IIA Newsletter

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In this issue...

Siraj Hasan takes over as Director

Professor Siraj Hasan assumed charge on January 3, 2006 as Director of the Institute. Hasan, a Senior Professor and Chairman of the Group on Sun and Solar System Studies at the Institute, and the Vice-President of the Astronomical Society of India is known for his distinguished academic career and research work in solar astrophysics. He has held visiting faculty positions in many premier international institutions such as the Universities of Harvard, Oxford and London. His research publications are widely cited and have made a significant impact in solar physics

Hasan, a national science talent scholar, had his undergraduate and postgraduate education at the Aligarh and Delhi Universities respectively. He received his doctorate in theoretical astrophysics from the University of Oxford, U.K. in 1977. Soon after, he joined the Indian Institute of Astrophysics, Bangalore in the position of Fellow. He has been a recipient of the Commonwealth, Alexander von Humbolt and Smithsonian Fellowships and is an Associate of the Harvard College Observatory.

Hasan has been participating in several national and international research programmes as a collaborator and a principal investigator. Some of his ongoing collaborations are with the Paris Observatory, the Kiepenheuer Institute, Freiburg and the Harvard-Smithsonian Center for Astrophysics.

As Director, Professor Hasan has taken initiative on a number of new projects, among them the National Large Solar Telescope and the Large Optical Telescope projects. His support of the Public Outreach activities of the Institute has led to a revival of the publication of IIA Newsletter after a gap of more than ten years.

Observations of Solar Corona during Total Solar Eclipse of March 29, 2006

Image of the coronal structures (visible only during eclipses), taken with green filter.

There was a total solar eclipse of 4 minute duration, visible from South Africa, Egypt, Turkey and some other middle eastern countries. The weather was very good during the eclipse in Turkey. IIA had planned an Indian expedition to Turkey comprising of teams from IIA, Bangalore and ARIES, Nainital to conduct experiments during the eclipse. They performed high spatial resolution narrow band photometry of coronal structures to investigate the nature of coronal waves from the study of intensity oscillations in the coronal green and red emission lines. Two 14 inch Meade telescopes, 0.5 nm pass-band filters and CCD cameras with readout speed at 1 MHz were used. Analysis of the data is currently under progress.

The group photo taken at the total solar eclipse site at Manavgat in Turkey (From l. to r. :F. Gabriel, Jagdev Singh, S.S. Hasan, R. Srinivasan and S. Bagare)

PLUTO : Planet to Dwarf Planet

Until recently Pluto was considered the outermost planet of our solar system. Ever since its discovery by Clyde Tombaugh, Pluto has been an enigma. Initially, it was thought to have a mass a few times the mass of the Earth as that was what was required to account for the additional perturbations in Neptune's orbit. When its diameter was first measured in the 1950s, it gave a value of half that of the Earth. This created a puzzle as it implied a density several times the Earth's ! Exotic explanations were proposed for this unusually dense phase and suggestions were made, with the advent of the space age, that a space probe be sent to Pluto so that its secrets are revealed. All speculation ended with the discovery of a satellite to Pluto in 1975. It was named Charon. Its synchronous orbit around Pluto (with a period of 6 days 9 hrs) at a distance of twenty thousand km from it easily enabled a fresh estimate to be made of Pluto's mass and this turned out to be about 1/500 that of the Earth or 5 times less massive than the Moon! Also its earlier diameter was much of an overestimate, so that the density of Pluto turned out to be a typical two grams per cubic centimetre. Doubts began to be expressed whether it should be considered a planet at all ! Indeed the earliest expression of dissent goes back to the time of its discovery in 1930, when the astronomer William Pickering disappointed at its faintness (and small size) felt that it just cannot be the Planet X (which he had predicted to account for the perturbations in Neptune's orbit). He felt Pluto had stolen the credit and should be called Loki (the god of thieves!). With more accurate computations the anomalies in Neptune's orbit were no longer present and the discovery of Pluto was considered more of an accident.

In recent years, the discovery of a large number of Trans-Neptunian Objects (TNOs), many of them believed to be of the same size as or even larger than Pluto, further diminished the status of Pluto. Several hundred TNOs are now known. More than a hundred thousand smaller objects comprise the Kuiper Belt, a disc-shaped region extending from 35 to 100 A.U. from the Sun. These are KBOs or Kuiper Belt objects. It is in this context that we should consider the IAU General Assembly's adoption of a new definition of a planet, at its meeting held in Prague in August 2006. Initially, it was stated that round objects in orbit around the Sun are planets. Pluto satisfied this criterion. Further Pluto is not a moon of another planet, a criterion that disallowed calling Titan and Ganymede planets. However, the final IAU definition stipulates that apart from being round, and not a satellite, a planet must also dominate the mass of its orbital zone. So a full-fledged planet must have no competition in its zone. It is this criterion that Pluto failed to satisfy. With this new definition a new category of planetary objects has been introduced. These are the dwarf planets, which orbit the Sun, are not satellites and almost round but they are not massive enough to dominate their orbital zone. 'Roundness' is a characteristic common to both planets and dwarf planets. It was stated that to be round the object has to be, in general, more than 800 km across. In this context, a paper written more than twenty years ago may be relevant (Sivaram 1986, Earth Moon and Planets, 34, 231). In this paper, the dividing line between the sizes of planets, which are round, because of their own gravity and of smaller bodies, which are irregular, because the elastic shear forces tending to deform them are larger than their self-gravity, was calculated. The critical diameter was estimated to be about 750 km, very close to the 800 km mentioned in the above definition. Further, from the stability of rotating bodies, typical angular momenta of such bodies tending to a constant value was estimated, which yielded, given Pluto's diameter, a rotational period of a week, consistent with what is observed.

Even if demoted to a dwarf planet, Pluto has had a checkered history of over 75 years. Ironically, NASA's New Horizons Spacecraft was launched in January 2006 to investigate through a close encounter the mysterious worlds of Pluto-Charon and KBOs that reside at the edge of our solar system. With extra thrust from a Delta Rocket and assisted by flybys past Jupiter and Saturn, the spacecraft is expected to fly past Pluto in just ten years i.e., in 2015. As Pluto is now moving away from the Sun towards aphelion, its atmosphere (perhaps mainly methane) is expected to condense on to its surface beyond that date. The gaseous atmosphere of the planet will cease to exist much beyond this time. Hence the hurry to reach it by 2015! Recent ground-based temperature measurements indicate that Pluto (40 K) is 10 degrees cooler than Charon (50 K). The reason for this is that the meagre sunlight impinging on Pluto is partly used up to sublimate the icy material on its surface making it cooler than Charon which has no atmosphere. Another distinct feature of Pluto is its very eccentric orbit ($e = 0.25$). It is also interesting that Pluto is observed to be in a 3:2 resonance with Neptune. This odd synchronization is believed to have existed since the time of planetary formation several billion years ago. What is remarkable is that more than a third of the KBOs are also in a 3:2 resonance with Neptune. These objects have much in common with Pluto. These objects, sometimes dubbed Plutinos, have very eccentric orbits $0.1<e<0.4$.

What is the origin of the large orbital eccentricities of the resonant TNOs? A rather widely held view is that these resonances are a result of Neptune's orbit migration during the final stage of planetary formation. The orbital radius of Neptune experienced a slow increase by about a third due to some migration mechanism (such migration is perhaps not uncommon in several exoplanetary systems where hot Jupiters orbit very close to their parent stars). The force exerted by the orbiting Neptune acted as a quasi-periodic force on the Plutinos passing through capturing many of them in resonances just as a non-linear pendulum phaselocks to its drive. Their initial circular orbits developed growing oscillations and became increasingly eccentric. The observations show almost no KBOs in a 2:1 resonance. This dearth of 2:1 resonant KBO's has a possible explanation given only recently (Friedland 2001,Ap J 547, L75).

C. Sivaram

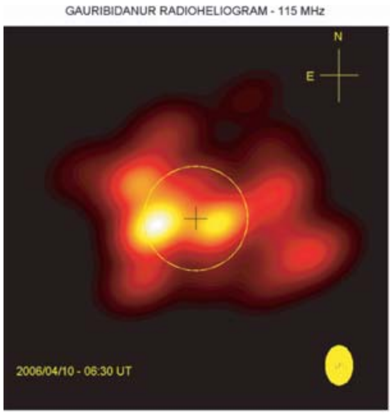
XXVI IAU General Assembly, Prague, August 2006

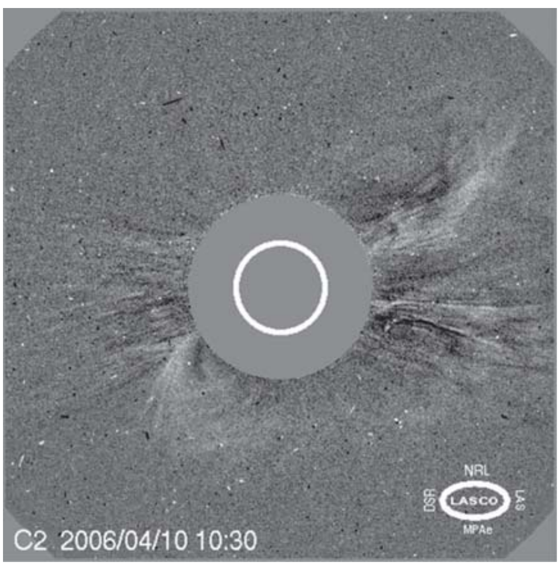
The 26th General Assembly of the International Astronomical Union was held in Prague, Czech Republic during Aug 14 - 25, 2006. It was after 39 long years the IAU was meeting again in Prague. From IIA, Prof. S.S. Hasan and Prof. S. Giridhar attended the GA. As is true of most General Assemblies, GA-26 was a vast affair with representations from all fields of astronomy. It contained symposia (235-240), Joint Discussions (JD) JD 01-17, Special Sessions (SP) SP 01-07, Working Group (WG) meetings, Business sessions for various IAU commissions, and also meetings of executive bodies of IAU. The 2006 Cosmology Prize of the Peter Gruber Foundation was awarded to John Mather and the COBE team during the Opening Ceremony of the General Assembly. There were invited discourses in the evenings, such as the one by Jill Tarter on "The Evolution of Life in the Universe" (16-08-06). A special evening lecture was given by Alan Title on " The Magnetic Field and its Effects on the Solar Atmosphere as Observed at High Resolutions" (17-08-06). Prof. M Parthasarathy took over as President of IAU Commission 29 on Stellar Spectra and Prof Sunetra Giridhar as that of Commission 45 on Spectral Classification for the triennium 2006-09. Exhibition stalls were put up by many publishers like Blackwell Publishing / Royal Astronomical Society, Cambridge University Press; and by companies specialising in astronomical instrumentation e.g., EOS Tech, ESO/ALMA, Gemini Observatory, NRAO etc. The event that drew the maximum media attention was the new official definition of what planets are and a resolution to demote Pluto from a Planet in the classical sense to the status of a Dwarf Planet. The final vote and resolution in the matter was taken on August 24. With this new definition the Solar System now consists of only eight Planets — Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Pluto, along with Ceres and 2003 UB313 became the defining members of a new class of Solar System objects — the Dwarf Planets. It is expected that in the coming months and years more "dwarf planets" will be announced by the IAU.

The next IAU GA will take place in Rio de Janeiro, Brazil in 2009. The Director-General of ESO, Professor Catherine Cesarsky, was elected the President for the triennium 2006-2009. The social events included welcome cocktail on August 15,2006, a concert by the Prague Philharmonia on the eve of 18-08-06 and a farewell reception at the Industrial Palace on the eve of 24-08-06. Conducted tours were organised to Prague Castle, Lesser Town, Charles Bridge, Ondrejov Observatory, Medieval Town of Kutna Hora, Bohemia Glass factory and many other places.

Sunetra Giridhar

Observations of Coronal Mass Ejections with the Gauribidanur Radioheliograph





Studies of the influence of solar activity on our terrestrial environment has taken on increasing importance in recent years, as has been the realization of how damaging space influences can be. The state of near-Earth space environment is significantly controlled by CMEs, the most geo-effective manifestation of solar activity. Though CMEs are primarily observed with whitelight coronagraphs on board space missions, one needs non-coronagraphic data to obtain information on the early evolution of CMEs, in particular for those directed along the Sun-Earth axis that lies far from the plane of the sky.

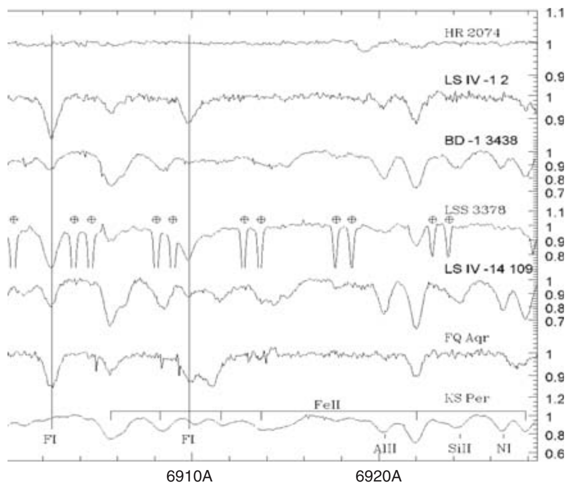
The latter class of events have a large angular span (close to 360 degrees) and appear as a 'halo' of enhanced emission encircling the Sun. But not all 'halo' CMEs are Earth-directed and there are several false alarms. One reason for this is that their source region could be on the back side of the visible solar disk. Since the occulting disk of a coronagraph covers the solar disk, it will be difficult to establish the source region of a CME using a whitelight coronagram alone. Radio observations play an useful role in this regard since there is no occulter here. By noticing the presence / absence of transient activity in the visible solar disk, one can establish whether a 'halo' CME is Earth-directed or not. The frequency coverage of Gauribidanur Radioheliograph (GRH) is well-suited to study CMEs in the 1-2 R_o radial distance range, above the solar surface. The coronagraphs that are in operation at present do not cover the above region due to the large size of their occulting disk. We present here observations of the 'halo' CME of April 10, 2006. By carrying out a multi-wavelength study using GRH and SOHO-LASCO data, we were able to establish that the source region of the event was located on the back side of the solar disk. The low corona kinematics of the event derived using GRH data were also in support of the above.

R. Ramesh

Discovery of Fluorine in Cool Extreme Helium Stars

For a long time, the solar system has been the only source of information about the fluorine abundance in the Galaxy (Hall & Noyes 1969: Astrophys. Lett., 4, 143). The astrophysical origin of the solar system's fluorine is not yet identified from the known theories of stellar nucleosynthesis. The major problem with fluorine production is that the element has only one stable, yet rather fragile, isotope, ^{19}F. In stellar interiors, it is readily destroyed by hydrogen via ^{19}F(p,α)^{16}0 and by helium via ^{19}F(α,p)^{22}Ne. The high F abundances that were measured using infrared HF vibration-rotation transitions in the asymptotic giant branch (AGB) stars from the Jorissen et al. (1992: A&A, 261, 164) sample provided us with clues for fluorine production in AGB stars. Apart from the third dredge-up in AGB stars, the other two sources of fluorine are Type II supernova (SN) explosions and stellar winds from Wolf-Rayet (W-R) stars. In AGB stars, ^{19}F is predicted to be produced in the convective He-rich intershell and then dredged up to the surface during the He-burning thermal pulses (Forestini et al. 1992: A&A, 261, 157). The reaction chain for F production in the He-burning environments of AGB and W-R stars is ^{14}N(α,γ)^{18}F(β^+)^{18}0(p,α)^{15}N(α,γ)^{19}F. Protons are provided by the ^{14}N(n,p)^{14}C reaction with neutrons liberated from ^{13}C(α,n)^{16}0. The ^{14}N and ^{13}C nuclei are the result of H burning by the CNO cycle, and the initial ^{13}C stock acts as a limiting factor for the ^{19}F yield.

Extreme helium (EHe) stars (Pandey et al. 2006: ApJ, 638, 454, and the references therein) are suggested to have gone through the AGB phase in their earlier evolution; hence, fluorine should be present in their atmospheres. The presence of fluorine in an EHe star's atmosphere can serve as a test bed for fluorine production in AGB stars.



A sample of F I lines, that are indicated by vertical solid lines in the spectra of cool EHe stars plotted with their effective temperatures increasing from bottom to top. The positions of the key lines are identified in this window from 6900 A to 6928 A. The telluric absorption lines in the spectrum of LSS3378 are shown as marked. The spectra of KSPer and HR2074 are also plotted.

Neutral fluorine (F I) lines are identified in the optical spectra of cool extreme helium (EHe) stars (see Figure). The spectra were obtained from CTIO, McDonald Observatory, and VBO. These are the first F I lines identified in a star's spectrum, and they provide the first measurement of fluorine abundances in EHe stars. The results show that fluorine is overabundant in EHe stars. A sample of cool EHe stars show F enhancements about 100 times solar. Since ^{19}F is overabundant in cool EHe stars, the reaction ^{22}Ne(α,n)^{25}Mg is unlikely to be the neutron source in EHe stars (the reaction rate of ^{19}F(α,n)^{22}Ne is much higher than that of ^{22}Ne(α,n)^{25}Mg). The work has been published in the 2006 September 10 issue of ApJ Lett.

Gajendra Pandey

Could the total dust mass in the Milky Way be very high?

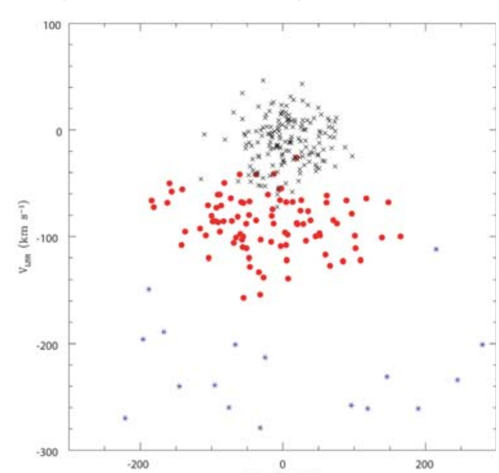
Research on a seemingly distant topic of determining abundances in Planetary Nebulae has led to some far-reaching and interesting insights. Several papers dealing with accurate determination of chemical abundances in PNe using state-of-the-art techniques and complete observational datasets have been published by us over the years. In the latest paper of the series (accepted in A&A), while dealing with the case of the PN Hubble 5, a new genre of modeling methodology called an "End-to-end modeling" has been introduced for the first time which deals with not only the usual ionized zone but also a neutral zone and a photodissociation region (PDR) all packed together in a single structure. Molecules and dust grains have also been introduced in a self-consistent way. Background radiation sources have also been considered in the calculations for the first time. When trying to systematically explain all the observed ionic and molecular (mainly H_2) features using this new kind of model, it was found that the Silicate grains and H_2 molecules can have a synergistic symbiosis which leads to egregious emission in H_2 molecular lines. Extending this idea in an intuitive way, the authors speculate that the total dust mass in our galaxy could have been underestimated since H_2 molecular emission is observed to be very strong in many locales and the above-mentioned mechanism could be the basic engine.

R. Surendiranath

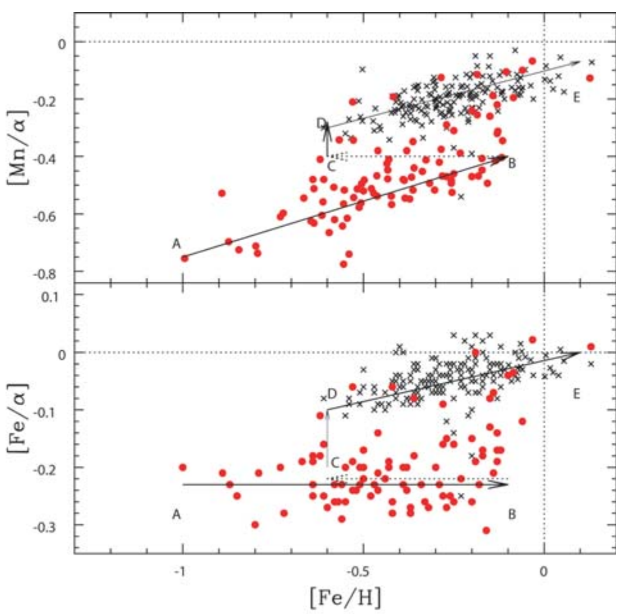
Decomposition of the Milky Way Galaxy: kinematics and abundances

Clues to the formation and evolution of our Milky Way galaxy are embedded in its building blocks - the stars. A systematic study of stellar motions and the composition reveal the origin and evolution of the Galaxy and its present structure. In collaboration with David Lambert and others from the University of Texas, Austin, we embarked on a systematic study of a large number of stars in our Galaxy. Unevolved stars of spectral type F, G and K are well suited for this purpose as they retain the chemical composition of their natal clouds. Kinematic motion of any star can be computed given its astrometric data: parallax and proper motion, and radial velocity.The astrometric data were taken from the European space mission *Hipparcos*. At present accurate astrometry is available for only nearby stars of magnitudes $m_v \leq 10.0$. This puts limits on the sample selection. Radial velocity measurements were done using high resolution spectroscopy.

A sample of 400 stars were grouped into thin disk, thick disk and the halo categories based on their kinematic properties: space velocities (U, V, W) and velocity dispersions (σ(U), σ(V), σ(W)). For each star the probability of its belonging to one of the three categories was estimated and a probability >.70 was used as the basic criterion to put the stars in one of the three groups. This is illustrated in the figure. Stars with ambiguous probabilities (<0.7) are excluded from the figure. In the U-V plane one can easily notice larger dispersions in velocities as one scans from top to bottom: thin disk - thick disk - halo. Thin disk stars are confined to the Galactic plane (within 300pc) and they move with the Galactic disk. Thick disk stars move slowly and lag behind the thin disk stars by ~40 - 100 km s^{-1}. They have eccentric orbits. They lie around 600 - 1000 pc from the Galactic plane.



Abundances were computed for 27 elements from Carbon to Europium using model stellar atmospheres and the reduced spectral line strengths. Elements chosen for the study form three groups: - elements produced mostly in SNII (massive star explosions), Fe - peak elements mostly produced in SNIa (low mass binary stars), and s-process elements mostly produced in AGB stars. Abundance ratios are compared for the three groups of stars. It is found (a) Thick disk stars are more metal-poor ([Fe/H] ~ -0.6) and older (Age ~10-12 Gyrs) compared to thin disk stars: (b) Ratios of α-elements to Fe ([α/Fe]) are larger for the thick disk stars than the thin disk stars at given overlapping [Fe/H]. This implies that the composition of the thick disk stars is influenced by SN II whose lifetimes are small. (c) For the thick disk [α/Fe] versus [Fe/H] diagrams show little or no trend suggesting that it formed rapidly within 1-2 Gyrs with very little/no contribution from SNI. (d) Plots of abundance ratios against metallicity show a scatter which is within the measurement errors. This suggests stars in the disk formed from well mixed gas.



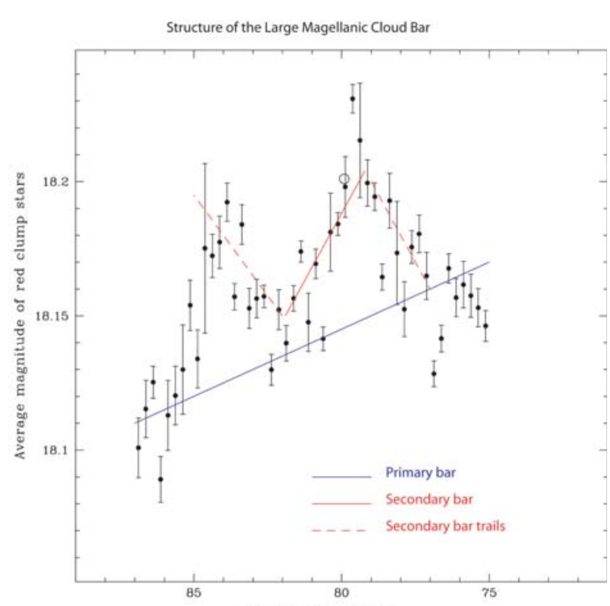
Results refute earlier suggestions that the thick disk is a simple extension of thin disk at the metal-poor end or of the halo at its metal-rich end. Instead, results suggest a major merger event in the early epoch of our Galaxy i.e 10-12 Gyrs ago. This is illustrated in Figure 2. Element ratios [Mn/α] and [Fe/α] are shown against [α/H]. The arrow AB is the evolution of thick disk. At point B a major merger of a very metal-poor dwarf galaxy with our Galaxy might have occurred. The resultant metal-rich gas in our Galaxy and the metal-poor gas from the victim might be the fodder for the thin disk star formation (point D). The jump CD can be interpreted due to the delayed SNI (Fe contributor) in the thick disk. The arrow DE (notice the slope) is the evolution of thin disk with major contributions from SNI products. These results are in concurrence with the recent predictions from hierarchical Λ–CDM model for structure formation.

B.E. Reddy

Large Magellanic Cloud - revealing the bar structure

The LMC, a small irregular galaxy, is dominated in its appearance by a stellar bar. The old stellar population shows a bar-dominated featureless distribution, whereas the young stars indicate a barless, single-armed spiral like structure. This dual appearance of the LMC has been a long standing puzzle. The brightness of core helium-burning red clump stars in the bar region of the LMC was used as a probe to understand the bar structure. These stars are standard candles to estimate absolute distances. The LMC bar was found to have a structure and a warp, indicating that the bar is dynamically disturbed (Subramaniam 2003, ApJL, 598, L19). This was later found to be due to the presence of a mis-aligned structure in the central region, termed as a secondary bar (Subramaniam 2004). The central bar is inclined in the line of sight with trailing pattern on both ends, suggesting a possible counterrotation for the inner bar. The inner structure in the LMC is likely to be formed from early mergers.

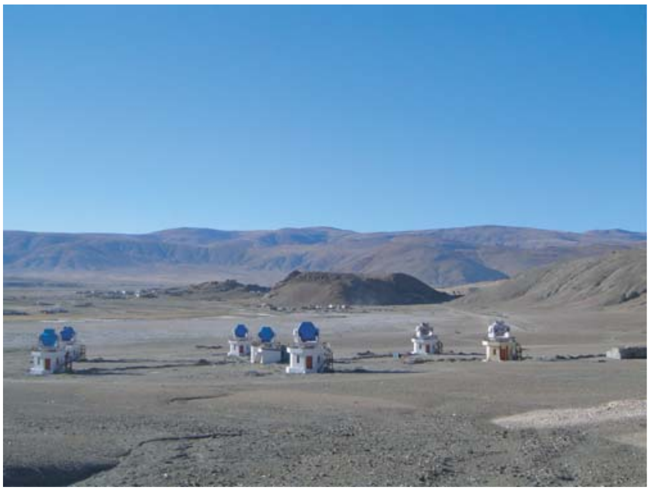
Kinematic analysis of stellar rotation in the inner regions was done to verify the counterrotation. Stellar radial velocity in the central region was used to estimate the radial velocity curve along various position angles including the line of nodes. The central part of the radial velocity profile, along the major axis shows a V-shaped deviation, instead of a straight line profile. This is a clear indication of counterrotation. The kinematics of stars and gas in the disk was also modeled, so as to explain the differences shown by these entities (Subramaniam & Prabhu 2005, ApJ 625, L47). A counterrotating contribution is added to the main stellar disk of the LMC along with a gas rich disk. The inner gas-rich disk of the LMC could be formed from this infalling gas tidally removed from the SMC. This shows that the LMC is in the process of accreting gas. This model explains the dual appearance of the LMC in gas and stars, it points out the source of gas for the formation of stars and explains the origin of recent star formation in the LMC.



All the above results clearly indicate that the nearest dwarf neighbour shows how a galaxy evolves through its lifetime. Even though it is much smaller than our Galaxy, the LMC seems to have gone through at least one merger and one gas accretion event in its lifetime.

A. Subramaniam

High Altitude Gamma-ray Array



The high altitude gamma-ray array (HAGAR), consisting of seven mounts, each with seven telescopes, each of aperture 0.9 m, is being installed in Hanle, Ladakh. The project is a collaborative effort between the Indian Institute of Astrophysics and Tata Institute of Fundamental Research. The array will exploit the Atmospheric Cerenkov Technique to study gamma-ray sources down to 20 GeV. The telescopes were designed by IIA scientists and fabricated by Bouring Fouress Ltd. and Avasarala Automation Ltd. in Bangalore. The focal plane instruments have been designed and developed by TIFR.

ASTROSAT Workshop

ASTROSAT will be the first Indian satellite fully devoted to astronomy, and will be a unique facility capable of making simultaneous, multiwavelength observations in the visible (3500 - 5500 A), ultraviolet (1300 - 3000 A) and X-rays (0.3 - 100 keV). The Ultra-Violet Imaging Telescope (UVIT) on ASTROSAT covers the visible and ultraviolet bands and has an angular resolution of 2". The workshop “UV AND MULTIWAVELENGTH ASTRONOMY WITH ASTROSAT”, with special emphasis on UV Astronomy, organized by the Indian Institute of Astrophysics was held in Bangalore from September 27 to 29, 2006.

Reviews and status reports on ASTROSAT, the satellite, and the various instruments were presented on the first day of the workshop. These include: UVIT, Large Area X-ray Proportional Counter (LAXPC), Scanning Sky Monitor (SSM), Soft X-ray Telescope (SXT), and the Cadmium - Zinc - Telluride (CZT) Imager for hard X-rays. UVIT filters and gratings, data pipeline, ground facility for tests and schemes for calibrations of UVIT were discussed.

The range of science that will be done with ASTROSAT was reflected in the large number (about 25) of talks, and some poster papers, that were presented at the workshop. How the UV and X-ray observations (timing, imaging, photometric and spectroscopic) with ASTROSAT will provide important information on a variety of astronomical objects like young stars, stars in binary systems and clusters, accreting white dwarfs, neutron stars and black holes, HII regions, planetary nebulae, novae and supernovae, UV luminosity profiles of external galaxies and their stellar populations, galaxies in groups and clusters, star-burst galaxies, active galactic nuclei were discussed by a number of speakers. Also discussed was the relevance of some recent and planned UV missions like GALEX and TAUVEX for the UVIT and ground-based optical and radio follow-up observations. There were talks on UV extinction, backgrounds and surveys.

In a special session of the workshop, practical observational constraints and possible observational strategies were discussed. It emerged from the workshop that work on ASTROSAT is progressing well. UVIT is now likely to achieve a spatial resolution of 1.0" to 1.5", better than what was originally planned. When launched in 2 to 3 years from now, ASTROSAT can be expected to give important and exciting results in many areas of astronomy.

The workshop was very well attended. There were about 90 participants, from India and abroad. Most of the presentations can be found at the web site of the Indian Institute of Astrophysics: http://www.iiap.res.in/uvit/uvitwork.html

H. C. Bhatt

Michael Dopita’s Visit

Michael Dopita of the Research School of Astronomy and Astrophysics, Mount Stromlo and Siding Spring Observatories, ANU, an authority on astrophysics of diffuse matter and emission-line nebulae, visited IIA during September - November 2006. He gave a course of lectures on “Astrophysics of the Diffuse Universe”, covering such topics as, line emission processes, atomic spectra, resonance lines, collisional excitation, the multilevel atom, density and temperature diagnostics, resonance-line absorption and the ISM, astrophysical masers, H I studies of galaxies, collisional ionization, cooling plasmas, interstellar shocks, photoionized plasmas including diffuse and planetary nebulae, novae and AGN emission-line regions, and interstellar dust.

The lectures were attended by a typical audience of about 35, including graduate students, post-doctoral fellows and faculty from IIA as well as ISAC, RRI and IISc. The lectures initiated a lot of discussions and the students as well as the faculty members immensely benefited from the course.

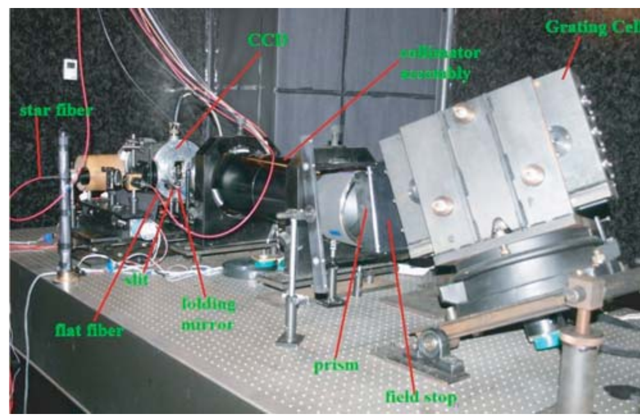
The 18th IIA Bicentennial Lecture
“Biology of Learning and Memory”.

February 23, 2007
by
Professor Obaid Siddiqi, FRS
TIFR National Centre for Biological Sciences.
Time: 5:00 pm
Venue: IIA Auditorium

Fiber-fed Echelle Spectrometer of VBT

Since early 2004 the VBT Echelle spectrometer has been in operation in a regular way for various stellar spectroscopic programmes, thus fulfilling one of the main aims that were initially proposed to build the telescope. Several modifications and changes have been and are being implemented since the initial setup. One of the very interesting results that emerged from the observations is the discovery of FIP (first ionization potential) effect in the surface abundance distribution of elements in some evolved stars of the RV Tauri class e.g., CE Vir, that suggests operation of stellar winds controlled by magnetic activity similar to the solar coronal slow wind.

The spectrometer is linked to the prime focus of the Vainu Bappu Telescope with an optical fiber of 100 micron core diameter and 45 meter length. The fiber diameter corresponds to about 2.7 arc sec on the sky that is slightly larger than the average stellar seeing disc at VBT. The optical design that was adopted is based on the use of transmitting optics with anti-reflection coatings applied to the optical surfaces rather than the use of reflecting optics. The spectrometer consists of a slit, a collimator (camera), an echelle grating, a cross disperser prism and a CCD detector. To optimize the throughput, the system operates in the Littrow mode. The fundamental consideration was the optimal spectral resolution to be realized. In the present case it is about 70000 (~4 km s^{-1}). Once this parameter was fixed the other considerations about the grating, the beam size, the collimator focal length, the detector size etc. followed depending on the cost as well as availability of the components. The echelle



Opto-mechanical layout of the spectrometer

grating selected has 52.67 gr/mm blazed at 70 degrees (R2.6) and size 208 X 408 mm. The collimated beam size of 151 mm just fills the grating.

The star light after falling on the primary comes to focus as a f/3.25 beam and is fed to a 100 micron core optical fiber (polymicro) located on the optical axis. An image acquisition unit containing an intensified CCD camera displays the stellar image and the fiber position on a monitor in the control room from where the guiding is done. Till recently the intensified camera system available could only allow stars brighter than about 11.3 mag to be placed on the fiber and guided on a dark night with good seeing. The fiber output is collimated and further converted to a f/5 converging beam that focuses on to the slit. The image size at the slit of the 100 micron fiber is 154 microns. The fiber output can also be used without the slit with lower resolution for maximum throughput. The light after the slit is reflected into the collimator by a 10 mm folding mirror that sends the beam at an angle of 0.05 degrees to the optical axis of the spectrometer. A six-element collimator, consisting of an off-axis beam corrector, a doublet and a triplet lens system that are antireflection coated and chromatically corrected to the wavelength range of 4000 A to 1 micron and mounted rigidly in a single cylindrical tube, has a focal length of 755 mm. The collimated beam passes through a LF5 prism of about 165 mm height and apex angle of 40 degrees,which pre-disperses the beam (in the cross dispersion direction) and sends it to the echelle grating that disperses the light. The dispersed beam retraces the same path and gets further cross dispersed by the prism for a second time and enters the collimator which now acts as a camera and focuses the dispersed spectrum on to a CCD chip. The camera (collimator) provides a corrected field of 60 mm diameter at the focal plane (the spot diagrams indicate image spread less than 30 microns even at the edge of the field). The spectrum is recorded on a 2048 X 4096 pixel CCD camera exclusively built for the spectrometer. The CCD is a back illuminated, thinned Marconi chip with 15 micron square pixels. The present 2K X 4K chip covers at an instant half the area of the displayed spectrum in the focal plane. The desired wavelength region is recorded either by moving the grating or CCD Dewar (the Dewar is mounted on a stage that provides movement in X,Y,Z).

All the optical components are mounted on a Melles Griot vibration-free table of 8 X 4 feet size. All the operations of the spectrometer are fully automated.

The spectrometer operates in two modes with a 60 micron slit (resolving power of 72000) and without the slit (full fiber at 27000 resolving power) although there is a provision to change the slit width.

The quality of the spectra is excellent and the accuracies of the equivalent widths obtained have been established through a comparison of the Arcturus spectrum obtained with the spectrometer at VBT and the Kitt Peak Atlas (Hinkle et al. 2000). The equivalent widths match within a standard deviation of 1.8 mA over a wide range and the match of the depths and shape of spectral lines is very good .

The optical quality of the system is such that by narrowing the slit to slightly over two pixel widths of the 2K X 4K system, a spectral resolution better than 100000 can be obtained as indicated by the Gaussian widths of the terrestrial water vapour lines in the spectrum of HR 3117. Such resolutions would be very useful for the study of circumstellar and interstellar lines.

One of the most interesting results using the instrument is obtained from our spectroscopic study of the RV Tauri star, CE Vir. It is seen that the surface elemental abundances of this star (and EQ Cas) are correlated with the First Ionization Potential (FIP) of the elements and not their condensation temperature (Rao, N.K., Reddy, B.E. 2005, MNRAS **357**, 235). This was a surprise. Earlier Giridhar, Rao and Lambert 1994, ApJ **437**, 476) discovered that the RV Tauri variable IW Car showed a good correlation of the surface abundances of the elements (depletions) with their condensation temperature, suggesting that the surface has accreted the gas that is left over from grain condensation. CE Vir was one star where the abundances of a few elements determined did not conclusively show this pattern, moreover lithium seemed to be present. The VBT study of several elements showed a strong FIP effect suggesting the elemental depletions are controlled by 'magnetic fields'. The stellar wind removed the elements that could get easily ionized. Both CE Vir and EQ Cas are cool RV Tauri's with T_{eff} close to 4200 degrees K and could be classed as A type RV Tauri's which might evolve into B type (hotter variety). We have started a study of cool RV Tauri and Semiregular variables with the VBT echelle. We have found a few additional stars showing the FIP effect, e.g., V Pyx. Figures 1,2 show the abundance (depletions) pattern with respect to condensation temperature (a scatter) and with respect to FIP. The strong correlation with FIP is obvious.

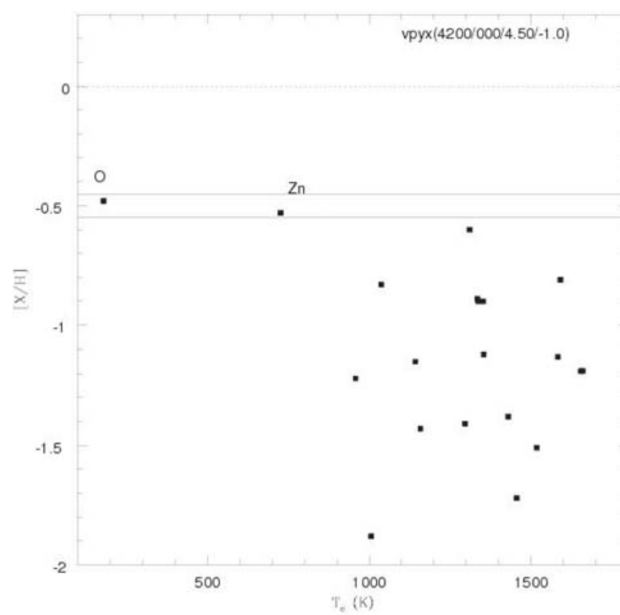


Figure 1. Abundance ratios [X/H] against condensation temperature T_c for V Pyx.

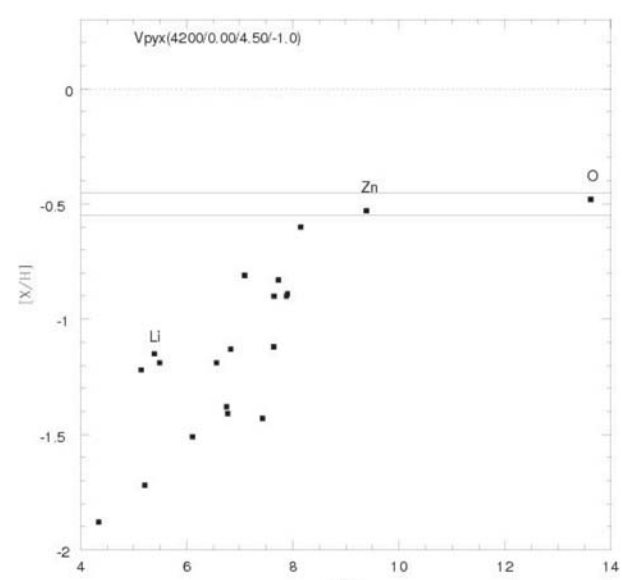


Figure 2. Abundance ratios [X/H] against first ionisation potential (FIP) for V Pyx.

N. Kameswara Rao

TAUVEX Mission

The TAUVEX mission is a collaborative venture between the Indian Institute of Astrophysics (PI: J. Murthy) and Tel Aviv University (PI: N. Brosch) to fly a set of three telescopes designed to observe the ultraviolet sky with a spatial resolution of 6 – 10". Originally intended as part of the multi-wavelength Spectrum-X-Gamma mission, TAUVEX was recast into a secondary payload on the Indian GSAT-4 satellite which is currently scheduled for launch into a geosynchronous orbit in late-2007 by an ISRO GSLV. The instrument has been fabricated at ElOp in Israel with the satellite interfaces and the launch provided by ISRO. The pipeline and other software is the responsibility of the Indian Institute of Astrophysics. The mission will be open to all Indian and Israeli scientists with equal participation by both teams in the science.

The TAUVEX instrument consists of two separate modules: an optical module (OM) consisting of three identical co-aligned telescopes; and an electronics module with the associated electronics. The structure is made of aluminium with a carbon composite for parts where thermal expansion is critical, allowing for loose constraints on the operating temperature (20 to 50 C) with no further requirements on thermal gradients.

The telescopes are of a standard Ritchey-Chretien design with a 20 cm primary mirror and a field of view of 0.9°. The primary and secondary mirrors are both made of lightweighted zerodur coated with Al + MgF_2 with an effective reflectivity of better than 90% in the ultraviolet. Standard wedge-and-strip detectors with 25 mm CsTe photocathodes are used to give a spectral range between 130 and 300 nm with filters providing further flexibility in choosing bandpasses.

Because TAUVEX is a secondary payload on GSAT-4, it will operate in a different mode than most scientific missions. The normal mode of operation is to scan a line of celestial latitude per day. The instrument sits on a rotating plate fabricated by the ISRO Satellite Centre (ISAC) which allows coverage from the South Celestial Pole to the North. The exposure time is dependent on the latitude and can range from about 200 seconds per day at the equator to more than 86000 seconds at the poles. As a result of the scanning, TAUVEX is not well suited to observe individual targets; rather, it is intended for use as a survey instrument observing large areas of the sky with moderate spatial resolution and high sensitivity.

The primary constraint on TAUVEX observations is sunlight scattering off the spacecraft — the solar panels, the thrusters, or other parts of the spacecraft. We are now evaluating the level of scattering as a function of time of day and season of the year. Other mission constraints come from the Moon, the Earth, bright stars and the brighter planets all of which may affect the lifetime of the instrument. We are now working on a mission plan to best achieve the science goals of the mission as well as that of the user community.

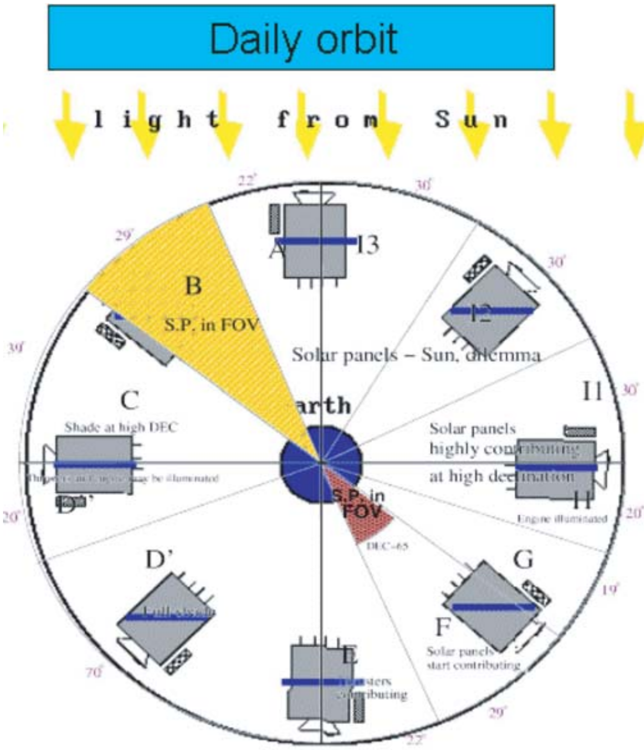
Figure shows TAUVEX sitting in an ElOp (the instrument contractor) cleanroom in Israel

Because TAUVEX is a scanning instrument, the science is best suited to surveys of objects or areas rather than observations of individual objects. We have constituted a number of teams with a mandate to define science plans for different classes of objects. These science plans will be integrated into our observing schedule such that the science return is maximized.

One of the primary responsibilities of the TAUVEX team at IIA is to create the pipeline software system to convert the raw instrument data into images and other data products required for scientific work. This has been a major effort but is now almost complete barring detailed testing and verification. A simulation system has been written to create data for both purposes of mission planning and to test the pipeline software. Further routines are being written for general astronomy display and analysis.

The latest information about the TAUVEX mission including contact information, the latest status and, when available, data products may be obtained from our web page: http://tauvex.iiap.res.in.

The TAUVEX team at IIA consists of Prof. J. Murthy (P. I.), Drs. R. Mohan (Project Scientist), M. Safonova (Science Planning) and P. Gopakumar (Observation Planning) with software trainees M. Fayaz, S. Vaishali, L. Geetha, and S. Sowjanya.



A Laboratory for Space Sciences

IIA is a major participant in ISRO's ASTROSAT mission. ASTROSAT, a multiwavelength space observatory for carrying out astronomical observations over a large part of the electromagnetic spectrum – from hard x-rays to near ultraviolet and visual wavelengths, will support several internationally competitive instruments capable of detecting radiation emitted by the cosmic sources over a wide frequency range. Since IIA proposed the Ultra Violet Imaging Telescope (UVIT) on ASTROSAT in the first place, the full responsibility of design, fabrication, testing and final integration of the uv payload with the satellite has quite naturally devolved on IIA.

UVIT is to be tested and calibrated both as a set of individual components and as an integrated unit with telescopes and detectors. IIA is building a major state-of-the-art UV calibration facility at its new campus in Hosakote, near Bangalore. The facility is named after Professor M. G. K. Menon, the first Chairman of the IIA Council. The primary purpose of this facility is to test, integrate and calibrate components and instruments for space-based observational platforms. It is the first facility of this kind, both in utility and sophistication, in an academic institution in the country.

Some of the proposed tests include evaluation of image quality, spectral response, and sensitivity. The facility

will perform the pre-flight optical end-to-end test and calibration, essential for assuring that UVIT conforms to the design parameters. Testing of operation in UV (λ < 180nm) requires a clean room with vacuum facilities. An ultraviolet instrument is likely to suffer from performance degradation as a result of contamination of the optical surfaces. A strict control of particulate and molecular contamination is thus needed for maintaining its performance.

The project involves a pro-active and comprehensive contamination control and monitoring programme. The facility in Hosakote consists of clean laboratories in compliance with FED209E, ISO 14644-1 and ISO 14644-2 standards to meet VUV cleanliness requirements. The laboratory is a totally automated centre with 24/365 monitoring facility to meet ISO standards.

At the M G K Menon Laboratory, we shall be adopting the following clean-room procedures in common with those followed in other space missions and also in conformity with ISO 14664-1 standards. These are:

1. Unidirectional airflow clean rooms for telescope integration and testing.
2. Strict control of particulate and molecular contamination and parameters such as temperature, humidity (< 30% at telescope integration room) and pressure.
3. Facility to monitor temperature, humidity, pressure and particulate and molecular contaminants.
4. Restrictions on the entry of people in the clean room.
5. Prescribed clothing of the personnel, e.g., ISO 1/2 specified garments including hoods, gloves, and jumpsuits.
6. Clean-room maintenance/cleaning methods, frequency, prohibition on using contaminant generating cleaning agents or methods.
7. Use of HEPA filter vented vacuum cleaners, clean-room certified tools etc for the facility.
8. A training programme for all the personnel in cleanroom procedures based on specifications provided by other space missions.

The Laboratory will be equipped with Fizeau Interferometer (Zygo Corporation), Thermovac chamber, Vacuum reflectometer, VUV test chamber (1m by 5m ultra-clean vacuum chamber with VUV source, monochromator, precision motion stages etc.), Ultra-clean vibration isolation tables (Newport), VUV photon counting detectors (Photek), Metrology equipment (Zeiss), Ultra-clean gas lines (Class-c or better) and Clean-room monitoring systems.

B. Raghavendra Prasad

2006 Solar Physics Winter School

Indian Institute of Astrophysics

Kodaikanal Solar Observatory

India

December 10-22, 2006

Vainu Bappu Memorial Lecture

Beginning 2007, a new lecture series is being instituted by IIA, named after the Founder-Director, M K Vainu Bappu. The Vainu Bappu Memorial Lecture will be delivered each year by an eminent astrophysicist on a topic of broad interest.

IIA is pleased to announce that the First Vainu Bappu Memorial Lecture will be delivered by Professor E N Parker of the University of Chicago on January 4, 2007. Professor Parker will speak on
The Sun, Space, Cosmic Rays and Climate

Time : 5.30 pm

Venue : IIA

Young Astronomers' Meet

January 3 – 5, 2007

Indian Institute of Astrophysics
Bangalore

2nd UN/NASA Workshop on International Heliophysical Year and Basic Space Science

Indian Institute of Astrophysics,
Bangalore
27 November – 1 December, 2006

Editors: D. Banerjee, D.C.V. Mallik, B. A. Varghese

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