening across the cluster field is determined and found to vary from E(B-V) = 0.48 to 1.21 mag. The true distance modulus, $(V_0—M_V)$, to the cluster is estimated to be 10.4 $\pm$ 0.3 mag. It is found that cluster stars are not coeval.

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What stars make supernovae?

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We show that the observed properties of supernovae (SN) can be explained in terms of the hypothesis that 'all' SN come from short lived stars—supernovae of type I (SN I) from stars of mass 4–6.5 $M_\odot$ and SN II from more massive stars. Thus SN can occur only in those galaxies in which star formation has taken place in recent times. We propose that the presence of density waves is essential for the formation of massive stars and hence for SN II. A typical E/SO galaxy will not produce SN; only those will which went through a phase of star formation a few times 10^7 yr ago, so that stars formed then are exploding now. E/SO galaxies in which star formation is continuing will not be called E/SO; they would be classified as I0 which would therefore be prolific producers of SN I.

UBV photometry of XX Cassiopeiae

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UBV photometry of the eclipsing binary system XX Cas is presented. Observations spread over 27 nights include one primary and two secondary minima. Present results differ considerably from earlier findings in the sense that the primary eclipse comes out to be a total occultation rather than a partial transit (Pierce 1938) and that the components of the system belong to F2I, F3V spectral type instead of B4, B6 (Wyse 1934). After rectification, improved geometrical elements, colour indices and provisional densities have been determined. A slightly improved period of $3^d.0671707$ has been obtained. Densities derived from the present observations

are in agreement with the values derived by Wyse (1934) but differ from those given by Pierce (1938) and McLaughlin (1927).

McLaughlin, D. B. (1927) *Astr. J.* **38**, 45.
Pierce, N. L. (1938) *Princeton Contr. No. 18*, 10.
Wyse, A. B. (1934) *Lick Obs. Bull.* **17**, No. 464, 37.

Three colour photometry of BZ Eridani

R. K. Srivastava and B. K. Sinha *Uttar Pradesh State Observatory, Naini Tal 263 129*

The photoelectric observations of the eclipsing binary system BZ Eridani in U, B and V filters have been made . Observations spreading over ten nights include two primary and one secondary minima. A slightly improved period of $0^d.6641701$ has been obtained. Depth of primary minimum obtained in the present observations is less than half of that reported by Meinunger (1966). Likewise the spectral type of the system is also considerably different from that given by Götz & Wenzel (1961). The spectral types of the primary and the secondary components come out to be G0III and G2III respectively. The system does show some properties of W UMa type variables but does not fit in this type fully. We infer that the system is Algol type.

Götz, W. & Wenzel, W. (1961) *Mitt. Verandrl. Sterne, Sonnenberg* 529.
Meinunger, L. (1966) *Mitt. Verandrl. Sterne, Sonnenberg* **3**, 200.

On the frequency distribution in mass ratios of close binary stellar systems and its explanation based on mass transfer

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Close binary stellar systems have been studied for their mass ratios. A frequency distribution in mass ratios is plotted. While it confirms the bimodal distribution for all binary stellar systems with peaks at $\sim$0.3 and $\sim$0.95 and a deep trough at $\sim$0.65, we notice that the peak at 0.3 is due to the semi-detached systems alone while the one at 0.95 is due to detached systems. The contact systems are found spread over the entire range of mass ratios. Such a distribution is explained in terms of a formation mechanism which requires the mass ratio to be very close to unity but not exactly unity. The small difference in mass ratio introduces differential evolution leading to mass transfer. The transfer mechanism continues till the ratio becomes $\sim$0.3. This takes place on a thermal time scale of $\sim$1 Myr (Morton 1960), which is very short and this explains the deep trough at $\sim$0.65. On plotting the mass ratio against the orbital period for semi-detached systems, we find a linear relation showing the mass ratio decreasing with increasing orbital preiod. This is found to be true for periods from $\sim$1 d to $\sim$15 d. We explain this relation in terms of mass transfer from the present lighter to the present heavier component leading to lengthening of the orbital period of the system.

UBV photometry and absolute dimensions of DI Pegasi

U. S. Chaubey *Uttar Pradesh State Observatory, Naini Tal 263 129*

Three colour photometric observations of eclipsing binary DI Pegasi taken with f/13, 104-cm telescope of Uttar Pradesh State Observatory through the standard UBV filters are presented. Two primary minima were obtained and an improved ephemeris has been determined. It is found that the primary star is surrounded by a disk of circumstellar material.

After rectifying the light curve with the Russell method correcting the light produced by gaseous disk, and assuming $x_h = 0.8, 0.7$ and 0.6, respectively in U, B and V filters, the light curve was solved. An inspection of fractional radii, surface brightness of the components, peculiarities of the light curves and variability of the orbital period suggest a semi-detached model of the system, in which the cooler star has filled its Roche lobe.

Analysis of the colour indices yields spectral types F3 for the primary and K3 for the secondary components. If the primary star is assumed to obey the mass-luminosity relation, the following absolute dimensions are obtained : Semi-major axis of the orbit, A = 4.36 $R_\odot$; Masses, $M_h = 1.48\ M_\odot$ and $M_c = 0.70\ M_\odot$; Raddi, $R_h = 1.34\ R_\odot$ and $R_c = 1.37\ R_\odot$.

Examination of the times of primary minima from 1962 to 1980 reveals that after a sudden period decrease around 1969, orbital period is gradually increasing. It is concluded that the eclipsing binary system DI Peg is in rapid mass transfer phase.

41 sextantis-A metallic line spectroscopic binary

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Twenty two spectra of the metallic line *A* star 41 Sextantis were obtained together with those of some standard radial velocity stars using the Meinel spectrograph at the Nasmyth focus of the 48-inch telescope of Japal-Rangapur Observatory during 1979 and 1980 The linear reciprocal dispersion in second order is approximately 33 Å mm^{-1} at λ 4200. The program star is confirmed to be a single line spectroscopic binary.

Structural parameters of hot stars

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Jayanta Kar and J. N. Tandon *Department of Physics and Astrophysics, Univeristy of Delhi, Delhi 110 007*

Equilibrium configuration of stars with significant radiation pressure has been considered. Using a modified perturbation technique the effect of both uniform and

differential rotation on various structural parameters like mass, radius, central condensation have been calculated. It has been noted that the mass and central condensation of both uniformly and differentially rotating star are significantly more than those of the corresponding non-rotationg star.

Relativistic clusters with distribution function of classical polytropes

M. C. Durgapal, P. S. Rawat and R. Banerjee *Department of Physics, Kumaun University, Naini Tal 263 602*

By assuming the distribution function of a classical polytropic cluster the equations of state in the framework of general relativity have been obtained. The equations of state are such that the energy momentum tensor remains positive for arbitrarily large values of central redshift. Detailed solutions corresponding to polytropic indices 1, 1.5 and 2 have been obtained. Clusters with extremely relativistic cores have also been considered. The stability of these structures has been checked by two methods. The more rigorous treatment leads to pulsationally stable structures with $z_c \lesssim 1.8$ which is much higher than the presently accepted limit of 0.73.

The two-component nature of the size-distribution of sunspot-groups in a solar cycle

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We have determined the statistical distribution of sunspot groups with respect to the maximum size reached by them, using the Greenwich photoheliographic data. We find that in each of the four solar cycles between 1889–1933, the size distribution has two distinct components. It is expected that this will provide a useful clue on theories of solar cycle based on the production of magnetic flux tubes within the Sun.

Bursts of star formation in the central regions of spiral galaxies

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Photographic evidence is presented favouring the hypothesis that the central regions of Sersic-Pastoriza galaxies exhibit different strengths and different evolutionary stages of the bursts of star formation in a region immediately surrounding a starlike nucleus. It is also shown that the structure of this perinuclear component is either a prolate ellipsoid rotating end over end, or a disk with an axis of symmetry different from that of its parent galaxy.

Periodicity of comets as known to Indian astronomers before eleventh century A.D.

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Bhattotpala (10th century A.D.) has mentioned categorically about the periodicity as claimed by earlier Indian astronomers. An earlier text *Bhadrabahu Sanhita* mentions some maximum and minimum possible periods of comets. Thus it is believed that Indian astronomers knew that cometary motions were periodic although at that time the methods of computations for predicting cometary positions were not developed.

Some *Samhitas* mention the details of the paths of certain comets which is a clear cut indication of the notion of periodicity of cometary motions. For example, the path of *Chala-Ketu* is given with respect to stars. Thus, some details about cometary orbits were known to Indian astronomers. Periods of some comets are listed in Bhattotpala's commentary on *Brihatsanhita*.

V. B. Ketakara's independent approach to some important problems in astronomy

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V. B. Ketakara (1854–1930) was an Indian astronomer who worked for modernization of panchangas. We have claimed that he predicted Pluto in 1910 A.D. with best accuracy using singular solutions for three body problem and Laplace's laws for mean motions and mean longitudes of satellites of Jupiter in the perturbation theoretical formulation by Poincare. In addition to this he developed a theory to compute the co-ordinates of solar apex from studies of cometary orbits. The results telly quite well with the modern values. He also tried to develop theory of rotation of heavenly bodies.

Astronomical content of the Rig Veda

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The Rig Veda (RV) contains allegorical references to the celestial sphere of around 3000 B.C. Devas are sidereal divisions of the lunar zodiac. The word Nakashatra was coined later and used sparingly for such divisions in the concluding stage of the Rig Vedic period. RV (10, 85, 3) relates that none but the Devas are competent to eat Soma, which is known to be Chandramas by the wise. Soma enjoys his night stay only in the laps of Nakshatras. The Rig Vedic Devas were 34 in number (27 Nakshatras, 7 "planets" including the Sun and the moon). Pleiades (Agni) was then on the Celestial Equator rising due east for 5 months in a year. The starting point

in dividing the Zodiac into 27 equal parts was offered by Pleiades and hence its importance. The moon, moving through the Devas was the month-maker. The solar calendar was introduced later. The Sun with four colurs in the ecliptic against the back ground of fixed stars was termed Vishnu. Vishnu was the divinity of supreme importance striding thrice and thereby covering the entire heavens, sustaining Dharma, which in that period was the performance of Yajnas.

The Veda mentions autumnal equinox where Indra (Jyestha Antares) was posited and winter solstice where Varuna (Lamda Aquarii) was posited. The year opened with autumnal equinox or winter solstice and so Vedic rishis pray for living 100 autumns or 100 winters. The Sun was the leading division and Indra had the privilege of riding upon it for the first time, i.e. the Sun and Antares were strung together. The 34 Devas (27 Nakshatras, 5 visible planets, Sun and moon) were regarded as generated again and again by Yama, the immortal which we identify with the pole star. Yama maintained the Ritam, *i.e.* it regulated the course of the universe. Its *ratha* had no wheels, it was just near the *sapta rishis* (Ursa Major) who guarded the years. Yama resided at the centre of a five spoked wheel ever revolving with the heaviest load without the axle being heated or broken down. We suggest that the pole star at that time was the star alpha Draconis.

The following papers were also presented

Effect of temperature on Cerenkov radiation

D. N. Patro *Physical Research Laboratory, Ahmedabad 380 009*

Effect of seeing plus scattering on the observed intensity of corona

K. D. Abhyankar, P. V. Subramanyam and K. Anthony Raja
Centre of Advanced Study in Astronomy, Osmania University, Hyderabad 500 007

Time structure of the solar drift pair bursts at 34.5 MHz

K. R. Subramanian and Ch. V. Sastry *Indian Institute of Astrophysics, Bangalore 560 034*

Light curve of V 711 Tau = HR 1099 during observing

M. B. M. Sarma and B. D. Ausekar *Centre for Advanced Study in Astronomy, Osmania University, Hyderabad 500 007*

The galactic pole with respect to pulsars

V. R. Venugopal and K. S. Balan *Radio Astronomy Centre, Tata Institute of Fundamental Research, Ootacamund 643 001*

Effect of central condensation on the model of non-radial oscillations of stellar models

C. Mohan and K. Singh *Department of Mathematics, University of Roorkee, Roorkee (U.P.) 247 672*

Second order terms in tidal problem

V. P. Singh *Department of Mathematics, Institute of Paper Technology, Saharanpur*

The structure of rotating polytropes

Manmohan Singh & Gaj Raj Singh *Department of Mathematics, University of Roorkee, Roorkee 247 672*

Surya-Prajnapti as an advancement in theoretical formulations of Vedanga Jyotisha

S. D. Sharma *Physics Department, Punjabi University, Patiala 147 002*