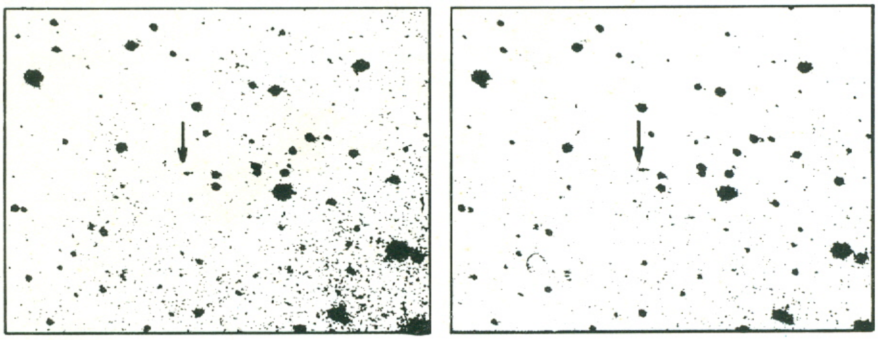
Newsletter

Quarterly Newsletter of the Indian Institute of Astrophysics

Volume 4 Number 4 October 1989

Discovery of Asteroid 4130 Ramanujan



1988 Feb.17 17.4 Hrs UT

1988 Feb.17 18.3 Hrs UT

Project KALKI was launched in January 1987 for survey of asteroids, comets and the tenth planet. As mentioned in an earlier Newsletter (Vol. 2 No. 3, 1987) it took us only a couple of years to add an object to Pogson's list of minor planets discovered from India. Pogson had discovered 5 new minor planets from Madras, the last one in the year 1885.

R. Rajamohan led the team for this project which he named as KALKI after the tenth expected incarnation of VISHNU. The observations in 1987 and 1988 were carried out by K. Kuppuswamy and V. Moorthy. During 1987, the amateur astronomers of the Bangalore Amateur Astronomical Association also took part in this search programme. The project KALKI owes its success to the enthusiastic support and participation of J. C. Bhattacharyya, and has also benefited considerably by collaboration with Tom Gehrels of the University of Arizona.

1988 DQ1 was discovered by Rajamohan on plates taken on 1988 February 17. The measurements of its position was carried out by Arvind Paranjpye. The object was followed up and totally five positions were reported to the Minor Planet Center. A preliminary orbit for this object was reported by Nakano in MPC 13 054 in May 1988. R. Vasundhara developed programmes for predicting its position for future dates and her predictions matched closely the ephemerides that was published by Nakano in December 1988 in MPC 14 045.

1988 DQ1 was recovered close to its predicted position on plates taken with the 45 cm Schmidt by Mr. V. Moorthy on 1989 May 4, 5, 6 and 7. These observations led Nakano to derive firm orbital elements and the Minor Planet Center assigned number 4130 to this object in MPC issue of 1989 July 8. The asteroid has been named in honour of Srinivasa Ramanujan, the Indian mathematical genius.

R. Rajamohan

(4130) Ramanujan = 1988 DQ1

Citation: Discovered 1988 February 17 by R Rajamohan at Vainu Bappu Observatory, Kavalur

Named in honour of Srinivasa Ramanujan (1887–1920), the Indian mathematical genius, Ramanujan is classed with Euler and Jacobi and is regarded as one of the truly great algorists in the history of mathematics. His work on theory of partitions done in collaboration with Hardy won him worldwide recognition. The Hardy-Ramanujan theory led to the circle method which is today one of the most powerful tools in analytic number theory. Ramanujan gave an analytic expression for Pi (π) which has recently been used on powerful digital computers to generate accurate values of it to seventeen million decimal places. During his stay at Cambridge (1913–1919) Ramanujan fell seriously ill and most of the latter half of his stay (1917–1919) was spent in Sanatoria. In 1918, Ramanujan was elected Fellow of the Royal Society, the first Indian mathematician to be so honoured. He returned to India in 1919 and died within a year, before he completed 33. In his last year in Madras, though terminally ill, Ramanujan continued to do a great deal of work and recorded them in a notebook. This 'Lost Notebook' was retrieved in the nick of time before it got incinerated in the home of the Cambridge mathematician Watson, after Watson's death. The American mathematician G E Andrews resurrected it in 1976, more than half a century later and made them available for wide study. The current revival of interest in Ramanujan's work is partly due to the rediscovery of his genius in the pages of the 'Lost Notebook'. Citation prepared by *D C V Mallik* at the request of the discoverer.

Minor Planets discovered by Norman Robert Pogson (1829–1891) Government Astronomer, Madras 1861–1891

The first minor planet discovered on Indian soil was by N. R. Pogson on 1861 April 17 two months after he took over as the Government Astronomer, Madras. He named it *Asia* 'in consequence of its being the first discovery made in this quarter of the globe'.

Before coming to Madras, Pogson had to his credit the definition of magnitude scale, computations of orbits of several comets and minor planets, and discovery of several variable stars and a few minor planets from Radcliffe Observatory, Oxford.

The first minor planet spotted by Pogson was 29 Ampritite which however had been found by Mr. Marth the night before. He had better luck two years later when he discovered on 1856 May 23, the minor planet 42 *Isis* (named after his daughter) for which he was awarded the Lalande Prize for Astronomy of the French Academy of Sciences. Miss E. Isis Pogson was an assistant to her father at the Madras Observatory, and later, Meteorological Reporter for Madras. In 1857 he discovered two more minor planets: 43 *Ariadne* (April 15) and 46 *Hestia* (August 16).

67 *Asia* was the first of the five minor planets discovered by Pogson from Madras. The other four were 80 *Sappho* (1864 May 2), 87 *Sylvia* (1866 May 16), 107 *Camilla* (1868 November 17), and 245 *Vera* (1885 February 6). Vera is also named after his Madras-born daughter who died in her infancy. The name Sylvia had been suggested a few years back by Sir John Herschel for a future new planet. The minor planet 76 *Freia* was independently discovered in 1864 February but turned out to be identical with the one detected by Professor D'Arrest of Copenhagen in 1862.

R. K. Kochhar

The Observing Conditions at Kavalur

J. C. Bhattacharyya

Over the past few months, some doubts are being expressed about the choice of Kavalur as an observing site. Options have been voiced too that the location is totally unsuited for an optical observatory, and that the Vainu Bappu Telescope should be shifted to a better site. Inaccurate figures concerning number of usable nights at some places in India are being circulated in support of such a move. This article aims at projecting the correct picture about sites for possible observatory locations in India and about the existing site at Kavalur.

At the outset, let me point out that an ideal observatory site is yet to be discovered on the surface of the earth; everywhere, a compromise is adopted. The compromise is between many factors such as number of clear nights, number of hours of good seeing, location on the surface of the globe, meteorological conditions like humidity, horizontal visibility, wind speed *etc.* as well as operational logistics. The cost involved in providing easy accessibility to an otherwise excellent site often comes in the way of its choice. Easy accessibility can be totally offset by strong light pollution from nearby urban centres; the example of the famous Mount Wilson Observatory in Western United States is well known. Almost all the city observatories of bygone era are ineffective today in tackling present-day problems.

The choice of site is, in fact, linked to the intended scientific programme of the observatory. In present-day big observatories, programmes are clustered around very faint objects—quasars, external galaxies, faint dwarf stars *etc.*; all these require as many hours of clear skies as possible with good seeing conditions. On the other hand, small observatories attached to universities can carry out their programmes from less ideal sites; easy accessibility being more important in their functioning. In observatories engaged in spectroscopic programmes on stellar objects, even partially clouded skies are useful.

From observers' viewpoint, the prime index for a good observatory site is the number of clear nights available for observations. Total number of observing hours at any site is taken as 3650—365 nights of 10 hour duration on average. The best site available today is Mauna Kea, atop the extinct volcano in Hawaii. The recorded average here is 2800, or roughly 77 per cent of the total. Next best sites are in the Chilean Andes; three observatories here are Cerro Tololo, La Silla and Las Campanas, the average is around 2600, or about 70 per cent of the ideal. Mount Palomar and Kitt Peak in the United States record about 2200, or 60 per cent of all available hours. Other big observatories, such as the Anglo-Australian Observatory at Siding Spring in Australia, or the Lick Observatory in California, USA, record still lower figures around 2000 i.e. about 57 per cent. Some of the old observatories in Europe and America record figures lower than this, sometimes as low as 1000 hours.

In India among the three regular observatories, Kavalur, Japal-Rangapur and Nainital, published data regarding observing hours are not readily available—except for Kavalur, which regularly publishes number of spectroscopic and photometric hours, month by month. From estimates by early observers the following average yearly figures of spectroscopic hours are prevalent: Nainital 1900, and Japal-Rangapur (JRO) 1600. For Kavalur the recorded hours of observation for the period 1972–88 are given in Table 1. The average comes out as 1535 or 42 per cent. There had been years when the figure had crossed 1850 mark. Figures for Nainital and JRO are based on observations almost thirty years ago; it is seen from records all over the world that wide unexpected variations are possible over the years, therefore, these figures can only be taken as tentative. From our experience we can say that chances of a programme of observations being vitiated by clouds appear equal in all the three stations.

Table 1. Clear hours at Kavalur.

Years	Total	Photometric
1972	1550	1025
1973	1485	886
1974	1787	1034
1975	1479	754
1976	1492	697
1977	1512	429
1978	1491	608
1979	1877	813
1980	1607	624
1981	1581	627
1982	1620	505
1983	1350	354
1984	1661	403
1985	1278	329
1986	1573	482
1987	1305	310
1988	1447	437
Average	1535	607

What about possible new sites? Except for observations by a few site survey teams over limited periods at selected spots, no reliable observations of night sky conditions are available. Only systematic observations of meteorological conditions over an extended network covering the entire country are summarized in the 'Climatological Tables', published by the India Meteorological Department in 1967. It is possible to have an idea of the average clouding conditions from which rough estimation of useful nights may be made. Table 2 shows estimated number of photometric and spectroscopic hours, as deduced empirically from meteorological data recorded at some of the stations where astronomical activities are pursued.

Table 2. Estimates of observing hours at different sites.

Site	Location	Photometric hours	Spectroscopic hours
1. Abu	Rajasthan	1760	2385
2. Udaipur	Rajasthan	1440	2250
3. Hyderabad	N. Deccan	590	1642
4. Leh	Ladhak	740	1774
5. Mukteswar (Near Nainital)	Kumaon Himalayas	1025	2060
6. Ootacamund	Nilgiris	445	1356
7. Kodaikanal	Kodai Hills	340	1121
8. Pachmarhi	Satpura Hills	915	1782
9. Vellore (Near Kavalur)	Javadi Hills	245	1439
10. Dalhousie	Western Himalayas	1970	2451

The above table concerns only with the clouding at the stations. The second important quality of the station is 'good seeing' which cannot be determined from meteorological data. Standard method of estimating this is through optical observation of stars; in recent years simultaneous meteorological properties of the boundary layers are also determined. Although any quantitative relation between the two sets of measurements is still to be established, generally seeing is better under less turbulent atmospheric conditions. It must be kept in mind that bad seeing in cloud-free nights can totally spoil efforts to conduct measurements on faint objects or in high-resolution imaging and high-dispersion spectroscopy. In other words the advantage of large apertures are lost due to bad seeing.

There are many opinions regarding conditions for good seeing at any site, and all of them are only partially true. The location of Kavalur does not conform to any of the standard models for stable atmospheric conditions which need cold ocean currents as found along Pacific coasts in north and south Americas, and a few other places in the world. But Kavalur is situated in a peculiar orographic configuration at the base of a bowl-like depression. At Kavalur, ringed by a string of hills, air remains trapped within the depression. This is evident from appearance of low stratified ground fog in winter mornings. Very often the air is calm and seeing excellent. At the time of selection of the site, extensive seeing observations were made, and compared with those of the best sites in the world. Table 3 gives a summary of these comparisons. As far as we are aware, the seeing quality at the other two sites in India comes nowhere near this performance. There may be better sites in the country, where good seeing conditions continue for longer durations, but only a concerted search can bring out that information. For the present, in spite of lower count of clear nights, Kavalur appears to be the best available site for a 2 metre class telescope that aims at reaching the faintest magnitude limits.

Table 3. Comparison of observing conditions at some of the best astronomical sites.

Location	Best seeing observed	Percentage of observed nights with average seeing as indicated				Total No. of nights observed
		1.0"	1.1" to 1.5"	1.6" to 2.0"	2.0"	
Tololo	0.70"	24	32	22	22	509
Junipero Serra	0.5"	26	38	13	23	558
Kitt Peak	0.75"	15	30	16	39	253
Canary Islands		50	29	10	11	38
San Pedro Martir	0.75"	15	25	17	42	52
Flagstaff	1.0"	1	5	29	65	80
Kavalur	0.5"	24.7	30.4	23.4	21.6	795

In his report recommending Kavalur as an astronomical site, Dr M. K. V. Bappu had pointed out another advantage of the location. I quote below an excerpt from his report written in August 1976:

> "*The advantage of a low latitude.* With its low latitude of 12.5°N, Kavalur can observe even the Magellanic Clouds. We are currently using the 102 cm for a survey of red stars in the bar of the Large Cloud, and have already completed more than half of it. The LMC is at declination −71°. We have obtained spectra at Kavalur of objects that are even at −74° declination. With most of the southern Milky Way being north of −62°, Kavalur is a very suitable location for study of problems of the Southern Milky Way".

This advantage provided us the unique opportunity to study the Supernova SN 1987A when detected in LMC in February 1987. Kavalur was the only observatory in India, which could point all their telescopes to study this rare event of a kind that appeared after a lapse of four centuries. In fact, except for a small area of the celestial sphere around the south pole, the entire sky is accessible from Kavalur; such a facility is not possible from locations at higher latitudes.

To summarize: (i) Kavalur has more cloudy nights, the amount being about 10 per cent more over the figure existing at other places in India, but (ii) has a far better performance in seeing, and (iii) has the maximum coverage of the celestial sphere from a single location. The idea of shifting the Vainu Bappu Telescope to a better location is, therefore, ill-conceived; such a move will result in poorer utilisation of the instrument, and vitally affect some of the observational programmes on the faint southern objects.

Wigner Crystallization in the atmosphere of neutron stars

The physics of Wigner Crystallization(1) is based on the competition between the kinetic energy and the electrostatic exchange energy of an electron system moving in the uniform background of positive charges. It was shown by Wigner, that for an electron gas at $T = 0$ K, the kinetic energy per particle is given by $E_{\mathrm{kin}}/N \sim \rho^{2/3}$, while the exchange energy due to Coulomb interaction is negative and is given by $E_{\mathrm{ex}}/N \sim -\rho^{1/3}$, ρ being the number of particles per unit volume. Hence for sufficiently low values of ρ, i.e. $\rho \leqslant \rho_{\mathrm{cr}}$, the exchange contribution can overcome the kinetic energy term. The energy of the system being thus potential energy dominated, the electrons will condense to form a crystalline lattice. Further, Wigner's calculations show that the effect would occur for higher densities in one-dimensional systems than in two-dimensional ones, while two-dimensional systems show Wigner Crystallization at lower densities than three-dimensional systems. In the last decade or so, there have been several reports of practical realization of Wigner Crystal states in condensed matter system(2).

It is in this physical background that the role of magnetic field in creating Wigner states is to be considered(3 − 6). The magnetic field effectively reduces the dimensionality of the system by constraining the electrons to move in Landau orbitals. The system can be considered as nonrelativistic and degenerate if $H \lesssim 10^{12}$G and $(2\pi)^{-4}(e_0 H/c\hbar)^3 > \rho > (m_e k_B T \Omega^2 / 2\pi^4 \hbar^2)^{1/2}$ where H is the magnetic field and $\Omega = m_e \omega_c / \hbar$, ω_c being the Larmor frequency.

Thus for a Crab pulsar the condition of degeneracy is valid for (with ρ in cm^{-3})

$$10^{27} < \rho < 10^{28}.$$

In this case one obtains the total free energy per particle to be

$$E_{\mathrm{tot}}/N = (E_{\mathrm{kin}} + E_{\mathrm{ex}})/N$$

where

E_{kin}/N = kinematic energy contribution

$$= (2\pi^4\hbar^2/3m)\,(\rho/\Omega)^2$$

$$E_{ex}/N = \text{exchange energy contribution}$$

$$= -16\pi^5 e_0^2(\rho/\Omega)$$

$$\times\left[\ln(e^2\Omega/4k_F^2) + \exp(-\mu/k_BT)\,[(k_BT/\mu)^2 - (2k_BT/\mu)\ln(2\mu e^\gamma/k_BT)]\right]$$

with

$$k_F = 2\pi^2(\rho/\Omega),$$

$$\mu = \hbar^2 k_F^2/2m_e,$$

$$e_0 = \text{electronic charge}$$

and $\gamma = e^c$, c being the Euler constant.

It is seen that the system is potential energy dominated, i.e. Wigner Crystallization takes place, for

$$1 - 2(k_BT/\mu)\exp(-\mu/k_BT)\ln(2e^\gamma\mu/k_BT) \geqslant (16\pi^4/e^2\Omega)\,(\rho/\Omega)^2\exp[(\hbar^2/24e_0^2m)\,(\rho/\Omega)].$$

For a neutron star, similar to the crab pulsar, i.e. $H \sim 10^{12}$G and $T \sim 3\times10^6$ K, the Wigner crystalline state can be achieved for $\rho \leqslant 10^{40}$ cm^{-3}. The melting point of the Wigner state is approximated as $T_m \sim 5.8 \times 10^6$ K, which is much higher than the neutron star temperature.

The complete details of the calculations will be published elsewhere.

References

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(2) Tsidilovskii, I. M. 1987, *Sov. Phys. Usp.*, **30**, 676.
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S. Chatterjee

Stellar Populations in Galaxies from Integrated Spectra

A knowledge of the stellar content of galaxies is of critical importance in studying their evolution. The evolution of galaxies has three major facets: photometric evolution, chemical evolution and dynamical evolution. Even though these three aspects are interrelated, photometric evolution is largely concerned with changes in the radiation output, chemical evolution with the net change in elemental abundances and dynamical evolution with morphological characteristics, rotation and interaction with the environment. The character of the net optical radiation emitted by a galaxy changes because the stars constituting it evolve; new generations of stars may form subsequent to the formation of the galaxy as a whole, and older generations may cease to contribute significantly to the light at the end of their evolution.

A study of the stellar content of galaxies at different redshifts (hence different lookback times), in addition to allowing one to trace the history of star formation, would indicate how the net luminosity changes with time, which in turn would affect the 'distance' parameter in the Hubble diagram. To render feasible the comparison of objects at high redshifts (whose morphological type cannot be determined with telescopes available at the present time, but would be determinable with telescopes of the next decade) with those at the present epoch, it is necessary to develop an understanding of the latter; different kinds of galaxies in the present epoch may have different counterparts at high redshifts.

We have undertaken a study of the stellar content of early type galaxies (of type E and S0) from integrated spectra, concentrating mainly in the wavelength region 5550–10000 Å. This region has received comparatively less attention in earlier studies than the region 3800–7000 Å. The technique of optimising synthesis was used to synthesize the spectra of galaxies by coadding the spectra of stars from a library of stellar spectra. The stellar library covered forty-eight groups of differing spectral type, luminosity and metal abundance and consisted of compilations by other researchers supplemented by our own observations. The observed and synthesized galaxy spectra were compared (as explained later) till a good fit was obtained.

Population synthesis was done for three galaxies, NGC 3308, NGC 4472 and NGC 5128. Spectra of these galaxies and of some late spectral type stars for the stellar library were obtained with a resolution of 6 Å over the spectral range 5500–10400 Å using the Reticon detector and the Boller and Chivens spectrograph at the Cassegrain focus of the ESO 1.5 metre telescope at La Silla. Data upto a long wavelength limit of 10000 Å was used for the synthesis, since stellar library data was not complete beyond this limit. The reduction of the spectra to a linear wavelength scale and calibration to absolute fluxes using observations of flux standard stars was done using the ESO IHAP software package. Further reductions of the data as well as synthesis calculations were done using the VAX 11/780 system at the

Vainu Bappu Observatory; the spectral reduction package SPICA (part of the STARLINK software collection) was used for arithmetic manipulations on the spectra and programs were written for other operations. All the flux-calibrated spectra were corrected to remove the bands due to the terrestrial atmosphere, using observations of hot, early type stars taken at positions on the sky as near as possible to the program objects. The spectra of the galaxies were corrected for redshifts using the best values of the velocity of recession available, and all spectra were normalized to the flux at 5556 Å.

The algorithm for optimising synthesis determines the best fit to the observed intensity at each point in the spectrum of the galaxy by the co-added contributions from different stellar types in the library. The goodness of fit of the synthetic spectrum to the observed one was judged by a merit function, which was the root-mean-squared residual, in magnitudes, over the entire spectral range. The optimising routines, originally developed at the Hatfield Polytechnic, were provided by Dr Andrew Pickles, whose stellar library was also used. The method of population synthesis used, therefore, is basically similar to that used by Pickles; some changes were made in the programs as well as new programs written to cater to different data formats and to include new data on the parameters of the different stellar groups. The optimising synthesis solutions were subject to simple astrophysical constraints set by stellar evolution theory: non-negative numbers of stars of different groups, increasing numbers of main-sequence stars below the turn-off and number ratios of certain stellar groups to others, in keeping with the known sequence of evolution and the typical times spent in different evolutionary stages. Further, a scheme of weights was included to emphasize the contribution from different parts of the spectrum; the continuum had a weight around unity, strong spectral features had higher weights and regions corrected for atmospheric absorption (especially where strong absorption occurs) had lower weights. In deriving relative numbers of stars of different kinds from the relative light contributions, and the overall mass-to-light ratio for the galaxy; the absolute magnitudes for different stellar groups were adopted taking account of the most recent stellar evolutionary calculations.

In addition to performing population synthesis, the behaviour of the strength of some spectral features as a function of spectral type, luminosity class and metal abundance was studied. Indices were constructed to quantify the absorption by a spectral line or molecular band with respect to the local continuum. Some of the standard features studied were the Na I D lines, several bands due to TiO, the Na I infrared doublet (8183, 8195 Å) and the triplet due to Ca II (8498, 8542 and 8662 Å); other features studied were a blend of atomic lines at 6362 Å, the CaH band at 6385 Å, the Wing-Ford band due to FeH at 9916 Å and some bands of TiO. The CaH band was found to be a good discriminant between dwarf and giant stars of spectral type later than about K4, being stronger in dwarfs. It is especially useful for measurements for distant galaxies since it can be optically detected at higher redshifts than the infrared lines of Na I. The band index is significant in the galaxy NGC 5128. The Wing-Ford band is detectable (at spectral dispersions feasible for galaxies) uniquely in main-sequence stars of type M4 or later. Our stellar library does not contain stars beyond type M6; the band index is appreciable in the case of NGC 4472 and 5128.

The results of population synthesis show interesting results. For NGC 4472, for the nuclear region observed, we find evidence for marginal star formation activity—about 3 per cent of the visual light is from main-sequence stars of type B6 to B9. The bulk of the stellar population appears to have formed about 8 to 10 gigayears ago, as indicated by the turnoff at spectral type F7-8. The main sequence is well-populated down to the latest spectral types in the library; the light at wavelengths around 1 μm is not dominated by giant stars as was thought earlier, but has significant contributions from main-sequence stars. Surprisingly, in the constrained solution, metal-rich giant stars contribute negligible light—normal abundance and metal-weak stars contribute most of the light due to the giant stars. It must be mentioned that the main-sequence stars in the stellar library span a range of metal abundances and may account for the fit to the line strengths without requiring metal-rich giant stars. Figure 1 shows the observed and synthesized spectra of NGC 4472; the overall blue nature of the continuum is apparent.

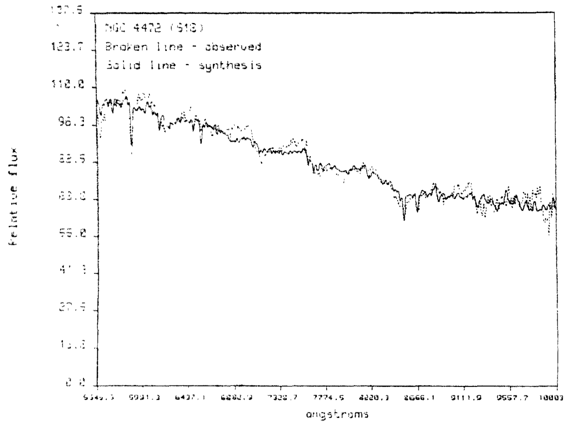

Figure 1. Observed spectrum of NGC 4472 compared with the spectrum obtained from the constrained synthesis solution.

The stellar content of NGC 3308 has been derived for the first time in this study. A member of the Abell 1060 cluster of galaxies in Hydra, it is the faintest and furthest (at an estimated distance of 36 megaparsecs) of the three galaxies in this study. The observed and synthesized spectra are shown in figure 2; the fit is quite good except for the noticeable upward turn of the observed spectrum redward of 9500 Å. Though the best turnoff is at spectral type K0-1, the solution does not give a well-populated main sequence. Surprisingly, this 'normal' early-type galaxy also shows signs of on-going star formation. Main-sequence stars of type A0-3 and giant stars of type B contribute significantly to the visual light. The light due to giant stars at wavelengths around

1 μm is dominated by stars of solar metallicity, the M giant stars contributing about 43 per cent with the latest M6 giants alone accounting for about 20 per cent. The contribution of the metal rich giant stars is negligible and the metal-weak giant stars contribute less than 5 per cent of the light both in the visual as well as in the near-infrared region. Despite the large contribution of late-type giant stars in the best synthesis solution, the synthesized spectrum falls short of the sharp upward rise of the observed spectrum in the 1 μm region; this perhaps indicates that stars of spectral type later than M6 are required in significant numbers.

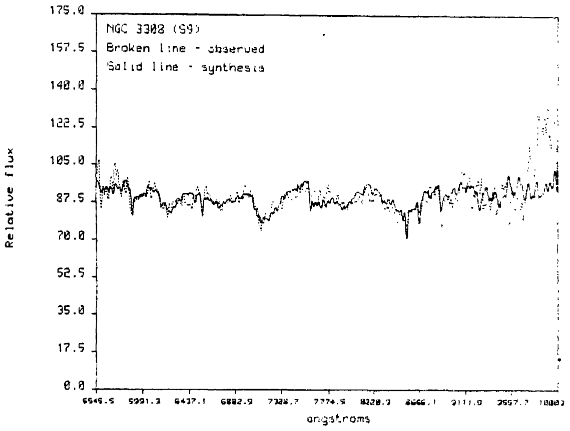

Figure 2. Observed spectrum of NGC 3308 compared with the spectrum obtained from the constrained synthesis solution.

NGC 5128, the well-known, powerful radio source (Centaurus A), has also been studied for the first time with the aim of deriving the stellar content. Being a large, nearby galaxy with evidence of large-scale activity, the study of stellar content from integrated spectra should ideally be done at different points on the galaxy. The results reported here pertain to one point approximately 30 arc sec south of the central, obscuring dust lane in the galaxy, and centred in the east-west direction; this point seems to be visually free of obscuring matter. The observed and synthesized spectra are shown in figure 3. Here again, the observed spectrum shows a sharp, upward rise longward of 9200 Å, which cannot be synthesized by the latest spectral types in the library. The most noticeable feature of the synthesis solution is the contribution of about 24 per cent to the visual light (5556 Å) by main-sequence stars in the spectral type range O to B3, and about 20 per cent by giant stars of type B. This is in keeping with earlier photometric studies which indicated that vigorous star-formation is taking place in this galaxy. Though the best turnoff is at spectral type K0-1, there are sufficient number of stars at earlier spectral types to indicate that star-formation has been an on-going process over the last few gigayears. The solution has a main sequence that is well populated down to the latest spectral types in the library (M5-6); the contribution at 1 μm from stars on the main sequence below the turnoff is about 27 per cent, whereas that from the giant stars (excluding B giant stars) is about 63 per cent. The latest M6 giant group contributes about 26 per cent of the light at 1 μm; the inability to fit the rising observed spectrum in this region indicates a requirement of later spectral types. Also, assuming the formation of massive stars, it may be necessary to include late-type supergiant stars in the stellar library. The contribution by the metal-rich giant stars to the light at 1 μm is about 19 per cent, indicating enhanced metallicity in the galaxy; the stellar library contains metal-rich groups to spectral types of K5. Metal-rich stars of spectral class in the late M range have been found in significant numbers in the nuclear region of our own galaxy. Perhaps the inclusion of such stars (which are quite faint) in the library may allow a better fit to the near-infrared spectrum of objects such as NGC 5128 and NGC 3308.

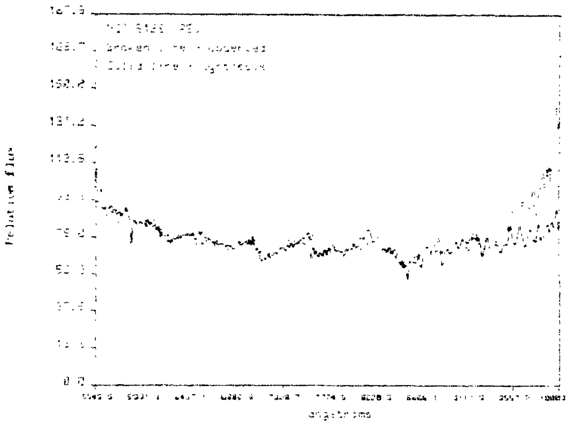

Figure 3. Observed spectrum of NGC 5128 compared with the spectrum obtained from the constrained synthesis solution.

A. K. Pati

(Synopsis of a thesis for which the Bangalore University has awarded its Ph.D. degree to A. K. Pati in April 1989.)

VBT news

Beginning from 1989 October, information on the Vainu Bappu Telescope will be published in *VBT News*, which will discuss the progress of the VBT including accessories, observational programmes on VBT and user's needs. All subscribers of IIA newsletter will also get *VBT News*. Those who want to subscribe for *VBT News* separately may write to the *Editor, VBT News, Indian Institute of Astrophysics, Bangalore* 560034.

out of context

Through out this dark age, a few—notably Alar Toomre—maintained . . . .

Nature, (1989) **340**, 595.

* * *

Although Cygnus X-3 is radiating between 100 000 and 100 000 solar luminosities of gamma radiation . . . .

Supernovae, (1985) *Cambridge University Press*, p.163.

* * *

In the Corona or outermost part of the [solar] atmosphere the temperature reaches very high levels (more than 10 degrees Kelvin).

The SOHO Mission, ESA SP-1104, 1989, p. 7.

Some of the Confirmed Attractions of the IAU Symposium 142 on Basic Plasma Processes on the Sun to be held at Bangalore during December 1–5, 1989.

1. The Plasma Universe *C G Falthammar* (Sweden)
2. Problems of Solar Convection *W Unno* (Japan)
3. From the Solar Plasma to Plasma on Neutron Stars *V V Zheleznyakov* (USSR)
4. Relaxed States of MHD Turbulence; Minimum dissipation or Minimum energy? *D Montgomery* (USA)
5. Magnetohydrodynamics of Sunspots *N O Weiss* (England)
6. Magnetic Reconnection *E R Priest* (UK)
7. Dusty Plasma Process in the Extended Solar Nebula *D A Mendis* (USA)
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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. 4, No. 4, October 1989

To: ______________________________

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Indian Institute of Astrophysics
Bangalore 560 034.