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IUCAA

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No. 32

A Bulletin of the
Inter-University Centre for Astronomy and Astrophysics
(An Autonomous Institution of the University Grants Commission)

October 1997

Welcome to PROFESSOR R.P. BAMBAH

...the new Chairperson of the Governing Board of IUCAA

As per the revised rules of IUCAA, which came into force on May 16, 1997, Professor R. P. Bambah has been nominated by the Chairperson, UGC to chair the Governing Board of IUCAA for a period of three years starting June 19, 1997.

Professor Bambah was born in Jammu in 1925, educated at the Government College, Lahore and St. John's College, Cambridge, where he got his Ph.D. and the Sc.D.(Cantab) degrees in mathematics. His long career in teaching and research has taken him to Delhi and Punjab Universities as well as to centres of learning abroad including St. John's College, Cambridge, the Princeton Institute of Advanced Study, and the Notre Dame and Ohio State Universities. He was Vice Chancellor of Punjab University, Chandigarh, during 1985-91 and a Member of the UGC from 1976 to 1979.

Professor Bambah has worked in Number Theory and Discrete Geometry. His professional career has brought him several honours including the INSA Srinivas Ramanujan Medal, UGC-Hari Om Trust Meghnad Saha Award, the Presidentship of the Indian Science Congress Association and of the Indian Mathematical Society and the Ramanujan Birth Centenary Award of the Indian Science Congress. He is a Fellow of several distinguished academies, like the Third World Academy of Sciences, the INSA and IASc.

We welcome Professor Bambah to the IUCAA family and look forward to his help and guidance in our various programmes.

Inside...

The Advent of Radio Astronomy

The end of the World War II saw the growth of a new branch of astronomy, which had made its first appearance in the 1930s through the pioneering work of Karl Jansky.

While investigating the cause of interference in the ship-to-shore communication system being built by the Bell Telephone Laboratories in 1930, Jansky built a rotating antenna 30 m wide and 4 m high. Operating it for more than two years, he was certain that he was receiving a radio hiss, from no local source, even from the Sun, but from the direction of the Galactic Centre. The discovery, announced in 1933 made headlines but failed to excite the scientific community.

The next pioneer was Grote Reber, a young engineer who built a large antenna in his own back garden at his own expense and working with it during the early 1940s, he was able to confirm that radio waves were coming from the plane of the Milky Way and he was able to make a contour map showing main concentration of the waves from the directions of the centre of Saggitarius and lesser ones from Cygnus and Cassiopeia.

After the world war was over, groups in the U.K. and Australia started building radio telescopes with the expertise acquired by physicists and engineers in wartime radar technology. Bernard Lovell at Manchester and Martin Ryle at Cambridge led the U.K. efforts while down under, Era Bowen, John Bolton and Bernard Mills constructed radio telescopes at Sydney and Parkes. By mid-1950s radio astronomy had come of age with several instruments working up and down the globe.

Meanwhile in Holland, Jan Oort was interested in radio spectral lines and at his direction a young student H.C. van de Hulst made a discovery in 1944, which was to prove to be of tremendous importance. He found that the change of spin state of the electron in the hydrogen atom produces a radio wave of wavelength 21cm (1420 MHz frequency). After his release from the hands of the Gestapo in 1945, Oort initiated a search for the 21cm line in the interstellar space and by 1951, he along with C.A. Muller, was able to establish its existence. Ever since its discovery, this line has played a key role in several different contexts in galactic and extragalactic astronomy.

Finally, this account would not be complete without the discovery of Cygnus A, a radio source first discovered by J.S. Hey, S.J. Parsons and J.W. Phillips in 1946 and whose angular structure was measured in 1952 by R. Jennison and M.K. Das Gupta. The source was optically identified by Walter Baade around that time and its extragalactic nature was to herald the era in which discrete radio sources would play an important role in cosmology.

The SAC Visit

The Scientific Advisory Committee (SAC) of IUCAA had its sixth meeting at IUCAA during July 8-10, 1997. The overseas members who attended included Richard Ellis from IOA, Cambridge; Katsu Sato from RESCEU, Tokyo and Ken Freeman from the ANU, Australia. Sailo Mukherjee from NBU, Siliguri; S.M. Alladin from CASA, Osmania University and G. Srinivasan from RRI, Bangalore made up the Indian component while two members, R. Cowsik (IIA) and S.M Chitre (TIFR)could not attend.

The SAC members had a busy schedule of discussions, presentations and visits after which they came up with a concrete set of recommendations which have been communicated to the Governing Board and the UGC. The SAC was very happy with the progress IUCAA has made on various fronts, in a comparatively short period. For IUCAA, the SAC visits have always acted as a big stimulus, and this one was no exception.

Welcome to . . .

S.K. Banerjee, Valerio Faraoni, Arun Mangalam and **Sumati Surya**, who have joined as post-doctoral fellows. Banerjee's research interest is cosmology; Faraoni's research interests are theoretical cosmology, general relativity and gravitational waves; Mangalam's research interests are magnetic fields in astrophysics, galactic dynamics and active galactic nuclei; and Surya's research interest are general relativity and quantum gravity;

S. Shankaranarayanan, who has joined as research scholar.

. . . Farewell to

Ravi K. Gulati, who has joined the Instituto Nacional de Astrofisica Optica Y Electronica, Puebla, Mexico;

Biman Nath, who has joined the Raman Research Institute, Bangalore;

Shiv K. Sethi, who has joined the Institute of Astrophysics, Paris, France;

Sukanya Sinha;

R. Balasubramanian, who has joined the University of Wisconsin-Milwaukee, USA, as a post-doctoral fellow;

Vijay Chickarmane, who has joined the Physical Research Laboratory, Ahmedabad, as a post-doctoral fellow; and

Soumya D. Mohanty, who has joined the California Institute of Technology, USA, as a post-doctoral fellow.

Astronomy Camp

A camp on Astronomy for high school and junior college students was organized at Hubli, Karnataka during August 10-11, 1997 by IUCAA and Chinmaya Seva Samiti Trust, Hubli. Ajit Kembhavi, Ranjan Gupta and Arvind Paranjpye of IUCAA lectured at the camp. There were also demonstrations of an 8" telescope and of astronomical images on computers. About 2,000 students and teachers attended the camp.

Mini school on
Introductory Astronomy and Use of Computers

A mini school on Introductory Astronomy and Use of Computers was organized by IUCAA and St. Thomas College, Kozhencheri, Kerala, at Charal Mount, which is a retreat close to Kozhencheri, during September 12-13, 1997. About 150 undergraduate and postgraduate students as well as college and university teachers participated in the school. Lectures were given by Jayant Narlikar, Naresh Dadhich, Ajit Kembhavi of IUCAA; Babu Joseph of the Cochin University of Science and Technology and Prabhakaran Nayar of the University of Kerala. In addition to the lectures, there were computer demonstrations and a discussion session, on the overlap between science and philosophy. Plans for further activities in the region were formulated at the school.

Talks during Visits Abroad

J.V. Narlikar: *Big Bang Cosmology*, Tubitak Basic Sciences Research Institute, Kandilli, Turkey, September 22; *Nature of the Universe*, Department of Physics, Middle East Technical University, Turkey, September 24; *Inter-University Centres: A new experiment in the university sector in India,* Tubitak Mustafa Inan Auditorium, Turkey, September 25; and *Nature of the Universe*, University of Amman, Jordan, September 27.

Varun Sahni: *Analysis of large scale structures using percolation genus and shape statistics,* IAU Symposium no. 183 on Cosmological parameters and evolution of the universe, Kyoto, Japan, August 25; *Dynamical and Statistical aspects of nonlinear clustering in the universe* at the Research Centre for the Early Universe, Tokyo, September 1; and *Geometrical methods of analysis of large scale structure in the universe* at Mitka, the Institute of Astronomy, Mitaka, Tokyo, September 2.

Ranjan Gupta: *New Applications of artificial neural networks in stellar spectroscopy*, Conference on Astronomy Data Analysis Software and Systems (ADASS'97), September 14-26, Sonthofen, Bavaria, Germany; and *Interstellar extinction by porous dust and related studies*, Astrophysical Institute and University Observatory, Jena, September 25.

Arvind Paranjpye: He attended the 23rd International School for Young Astronomers' which was hosted by the Institute for Advanced Studies in Basic Sciences, Zanjan, Iran, during July 4-22. He gave a talk on construction of a low cost astronomical photometer and its different uses. He also conducted day time and night time observational exercises. During the day time, the participants observed the Solar Limb Darkening using the photometer developed at IUCAA. They observed the phenomenon through B, V, R and I filter. The observational procedure and the results were discussed during a special session.

The night time observations were done using CCDs. The participants were made to take the observations all by themselves. It was a great experience for most of them as they were handling a CCD for the first time.

Vacation Students' Programme 1997

The VSP-97 was conducted during June 2 - July 11, 1997. Seven students, selected from various universities, participated in this programme. There were 24 lectures covering most aspects of Astronomy and Astrophysics. Each student worked on a project with the guidance of a faculty member. They also presented a seminar describing their research. This year one student was pre-selected for the Research Scholarship starting from August 1998. Ranjeev Misra was the coordinator for this programme.

GR 15 Conference

(at IUCAA, December 16-21, 1997)

Preparations for GR 15 meeting are in full swing. We expect around 500 participants. The third and final circular is being prepared and would be mailed by mid October, 1997.

IAGRG General Body Meeting

(at IUCAA, December 21, 1997)

The Indian Association for General Relativity and Gravitation (IAGRG) General Body will meet at 2:30 p.m. on December 21, 1997 in the Bhaskara 3 lecture hall of IUCAA. Besides the business of the general body, the Vaidya-Raychaudhuri Endowment Lecture and prize winning essays will be presented. The agenda of the general body meeting will be circulated by the secretary of the association.

Workshop on

High Energy Particle Physics - 5

(at IUCAA, January 12-26, 1998)

A workshop on High Energy Particle Physics -5 (WHEPP-5) will be held at IUCAA during January 12 - 26, 1998. The workshop will include a special section on Astroparticle Physics and is meant for advanced level workers in the field of high energy physics and cosmology. Lecturers to the workshop will include distinguished physicists both from India and abroad. Interested persons may apply to **Varun Sahni , IUCAA,** before November 15, 1997. Advanced level Ph.D. students and post-docs should arrange for letters of recommendation to accompany their applications.

Workshop on

The Physics of Stars

(at University of Tezpur, during January 1998)

A week long workshop on The Physics of Stars will be held at Tezpur University, Assam during January 1998. Lectures on various aspects of stellar structure and evolution will be delivered by experts on the subjects. Those interested in attending the workshop may write to **Atul Borkakati**, Dean, Faculty of Science, Tezpur University, Tezpur 784001, Assam (Tel. 03712-21539/20516/30408, Fax 03712- 21539, E-mail: atul@tezpuru.ren.nic.in) with a copy to the **Coordinator, Core Programmes, IUCAA**.

Workshop on

Stellar Structure and Evolution

(at IUCAA, during February 1998)

A workshop on Stellar Structure and Evolution will be held at IUCAA during the third week of February 1998. This will be an advanced level workshop, on different aspects of stars. It is primarily meant for those who are seriously interested in undertaking research in the area. Lecturers from India and abroad including Georges Meynet of Geneva Laboratory will be lecturing at this workshop. Interested persons may apply to the **Coordinator, Core Programmes, IUCAA**, before the first week of December 1997.

Introductory School in Astronomy and Astrophysics

(at Bangalore University, March 2-6, 1998)

An Introductory School in Astronomy and Astrophysics for Bangalore University teachers will be organized by IUCAA at the Bangalore University, during March 2-6, 1998. Interested persons may contact Dr. B.A. Kagali at the Deparment of Physics, Jnana Bharathi Campus, Bangalore University, Bangalore 560 056 (Fax: 080-3389295, Tel: 080-3355036 - Ext. 275).

Site Evaluation

1. INTRODUCTION

A site for optical observations has to satisfy the contradictory requirements of good accessibility and of good atmospheric conditions, free from man made light and other forms of pollution, which are most often found on isolated remote mountain tops. The atmosphere should not only be cloud free, but it should also have low thermal fluctuations in order to get sharp images. Thus, the astronomers chose sites for their telescopes to optimise the returns by considering the logistics as well as the atmospheric conditions. With the vastly increased size and improved quality of the telescopes in the last few decades, the problem of selecting the best possible sites has attracted a lot of attention and a variety of instruments and procedures have been developed to assess a site objectively. The status of the techniques and procedures in pre-optoelectronic days is well covered in the Proceedings of IAU Symposium No. 19, on Site Testing, held in Rome in 1962 (Bulletin Astronomique, Vol. 24, No. 2, 1964). Although many key ideas have not changed since the time of that symposium, the instrumentation used for site testing has changed a lot and the theory of atmospheric perturbations has been developed further. A more recent view of the situation can be had from proceedings of a conference held at Flagstaff, Arizona in 1986 on Identification, Optimisation, and Protection of Optical Telescope Sites (eds. *R.L. Millis et. al.*, published by Lowell Observatory, 1987).

Some idea on the efforts of Indian astronomers in identification of good sites can be had from the following reports :

(i) A Report on the Site Survey for the 2.34 m Telescope, 1976, published by the Indian Institute of Astrophysics, Bangalore,

(ii) Technical Report on Astronomical Site Survey in Leh-Ladhak (1984-1989), 1991, compiled by A.B. Bhatnagar and S.L. Gandhi, Udaipur Solar Observatory, Udaipur,

(iii) Technical Report on Astronomical Site Survey for the UPSO 4-metre Telescope Project 1981-1990, 1992, published by Uttar Pradesh State Observatory, Nainital, and

(iv) Recent Astronomical Site Survey at Hanle, Ladakh, 1996, by Hirot Team, Bull. Astr. Soc. India Vol. 24, p 859.

In this summary, we would concentrate on discussing the observations on some of those parameters of the sites which are specific to optical astronomy. However, methods used to study the meteorological parameters, which are equally important for characterising the sites, would not be discussed.

2. SEEING

Perhaps the single most important parameter of a site is seeing, which can be roughly specified by the size of stellar images (typically about one arcsec) seen with a large telescope or from a long exposure with a small telescope. The measurements of seeing play a very important role in attempts to improve the spatial resolution of the telescopes through techniques like active optics and adaptive optics. One of the first objective methods used to measure seeing was based on the idea that a long exposure image from a small telescope is a superposition of multiple short exposure records of a relatively sharp image which is moving in a random fashion, and therefore the random motion of these records can be used to estimate seeing. Star image trails are photographed in a small stationary telescope and deviation of the trails from a straight line is used to estimate this random motion, and hence seeing (Stock and Keller,1960; Meinel,1960; Stock, 1964). The method of star trails was standardised by Harlan and Walker (Harlan and Walker, 1965), and the Polaris trails were very effectively used by Walker (see for example Walker 1970, 1983). The effect of wind shakes on these measurements can be eliminated by using double-beam telescopes with two apertures, and estimating the seeing from relative random motion of images (of the same star) made by the two apertures; separation between the two apertures is chosen few times the diameter of the apertures, and the two images are brought close to each other by mirrors (Meinel 1960, and Stock 1964).

The ideas of image-trails method have been used in photoelectric seeing monitors for some decades (see for example, Meinel 1960, and Bisht et. al. 1990), but the method has only gained popularity in the last decade due to easy availability of the CCD cameras; descriptions of a typical modern double-beam seeing monitor (now popularly known as Differential Image Motion Monitor) are given in Sarazin and Roddier 1989, and Vernin and Munoz-Tunon 1995. The image motion measurements can be significantly affected, for finite exposure times, due to the winds; these effects have been discussed theoretically by Martin (Martin 1987), and Soules et. al. (Soules et. al. 1996) have observed these effects.

To the lowest order, seeing can be represented by the Fried parameter and the methods discussed above are suitable for estimating this parameter. However, in order to have a better understanding of seeing more details have to be studied (for a review of the theory of effects of turbulent atmosphere on the images, see Roddier 1981). There are at least three questions of details which one would like to ask : (i) what are the length scales over which the theory based on Kolmogorov law of turbulence is applicable to the atmosphere, (ii) what is the temporal behaviour of seeing, and (iii) does a small number of turbulent atmospheric layers contribute to most of the seeing. Observations with the Keck Telescope, in which each of its segments is oriented to give an independent image, indicate that correlations in the motion of the images are smaller than those predicted by the theory (Dekens et. al. 1994). Measurements on wavefront tilts from two apertures separated by 1 - 10 metres show the effects of finite outer scale as reduced correlations (Agabi et. al. 1995). Wells et. al. (1995) have used aperture masks on the UKIRT to study differential image motion in the J, H, and K bands and find that the two seeing estimates, derived from relative image motions along the aperture-separation vector and the transverse direction respectively, are not the same. Limited observations at Mauna Kea show that the mean ratio of seeing at two different times grows exponentially with a characteristic time of about 17 minutes (Racine 1996). Based on the temporal behaviour of star trails in a field of about 10', Noethe and Gitton (1994) conclude that by using a time delay, to allow for motion of the atmospheric turbulence across the field of view, effective size of the isoplanatic patch for tip-tilt correction can be increased. It has been observed, by balloon sounding of the atmospheric temperature profile, that a large contribution to the seeing is made by a few relatively thin turbulent layers (Coulman et. al. 1995). This layered structure can be used to get a large isoplanatic field in adaptive optics by conjugating the wavefront-correcting mirror to the main turbulent layer instead of the telescope-pupil (Racine and Ellerbrock 1995).

3. SCINTILLATION

Scintillation too, like seeing, has its origins in atmospheric turbulence, but it has attracted much less observational attention in the past as compared to seeing. However, with the growing interest in stellar seismology, fast variability of stars, etc., importance of studies on scintillation is growing.

The typical time scales of scintillation are milliseconds and standard photoelectric-photometry techniques can be used with minor modification for observations on scintillation. Through observations with artificial stars sent up in balloons and through correlations of scintillation with wind speeds, it was shown in the 1950's and 1960's that the upper atmosphere was mainly responsible for scintillation (see Dravins et. al. 1997 I for references). Jakeman et. al. (1976) made some detailed observations of the temporal behaviour of scintillations (Sirius observed through a 0.84 cm aperture in a 50 A band) and found that the contrast of the fluctuations could be more than unity on time scales of millliseconds. He also found that the contrast decreased for broadband observations. Dravins et. al. (1997 I and 1997 II) have used a 60 cm telescope and photon-counting photomultipliers to study the temporal (on micro and milli seconds scales) and spectral behaviour of scintillation; they also review the past literature on scintillation. They find evidence of an inner scale of ~ 3 mm, and also find an indication of good seeing correlated with moments of high scintillation. The parameters of scintillation are found to evolve on a time scale of tens of minutes, which is similar to the time scale observed by Racine (1996) for the evolution of seeing. They also find that the atmospheric dispersion leads to relative time delays between the fluctuations for different colours, and for large zenith angles these delays could be as large as 100 ms.

4. MICROTHERMAL MEASUREMENTS

The spatial fluctuations in the atmospheric refractive index, which give rise to seeing and scintillations, can be directly related to the temperature fluctuations (see, for example, Marks et. al. 1996). The fluctuations can be measured with microthermographs which use thermistors made of thin (2 - 20 microns diameter) metal wires, to get a fast response (1 - 20 ms) and a high sensitivity (< 0.1 deg.); ideally a differential measurement is made between two sensors mounted at a separation of about one metre, the differential signal then has a typical frequency range corresponding to wind travel between the two sensors. The ground layer can be studied by mounting the sensors at various heights on a tower (see Lynds 1964, and Lawrence et. al. 1970), and the upper layers can be studied by sensors on balloons and aircrafts (see Lawrence et. al. 1970, and Coulman et. al. 1995). The temperature fluctuations in the boundary layer (30 - 1000 m height) have also been studied using accoustic sounders, which measure scattering of sound due to the density fluctuations.

5. INFRARED ABSORPTION AND EMISSION

The atmosphere has strong absorption in most of the infrared band, and the main contributor to this is water vapour. Therefore, estimates of the water vapour column in the atmosphere, as well as that of emission due to the absorbers are important for infrared observatories.

The water vapour column can be measured by sounding the atmosphere with balloon borne hygrometers. However, this method is tedious and alternative methods of sounding from the ground have been developed. In one of the methods, the absorption of solar (or lunar) radiation in one of the near infrared water bands is measured to estimate the water vapour column (see, for example, Tomasi 1983). Although, this method has been used widely (see, for example, Buscher and Lemke 1980, and Bhatt and Mahra 1987), the conversion from the observed absorption to the water vapour is not straight forward and requires careful calibration. The second method is based on measuring the sky radiance in several infrared bands (see Sarazin 1990). The sky emission as well as the corresponding noise in the near and mid infrared bands have been measured with liquid He cooled bolometers and small telescopes (see Morse and Gillet 1982, and Valenziano 1996).

6. EXTINCTION

The atmospheric extinction in the visible bands can be measured by observing stars at different altitudes with a photoelectric photometer. The extinction and its colour dependence can change over periods of hours due to changes in the concentration of aerosols; typical variations in range 0.1 — 0.3 mag. are reported for the V band (Krisciunas 1990, and Burki et. al. 1995), and the extinction law for the aerosols has been found to be $\lambda^{-1.39}$ at La Silla (Burki et. al. 1995). Small amplitude (0.001 mag.) oscillations in extinction have been observed on time scales of minutes (Clarke 1980).

7. LIGHT POLLUTION AND SKY BRIGHTNESS

The background light consists of at least three components: the extraterrestrial, the airglow, and the man made light pollution. All the components can be measured with a small CCD camera mounted behind a standard 35 mm camera lens and a band filter — the short focal length of the lens helps to give a significant solid angle per pixel and hence adequate background signal; care should be taken to ensure that some parts of the field do not suffer from vignetting. Observations of a field containing a standard star would give calibrated measurements. The same camera can be used for extinction measurements too. It is also possible to measure the background with a bare photo-diode based photometer, having a field of about 0.1 sterad, which has been calibrated.

The first component depends on the direction in which one is looking, and it can be as small as 22 mag. per sq. arcsec in V band. The airglow changes with the solar activity and it can increase the zenith brightness by as much as one mag. in V band (Walker 1988, Pilachowski et. al. 1989, Krisciunas 1990, and Ch. Leinert et. al. 1995); the air glow also decreases by about 0.3 mag. through the night (Walker 1988, Pilachowski et. al. 1989, and Krisciunas 1990).

The man made light pollution has been studied and modelled by Walker (1977) and Garstang (1989); it is found that the pollution at 45 deg zenith angle decreases as - 2.5 power of the distance from the source. Spectral studies have been used by Massey et. al. (1990) to estimate the relative contributions of the air glow and the man made light to the background.

8. CLOUD COVER

The cloud cover is usually measured by visual observations, but an estimate can also be made using the pictures from weather satellites (see for example Sapru et. al. 1993). Thermoelectrically cooled compact CCD cameras with wide angle lenses can also be used to monitor clouds by observing variations in the relative fluxes of stars. Erasmus and Peterson (1997) have investigated the possibilty of detecting cirrus clouds with satellite images at 6.7 micron wavelength.

9. CORRELATIONS WITH WEATHER AND PREDICTIONS

If the conditions can be predicted few hours or more in advance, the observations can be rescheduled to suit the expected seeing, cloud cover, etc. While the aim of predictability is not in sight at present, correlations between the standard meteorological parametres and the astronomically interesting parameters are being studied. Thus, Murtagh and Sarazin (1993) and Murtagh et. al. (1995) have studied the correlations between seeing and meteorological parameters, and Erasmus and Peterson (1997) discuss the possibilty of predicting cirrus clouds on the basis of wind data and satellite images at 6.7 micron wavelength. De Young and Charles (1995) have modelled airflow over potential sites to predict the turbulent boundary layer.

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Observing the Fraunhofer Lines in Sunlight

It is well known that the spectrum of sunlight has a lot of dark lines which are named after Fraunhofer — the German optician who made a detailed catalogue of these lines in 1814. The presence of these lines is understood, through an application of the Kirchhoff's laws of radiation, as being due to the absorption by the corresponding atoms in the relatively cooler layers of the solar atmosphere lying over the photo- sphere. Whereas the light of the photosphere at most of the visible wavelengths can pass through these cooler layers without any impediment, the light of those wavelengths which correspond to the excitations of the atoms present in these layers is absorbed and one observes dark lines at these wavelengths.

The Fraunhofer lines can be observed with a grating spectrometer, of the kind found in laboratories of most colleges. The lines have a large range of widths, some are less than 1 Å wide, whereas others are more than 10 Å wide— some of the prominent lines are listed in table on the right. In a typical spectrometer, it is possible to get a spectral resolution of a few thousand and hence the lines which have a width of more than about 2 Å can be seen easily.

In order to measure the wavelength and width of the lines we use the grating formula

$$\lambda = d \sin \theta$$

where λ is the wavelength and d is a constant which depends on the line-spacing of the grating and the diffraction-order being observed, and θ is the angle of diffraction, i.e. the angle between the axes of the telescope and the collimator of the spectrometer. The value of d can be estimated by measuring the value of θ for the D1 and D2 lines of sodium with a sodium lamp in the laboratory.

To observe the lines, arrangement shown in Fig. 1 should be used, and the angles θ measured for the centres of the lines; for the wider lines the angles can also be measured for the two edges. These measurements should be repeated many times and an average of these should be taken to estimate the wavelengths through the grating equation. In case of the lines for which you are able to make measurements for the two edges, the width of the line can also be estimated and compared with the value given in the table below; please remember that the table only lists some of the lines and depending on the conditions you might see more lines (for bad conditions you might only see the most prominent of the lines listed).

The measurement process can be quantified if you replace the eyepiece of the spectrometer with the photometer described in Astroproject 8 (Khagol 20) To take observations with the photometer, you would need to cover its photo- diode with a slit (of the same width as and parallel to that used in front of the collimator). The output of the photometer should be noted as a function of telescope angle θ and a graph should be plotted for the same — the angle should be changed in small steps e.g. 1 arcmin. **This method would give proper results provided the intensity of the sunlight falling on the slit is not changing during the measurements.**

Some Strong Fraunhofer lines

Wavelength Å	Designation	Emitting atom or ion	Equivalent width * Å
3934	K	Ca+	19.0
3968	H	Ca+	14.0
4102	h(H delta)	H	03.4
4226	g	Ca	01.5
4340	G'(H gamma)	H	03.5
4384	d	Fe	01.1
4861	F (H beta)	H	04.2
5184	b1	Mg	01.6
5890	D2	Na	00.8
5896	D1	Na	00.6
6563	C (H alpha)	H	04.1

** Equivalent width is directly related to the width and contrast of the line.*

Source - Guide To The Sun by Kenneth J. H. Phillips, Cambridge University Press.

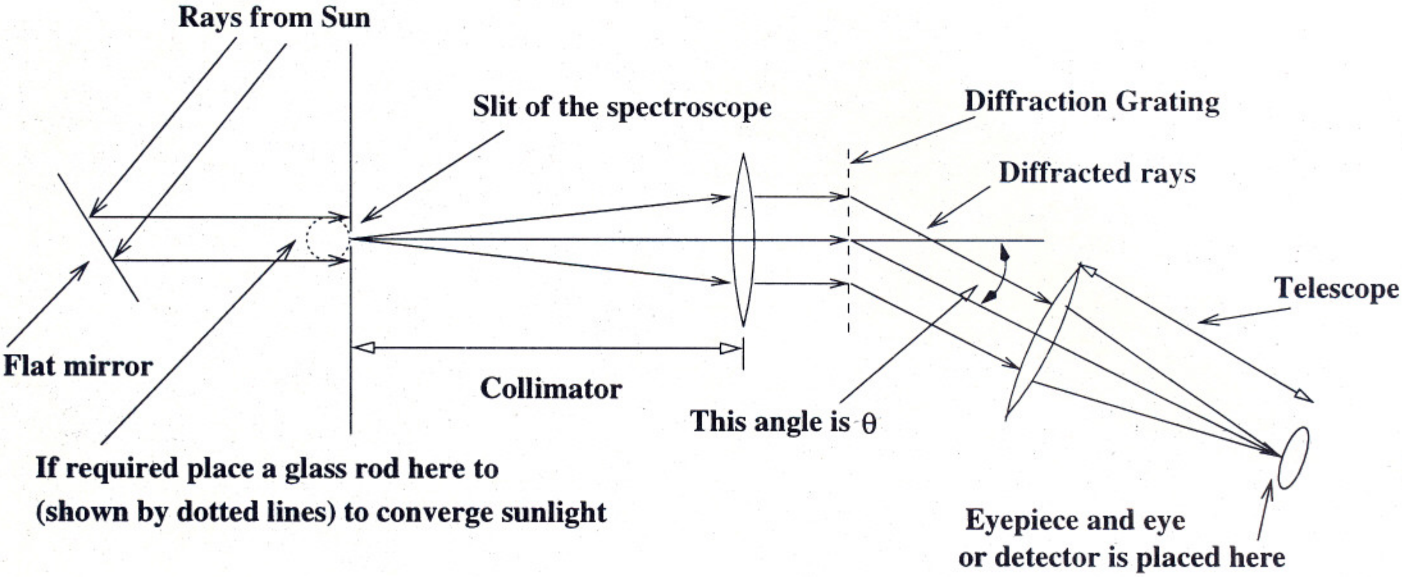


Figure 1

Seminars

17.7.97 Archana Pai *on* Mode analysis of the bar detector; 7.8.97 Y. Sobouti *on* Oscillations in spherical stellar systems?; 8.8.97 Urjit Yagnik *on* Baryogenesis in the early universe; 21.8.97 R. Balasubramanian *on* Interferometric detection of gravitational waves from coalescing binaries; 26.8.97 J.N. Islam *on* Confinement, Schrodinger equation for Yang-Mills theory, Wheeler-De Witt equation and all that; 10.9.97 Avinash Khare *on* Non-Archimedean algebra, the law of gravitation and red shift in a finite universe; 12.9.97 S.D. Mohanty *on* Efficient data analysis techniques for the detection of gravitational waves from some important astrophysical sources.

Colloquia

4.8.97 R. Amritkar *on* Control of chaotic systems; 12.8.97 Sriram Ramaswamy *on* Are moving lattices unstable?; 19.8.97 Abhay Ashtekar *on* Quantum mechanics of geometry and black hole entropy; 1.9.97 Sumit R. Das *on* Microscopic understanding of black hole radiation; 8.9.97 Peter Warlow *on* Catastrophes of the solar system

PEP Talks

26.6.97 Patrick DasGupta *on* For a few monopoles (or Less); 1.7.97 Jihad Touma *on* Oh! When the planets go marching in; 8.7.97 Naveen Gaur *on* Beyond the standard model.

IUCAA Preprints

Listed below are the IUCAA preprints released during July-September 1997. These can be obtained from the Librarian, IUCAA (**library@iucaa.ernet.in**).

Bagla, J.S., **Engineer, Sunu** and **Padmanabhan, T.**, *Scaling relations for gravitational collapse in two dimensions,* IUCAA-47/97; Bharadwaj , S. and **Sethi, Shiv K.**, *Decaying neutrinos and large scale structure formation,* IUCAA-48/97; Balasubramanian, R. and **Dhurandhar, S.V.** *Estimation of parameters of gravitational wave signals from coalescing binaries,* IUCAA-49/97; Vaidya, D.B. and **Gupta, Ranjan** *Extinction by porous silicate and graphite grains,* IUCAA-50/97.

Congratulations!!!

to **Professor G. Srinivasan** for becoming the President of IAU Commission 44 (Space and High Energy Astrophysics) for the trienniel 1997-2000.

Post-Doctoral Positions at IUCAA

The Inter-University Centre for Astronomy and Astrophysics (IUCAA), was set up by the University Grants Commission in December 1988 in the picturesque surroundings of the Pune University Campus. IUCAA is a national autonomous institution and aims at being a centre of excellence within the university sector for teaching, research and development in astronomy and astrophysics.

The Centre at present consists of about 30 academic members, including core faculty, post-docs and graduate students, and is in a growing mode. In addition to in-house activities, IUCAA runs a vigorous visitor programme involving short and long term visits of scientists from India and abroad. The Centre also has 71 associates from universities and colleges who visit periodically.

Applications are invited for post-doctoral fellowships in astronomy and astrophysics. The duration of the fellowship is flexible within a range of one to five years, with the possibility of conversion to a tenured position. *IUCAA offers challenging opportunities to young research workers in theory, observation and instrumentation in A & A. IUCAA plans to have a 2m optical telescope operational during 1999 and there will be special opportunities for optical astronomy and related instrumentation.* Candidates should apply to **The Coordinator, Core Programmes, IUCAA,** with curriculum vitae and list of publications and arrange for three confidential references to be sent independently. All the relevant material should reach IUCAA by **December 25, 1997.** Candidates will be informed of the result by **February 15, 1998.** The fellowship will normally commence **during 1998.** Accommodation on the campus will be offered to all post-doctoral fellows. For further details, please contact the Coordinator, Core Programmes, IUCAA.

Facilities at the Centre: State-of-the-art computer network, e-mail, tcp/ip, www; Instrumentation laboratory; Astronomical image processing and data centre; Modern library

Research areas covered: Cosmology and large scale structure; Galactic and extra galactic astronomy; High energy astrophysics; Galaxy dynamics; Interstellar medium; Quantum cosmology and quantum gravity; General relativity; Gravitational waves; Observational astronomy; Astronomical instrumentation

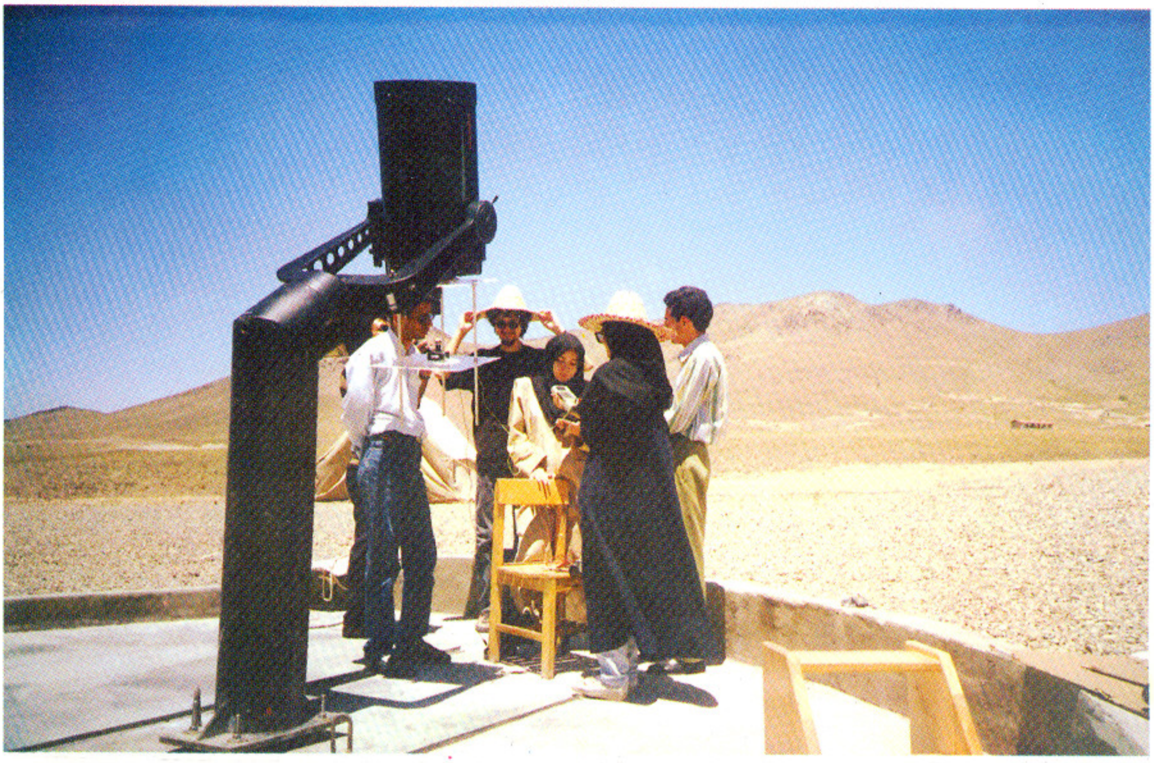
Other academic activities: Schools and workshops; Refresher courses; Graduate and post-graduate courses; Science popularisation

IUCAA is looking for a young physicist...

The Inter-University Centre for Astonomy and Astrophysics is setting up an optical-near-infrared observational facility with a 2 m size telescope. In order to carry out development of various instruments for the observations, the Instrumentation Laboratory of the Centre is looking for a YOUNG PHYSICIST, for the position of Scientist C, with a Ph.D. in any branch of experimental physics and having an aptitude for instrumentation. The selected candidate would be placed in the scale of 3000-100-3300-125-4500 (pre-pay commission), with the usual allowances applicable to central government employees stationed at Pune.

The candidate would be expected to take up development of instruments for observations with the telescope and take part in commissioning of the telescope. After commissioning of the telescope (expected in the year 1999), the candidate is also expected to carry out his own research.

Please apply to the **Director, IUCAA,** with biodata, a summary of the Ph.D. work and post Ph.D. research (with special reference to instrumentation work) and a list of at least three referees. The applicants should ask these referees to send their confidential recommendations directly to the Director.



Participants of the 23rd International School for Young Astronomers' held during July 4-23, 1997, at Zanjan, Iran, observing Solar Limb Darkening using the photometer developed at IUCAA. (Photo Courtesy: Arvind Paranjpye, IUCAA)

Visitors

July - September 1997

D. Syer, K. Freeman, S.M. Alladin, K.S.V.S.Narasimhan, P. Thakur, M.K.Sharma, D. Vijayakumar, S.M. Wagh, A. Chitre, S. Ganesh, R. Nityananda, R.S. Singh, S.K. Pandey, M.N. Anandaram, K. Sato, G. Ambika, P. Khare, G. Srinivasan, D.B. Vaidya, R.S. Ellis, B.A. Kagali, V.R. Venugopal, K. Dave, N. Rajasekhar Rao, M. Sobouti, K. Jotania, A. Mittal, Wahabuddin, S. Maharaj, S. Sahay, M.K. Patil, S. Ramaswamy, A. Ashtekar, C. Debiprasad, G.P. Malik, G.P. Pimpale, P.S. Wamane, J.N. Islam, K. Shankar, I. Srivastava, Sumit Das, Budh Ram, A. Khopkar, P. Warlow, A. Khare, B. Lokanadham, Y. Ravi Kiron, S.S. Prasad, P.K. Srivastava

Visitors

Expected

October: B. Ishwar, BR Ambedkar Bihar University; R. Ramakrishna Reddy, Sri Krishnadevaraya University; A. Pradhan, Hindu Degree College, Ghazipur; S. Banerji, University of Burdwan; B.C. Paul, North Bengal University; P.V. Kulkarni, Nasik; G. Yellaiah, Kakatiya University; H.P. Singh, Sri Venkateswara College; M.K. Das, Sri Venkateswara College; T. Subba Rao, Sri Venkateswara College; P.K. Srivastava, DAV College; L.P. Singh, Utkal University; K.P. Singh, TIFR; Asoke Sen, Assam University; and S.N. Karbelkar, College of Engineering, Akola.

November: M. Maharaj, University of Durban; R. Krishan Lal, National Physical Laboratory.

December: Delegates of GR15

Salads and Supernovae

In 1604 Johannes Kepler witnessed a supernova. It was the third known supernova sighting in the Galaxy, counting the Crab Supernova observed by the Chinese in 1054 as the first. In his book *De Stella Nova* published in 1606, Kepler conjectured whether the supernova arises from a random concentration of atoms in the sky. He wrote:

"(it is) not my opinion, but my wife's: Yesterday, when weary with writing, I was called to supper, and a salad I had asked for was set before me. It seems then, I said: '*if pewter dishes, leaves of lettuce, grains of salt, drops of water, vinegar, oil and slices of eggs had been flying about in the air for all eternity, it might at last happen by chance that there would come a salad*'. '*Yes*', responded my lovely, '*but not so nice as this one of mine*'."

Khagol (the Celestial Sphere) is the quarterly bulletin of IUCAA. We welcome your responses at the following address:

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Universal Resource Locator : **http://www.iucaa.ernet.in/**