IIA Newsletter

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National Meeting on India's participation in GSMT Projects

Extremely large telescopes, with effective apertures of more than 20 metres, are considered to be the next big step in ground-based astronomy. Generically called Giant Segmented Mirror Telescopes or GSMTs, they will vastly improve our knowledge of stars, planets and galaxies and address more sharply questions regarding the origin and formation of planets around other stars, the first objects in the Universe, and the nature and distribution of dark matter and dark energy that dominate the Universe. Two US-led groups and ESO with its user community of European astronomers have been independently planning three large ground-based telescopes with capabilities in optical and the infrared, which may usher in the new era in astronomy in the next decade and a half. The price tag on each instrument is a billion US dollars or more and none of the three groups have so far raised enough funds to fulfil their needs. Each project will need to have several partners and the lead agencies are in the process of finding them in countries that have serious professional interest and manpower in astronomy. This has naturally led to the possibility of India joining one of them at a level of 10% to 15% participation. A one-day national meeting was organised in IIA on September 27, 2008 to discuss the Indian science interests and possible modes of Indian participation in one of the GSMT projects.

The meeting was attended by representatives of all the major astronomy research institutions and the universities, where there is sufficient interest and activity in astronomy, namely, Utkal, Osmania, Delhi, SRTM University, Nanded, Pandit Ravishankar Shukla University, Raipur and Assam University, Silchar. There were a total of 75 participants.

The first session started with the opening remarks by Professor Siraj Hasan, who gave a historical perspective on the development of optical astronomy in IIA. He said as early as 1978, Dr Vainu Bappu was already thinking of the next big step after the 90-inch telescope and had said that India should go for a 6-metre class telescope. Professor Hasan also recalled IIA's quest for a large telescope that started in 1989 and led to the proposal, in the 1990s, of setting up a national large optical/IR telescope in the trans-Himalayan region. Although a 2-m telescope was set up in Hanle, the large telescope project failed to take off. Professor Hasan felt strongly that the astronomy community had waited long and it must now seize the opportunity to participate in one of the GSMT projects, which seemed to have come at the right time. Professor Ram Sagar endorsed this view and gave compelling reasons why we must actively participate in the venture. He mentioned areas where the need to have a very large optical facility is being felt ever so strongly. Professor Naresh Dadhich spoke on behalf of the astronomers in IUCAA, how they are very keen on this participation. He said if a challenge were thrown, our astronomers would rise to match it. He felt that the initiative to participate has to be a national one and should not come from any one institution.

B. Eswar Reddy (IIA) and R. Srianand (IUCAA) made presentations on the status of the three GSMT projects and their technical capabilities. While Reddy gave a comparative budget analysis of the American projects, the Giant Magellan Telescope (GMT) and the 30-metre Telescope (TMT), and shared with the audience some of the official communications received from the GMT and TMT consortia inviting India to join in a partnership, Srianand argued for a re-orientation in our thinking and way of working when these big telescopes become available to us. He pointed out that 16 nights of observations at a telescope like SALT are equivalent to a year of observations with a 2-m class telescope. A 30-m telescope is even more different as the science expected from it is entirely different from what is expected of even a 8-m telescope. According to Srianand, it is not just a matter of scaling up and the Indian community should prepare itself seriously to measure up to the potential offered by this new class of machines.

In the second session, the specific scientific interests of the Indian astronomers were discussed by G. C. Anupama (IIA), Swara Ravindranath (IUCAA) Pushpa Khare (Utkal University), D. K. Ojha (TIFR) and A. C. Gupta (ARIES).

In the third session, held after lunch, A. K. Saxena (IIA) gave a short presentation on the capabilities of the Indian industries. Ajit Kembhavi (IUCAA) talked about the need for resource development including human resources. If India did indeed decide to participate in one of the GSMT projects, there is every likelihood that a large number of opportunities in software would open up and Indians should be able to seize such opportunities, given the strong software capabilities present in the country. B. R. Prasad (IIA) spoke of IIA's synergy with the Indian industries in developing and delivering many projects. Uday Shankar (RRI) summarised various international partnerships his institution has already successfully participated in, e.g., the RRI-MWA and RRI-GBT partnerships. He was confident that in certain areas like the possible application of radio imaging technology to adaptive optics, building control systems and hardware and in handling astronomical data centres, RRI could contribute substantially.

The last session was a moderated discussion chaired by Professor Hasan. Issues like manpower and its projected development, the need for training students in using 8 to 10 metre class telescopes to prepare to handle the GSMTs and accelerated growth of astronomy in the Indian universities were discussed threadbare. The present initiatives taken by IIA and IUCAA in training students in astronomy and astrophysics were described. Several other useful suggestions were made. Ranjan Gupta (IUCAA), the current Secretary of the Astronomical Society of India, suggested that a session should be organised on the GSMT project proposal during the forthcoming meeting of the Society. A word of caution was added by Professor Harish Bhatt saying that the existing astronomical facilities in the country should by no means be neglected.

Professor T. Padmanabhan gave the concluding remarks. It was clear from the deliberations at the meeting that there is a consensus among the Indian astronomers with regard to the participation in one of the GSMT projects, as the community requires access to a cutting-edge facility. To proceed further several tasks need to be undertaken in parallel. A serious dialogue has to start with the funding agencies. The astronomy institutes need to prepare a proposal document summarising the discussions at the meeting. Much more information in much greater detail on all three GSMT projects need to be obtained and a serious analysis on the relative merits and demerits of each has to be made before choosing one of them for the Indian needs. It was also stated that the funding authorities might insist on participation in kind, e.g., in software and/or instrument development, in addition to payment in cash, and the modalities would then have to be worked out with the concerned lead agencies of the projects.

The meeting concluded with a vote of thanks proposed by the Convener, B. Eswar Reddy.

– D. C. V. Mallik

Radio observations of the solar corona at 170 MHz during the partial solar eclipse on August 1, 2008

The solar corona can be imaged routinely from the ground over the frequency range ~ 30 – 300 MHz since the observed emission originates primarily there. The main limitation in the observations is the angular resolution: one requires a radio telescope array of size about 50 km in length to probe the solar atmosphere with a resolution of about 1 arc min at 30 MHz. During a solar eclipse, radio observations of the Sun can be carried out with high angular resolution even with small sized antennas through the diffraction effects provided by the Moon's sharp limb, similar to lunar occultation studies of extragalactic radio sources. The limiting resolution, given by the width (θ_f) of the first zone of the Fresnel diffraction pattern is, $\theta_f = 2 \times 10^5 (\lambda / 2D)^{1/2}$ arc sec where λ is the observing wavelength and D is the Earth-Moon distance (~ 3.8×10^8 m). The added advantage is that the atmospheric conditions, particularly the cloud cover, are not a major hindrance. The covering or uncovering of a discrete source of intense emission in the corona by the limb of the Moon coincides with a sharp change in the slope of the occultation curve. The angular dimension of the occulted source is $f = b(t_2 - t_1)$, where $(t_2 - t_1)$ is the time interval taken by the limb of the moon to either fully cover or uncover the source and b is the apparent rate of movement of the Moon in the sky. At the Gauribidanur radio observatory near Bangalore (refer http://www.iiap.res.in/centers/radio for details about the observatory) there was a partial solar eclipse on August 1, 2008 with a maximum magnitude (defined as the fraction of the Sun's diameter occulted by the Moon) of 31% and an obscuration (a measure of the Sun's surface area occulted by the Moon) of 20%. The first contact of the Moon with the Sun took place at 11:12:20 UT (04:42:20 PM IST). The position angle (PA, measured counter clockwise from the north point of solar disk) of the point of contact of the Moon with the solar limb was 346°. The corresponding values for the fourth contact were 12:36:58 UT (06:06:58 PM IST) and 76°, respectively (refer http://eclipse.gsfc.nasa.gov/SEgoogle/SEgoogle2001 SE2008Aug01Tgoogle2.html for details about the eclipse). We would like to emphasize here that solar eclipses at radio frequencies are usually partial since the size of the 'radio Sun' is larger than the solar photosphere.

We carried out radio observations of the solar corona during the eclipse with a two-element interferometer on an East-West baseline at 170 MHz, from the observatory. The spacing between the individual antennas of the interferometer was ~50 m. This gives well defined interference fringes from the Sun with a frequency of about 2^0 under normal observing circumstances (refer http://www.iiap.res.in/outreach/ihyoutreach for details about the instrument). The observations on the eclipse day were started at 10:45:00 UT, well before the first contact mentioned above. Figure 1 shows the results of our observations. One can notice that there is a well defined fringe to begin with (as mentioned above) and a reduction in the observed fringe amplitude after the first contact. But beginning from about 11:30:00 UT onwards, there is almost a collapse of the fringes. Additionally there is a gradual and sharp fall/rise in the observed intensity over the time interval 11:45:00 – 12:14:00 UT and 12:14:00 – 12:25:00 UT, respectively. The Sun was almost at the horizon (elevation ~ 5^0) at the time of the fourth contact and so we couldn't continue the observations for a longer period to notice the re-appearance of the interference fringes after the fourth contact. We looked at the solar images obtained on August 1, 2008 to identify possible radio wave emitting sources that could explain the behavior of the interference fringes observed by us.

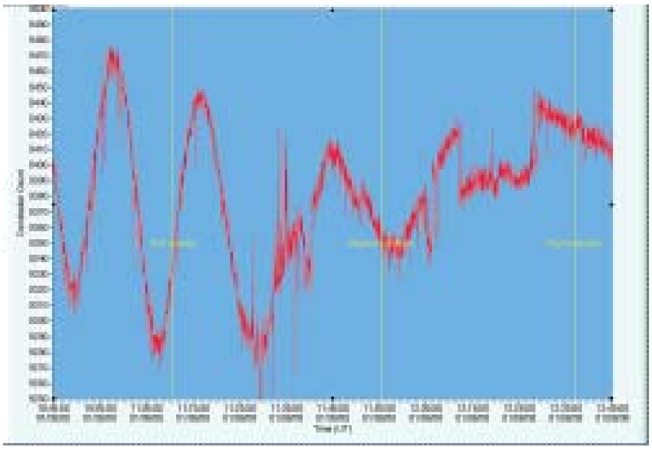

Figure 1: Radio observations during the partial solar eclipse of August 1, 2008 from the Gauribidanur observatory with a two-element interferometer at 170 MHz.

Figure 2 shows the observations with the radioheliograph at the observatory, two hours prior to the eclipse. Note that we were not in a position to carry out eclipse observations with the heliograph since the elevation of Sun during the eclipse period was low for the heliograph. For the eclipse observing setup, i.e. the two-element interferometer, we had tilted the individual antennas towards the west to overcome the above problem.

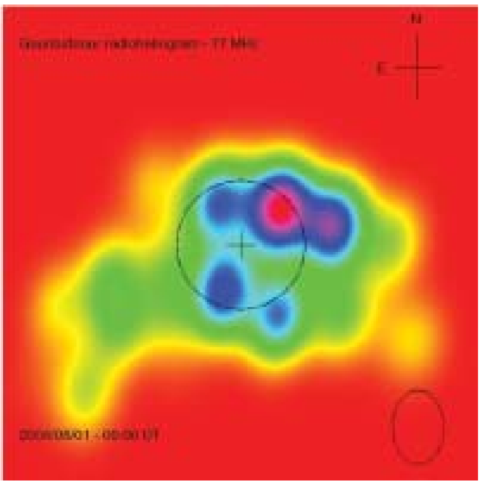

Figure 2: Observations with the Gauribidanur radioheliograph (GRH) at 77 MHz on August 1, 2008 around 09:00 UT, about two hours prior to the eclipse. The open circle at the center is the solar limb and the ellipse near the right corner below is the size GRH 'beam' at 77 MHz.

Figure 3 shows the composite of the images obtained with the Extreme Ultra-violet Imaging Telescope (EIT) onboard SOHO, the Mark-IV coronagraph at Mauna Loa and the LASCO-C2 coronagraph onboard SOHO, on the eclipse day. There is a good correspondence between the extended structures beyond the solar limb in Figures 2 & 3. Additionally one can notice from Figure 2, that there are isolated discrete sources within the region of the solar surface covered by the Moon between its first and fourth contact mentioned above. Since the fringe collapse and the intensity reduction(s) in our observations was after the first contact, we speculate that the partial occultation of the 'radio Sun' at 170 MHz and the covering/uncovering of the aforementioned discrete sources by the Moon might be the reason for this. Further analysis of the data is in progress and the detailed results shall be reported elsewhere.

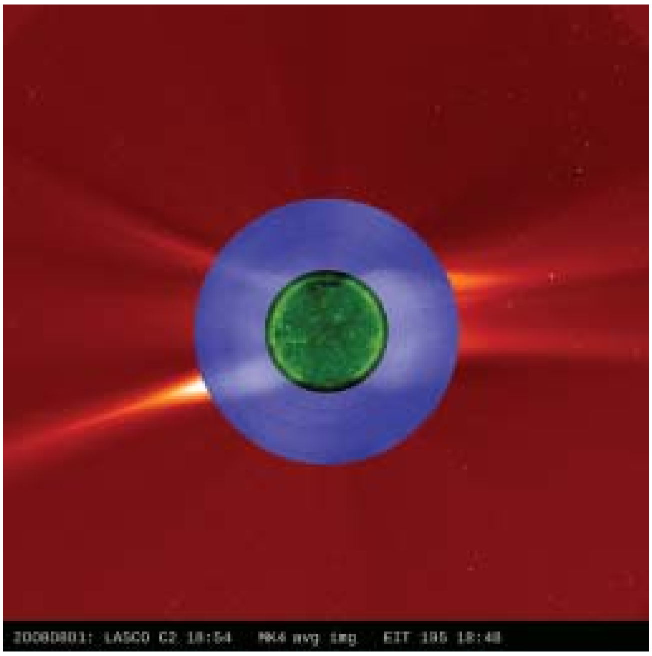

Figure 3: A composite of the images obtained with Extreme Ultra-violet Imaging Telescope (EIT) onboard SOHO (green), the Mark-IV coronagraph at Mauna Loa (blue) and the LASCO-C2 coronagraph onboard SOHO (red), on the eclipse day.

- R. Ramesh, Indrajit V.Barve & C. Kathiravan

Searching for the metal-weak thick disc in the solar neighbourhood

Introduction of the concept of the thick disk is broadly attributed to Gilmore & Reid (1983) who from star counts had found that a double-exponential offered a good fit to the space density distribution of stars perpendicular to the Galactic plane toward the South Galactic Pole. Study of the thick disk component and its association with the Galactic disk is one of the high priority topics for understanding the formation and evolution of our Galaxy, in particular, and any disk galaxy, in general. After its introduction, the thick disk was a controversial innovation for quite some years, but today many properties of the thick disk are well determined. Stars in the thick disk are old, kinematically distinct from the stars in the thin disk, and most of them fall in the [Fe/H] interval of – 0.3 to – 1.0, and their composition is mainly attributed to SN II events (Reddy et al. 2006).

There are still some issues to be resolved, for example, we do not know for sure the upper and lower bounds to the [Fe/H] distribution for the thick disk stars. In our latest study (Reddy et al. 2008), done in collaboration with Professor David L. Lambert of the University of Texas, we have attempted to understand the metal-poor end of the thick disk in the solar neighborhood. Sample selection for the study of the metal-weak thick disk stars is a complicated process and this is well illustrated in our work. We assigned all the thick disk stars which have [Fe/H] ≤ -1.0 as metal-weak thick disk stars. Below [Fe/H] $= -1.0$, presence of thin disk stars is insignificant but halo stars dominate the sample.

Separation of metal-weak thick disk stars from the halo population is severely hindered by four issues: (i) Defining the kinematic criteria for halo stars in the solar neighborhood is complicated by the suggestion that the halo consists of two components: an inner halo with a metallicity centred on [Fe/H] ~ -1.6 and a small net prograde velocity, and an outer halo with a metallicity centred on [Fe/H] ~ -2.0 and a net retrograde motion. (ii) The velocity characteristics of the metal-weak thick disk stars must be extrapolated from those measured for the dominant thick disk population ([Fe/H] ≥ -1). (iii) The relative population of metal-weak thick disk and halo stars is not known *a priori*. (iv) There is no single catalogue for the accurate astrometry (there are not many metal-weak thick disk stars in the Hipparcos Catalogue) which means selection effects in the chosen catalogue play a role in our sample selection.

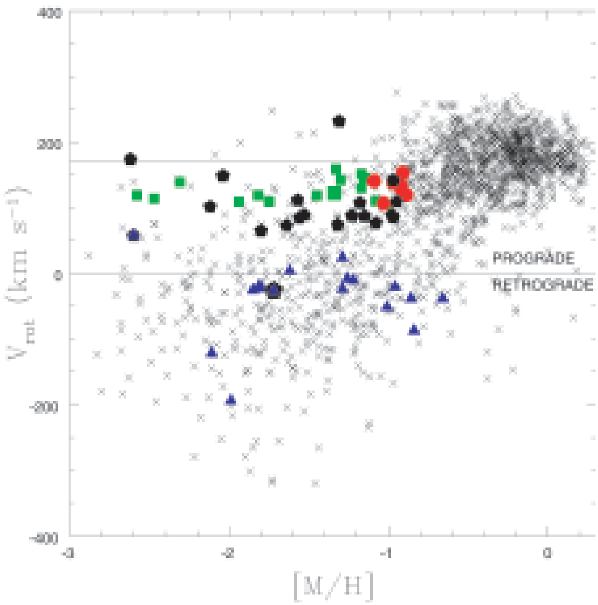

Figure 1 : The ([M/H],V_{rot}) plane for the stars from the combined catalogue (black crosses) showing the 14 metal-weak thick disk candidates (green squares), 8 thick disk stars (red circles), 20 hybrid stars (thick disk/halo) (black pentagons) from Table 1, and the 18 halo comparison sample from Table 2 (blue triangles). Two stars that have large radial velocity discrepancy are shown as two large symbols (green square and black pentagon).

For our study, we have used two catalogues (Arifyanto et al. (2005); Schuster et al. 2006) with a combined sample of 1800 stars. To isolate the most probable metal-weak thick disk stars, we have applied the kinematic criteria $V_{rot} \geq 100$ kms^{-1}, $|U_{LSR}| \leq 140$ kms^{-1}, and $|W_{LSR}| \leq 100$ km s^{-1}. Fourteen stars satisfying these criteria and having [Fe/H] ≤ -1.0 and 18 stars with kinematics distinctive of halo are included. A total of 60 stars are included for the detailed chemical composition analysis. The selected sample is shown in the plane of [M/H] $-$ V_{rot} (Figure 1).

Analysis of the kinematics and chemical composition of the selected metal-weak thick disk candidates suggests the following salient features:

a) If we assume that there are no kinematical differences between the thick disk i.e. defined by stars with metallicities [Fe/H] ≥ -1.0, and the metal-weak thick disk, then the latter are very rare in the solar neighborhood compared to the thick disk stars.

b) The mean of our age estimates (10 - 13 Gyrs) for metal-weak thick disk candidates is the same as the WMAP age of the Universe. The halo, the thick disk and the metal-weak thick disk cannot be distinguished by using age estimates at the level of their current precision,

c) The abundance ratios [X/Fe] of halo stars and of metal-weak thick disk candidates with similar metallicities are not distinguishable. However, the compositions provide a continuous trend in [X/Fe] versus [Fe/H] indicating that the metal-weak thick disk is the metal-poor tail of the thick disk.This is demonstrated in Figure 2 showing the results of abundance analyses of four α-elements for halo, thin disk, thick disk and metal-weak thick disk components.

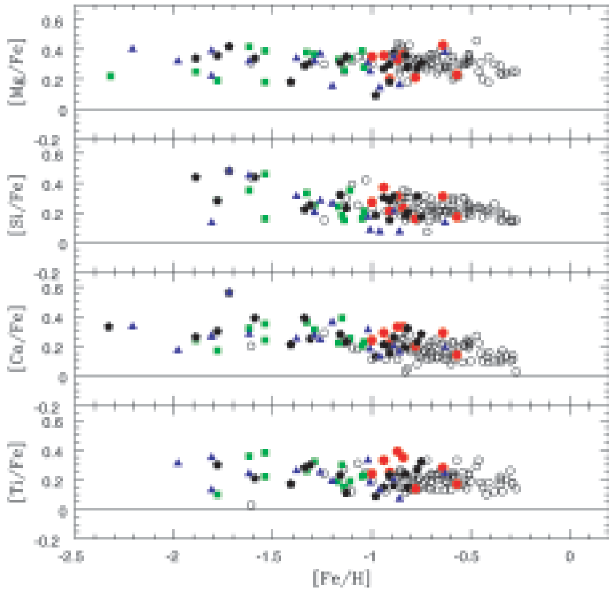

Figure 2 : Abundance ratios [α/Fe] for α = Mg, Si, Ca, and Ti against [Fe/H] of metal-weak thick disk stars (green squares), thick disk stars (red circles), hybrid stars (black pentagons), halo stars (blue triangles) and thick disk stars from Reddy et al. (black open circles) are shown.

d) Our proposed sole discriminant, though it is imperfect, involves a combination of the kinematic parameters: mean eccentricity: 0.49 ± 0.1, 0.45 ± 0.10, and 0.87 ± 0.16 and mean galactocentric distance (R_m): 6.38 ± 0.44 kpc, 6.44 ± 0.70 kpc, and 6.59 ± 2.6 kpc for metal-weak thick disk, thick disk, and halo stars, respectively.

It is unfortunate that we have been unable to identify a conclusive signature distinguishing a metal-weak thick disk star from a halo star. However, the small sample of metal-weak thick disk candidates have the composition established for the thick disk and the halo at their interface. Obviously, the case for a metal-weak thick disk population needs refinement beginning with the isolation of a larger sample with reliable metallicities, reliable kinematics from accurate distances, radial velocities, and proper motions to establish that the stars have disk-like motions. The tools with which to meet these goals are on the horizon with the proposed launch of the European Space Mission "GAIA", designed to measure accurate astrometry (10-15 micro arcsec) for over 1 billion stars in our Galaxy and the ongoing RAVE (RAdial Velocity Experiment) to measure radial velocities of millions of stars.

References:

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- B. Eswar Reddy

John Evershed: The Instrument Builder

John Evershed (1864-1956) is well known in astrophysics, particularly in the area of solar physics, for his discovery of the radial motion in sunspots, an effect which bears his name. What is less known though is that Evershed was a designer and builder of instruments, especially spectroscopic instruments. While he was still at school and aged thirteen, Evershed constructed a telescope with odd lenses and used it through a plate glass window to observe Mars in near opposition. Later, with a spectroscope made out of two lenses from an old disused pair of opera glasses and a small but perfect prism given to him by his brother, he was thrilled to see the sodium D line of the solar spectrum split into its fine structure components. This experience probably gave the final direction to his scientific activities which followed and shaped his entire career. The early training in workshop practice that he had obtained from his brother served him well, not only in these early teenage days, but also throughout his whole life, especially in India. Instrument building remained, for Evershed, a lifetime passion (Stratton 1957).

Inspired by Norman Lockyer's observations of solar prominences, Evershed built himself a spectroscope with a battery of prisms at his private observatory in Kenley, England. He observed 13458 prominences between 1890 & 1905 and studied their pole-ward migration. In 1891, Evershed read about George Ellery Hale's invention of a new viewing device, the spectrohelioscope, and set about to build one for himself. In 1892, Evershed invented the technique of monochromatic photography of the whole disk of the Sun. He photographed the prominences in the Hβ line This was independent of Hale's invention of the spectroheliograph in the same year. Actually, Hale is supposed to have stated that Evershed was the only person other than he himself to have built a spectroheliograph (Wright 1994), thus acknowledging the ingenuity and craftsmanship of Evershed in instrument building.

In 1898, Evershed joined the total solar eclipse expedition of the British Astronomical Association to Talni in India, where he used a home-made prismatic camera to secure beautiful spectra extending far into the ultraviolet; he was the first to photograph the emission continuum at the head of the Balmer series. Evershed later took up expeditions to the total eclipses of 1900 (Algeria), 1905 (Spain), 1922 (West Australia), and 1927 (Yorkshire), though without much luck. He always built and used his own instruments; only the prisms were procured, which were of course among his prized possessions. He very successfully used his eclipse prisms to build a prismatic camera for observing Comet Daniel in 1907 and Comet Halley in 1910. He identified the cyanogen bands both in the nucleus and the tail of Comet Daniel. In the case of Comet Halley, he identified the cyanogen as well as the Swan bands in the nucleus and the carbon monoxide bands in the tail.

In 1906, at the initiative of Gilbert Walker, who was the Director General of Observatories in India, and with the support of William Huggins, Evershed was offered the post of Assistant Director of the Kodaikanal Observatory which he gladly accepted and joined in 1907. On their way to India, the Eversheds spent about a month at Mount Wilson where Hale was busy building the famous observatory. Evershed benefited from his scientific interactions there and also brought with him a large Michelson grating.

When Evershed arrived in Kodaikanal, there were already several instruments and he set forth to improve them. The main thrust of observations was sunspots and Evershed took a fascination for it, besides continuing his favourite prominence observations. Evershed's skill in designing and building instruments was best made use of during these early days in Kodaikanal. He put to working order the Cambridge spectroheliograph and soon built a large spectrograph

The Cambridge spectroheliograph. (Plate from IIA archives)

using the 6-inch Michelson grating which he had brought with him, and put it to use to observe sunspot spectra. Evershed also evolved a fine technique (the so-called positive on negative method) to measure the small line shifts. He also ingeniously used the image rotation caused by the siderostat to his advantage. In 1909, Evershed published the memoirs in which he summarised his observations on sunspots. The Evershed effect had thus been discovered.

The K line spectroheliograms were being obtained regularly at the observatory since 1904 and Evershed wanted to add an Hα facility for near-simultaneous recording. In order to achieve the necessary resolution, he used the Michelson grating to build an auto-collimating spectrograph and bolted it onto the framework of the existing instrument.

Grating and lens of the autocollimating spectroheliograph attached to the side of the Cambridge spectroheliograph. (Plate from IIA archives)

This twin spectroheliograph started working in 1911 (Evershed 1911), and with minimal necessary changes, has been functional until very recent times.

In 1923, Evershed retired from the Directorship of the Kodaikanal Observatory and returned to England where he established a private observatory in Ewhurst. The following remark by him shows his joy in building instruments and using them: 'I began with a prism containing just a cubic centimetre of glass, I end with a prism containing two litres of liquid; instead of barely splitting the D lines, D_1 and D_2 appear now half an inch apart, with a large number of solar lines between.' Till his death in 1956, at the ripe old age of 92, Evershed continued to observe the solar spectrum whenever conditions allowed. His doctor is said to have stated: 'He was an impossible patient and however ill would always refuse to leave his underground observatory.' (Stratton 1957) After all, it was an eighty year love affair with the solar spectrum!

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- S.P. Bagare, A.Vagiswari, Christina Birdie

Inauguration of Bhaskara

Bhaskara, IIA's spanking new hostel and guest house, was inaugurated on Sunday, November 16, 2008 by the Secretary of the Department of Science and Technology, Dr T Ramasami. The Director, Professor S. Hasan and his wife, special invitees and a large number of the scientific, technical and administrative staff of IIA were present. Bhaskara is located on the 100-ft Road of Koramangala near Madivala Gate, a short distance away from IIA's main campus. It is a multistoreyed building with 45 rooms to house visitors, guests and also IIA students and visiting fellows. It is equipped with a modern kitchen, a sunny and spacious dining hall and other modern facilities. It will have internet access in each room. Although the land was procured through a public auction a long time ago,

due to various reasons the construction of the building was highly delayed and only in 2006, the actual construction of it started. K Jaisim, the renowned Bangalore architect designed the building and Messrs J N Constructions were entrusted with building it.

Welcoming Dr Ramasami and the invited guests, Professor Hasan mentioned a bit of the history and went on to name the large number of people who helped at various stages of the planning and construction of the building. The Civil Engineer of IIA and the staff of the Electrical and Civil Divisions were praised for their hard work, the administration for its support and the Building Committee members for their help. Professor Hasan apologised if he had inadvertently left out some names, for the list was long. At the end, he especially thanked his wife, Mrs Sultana Hasan, for her tireless help and co-operation in the project and for overseeing its various aspects to the minutest detail to ensure the quality of the interior work and for taking care of the aesthetic aspects of the place.

Dr Ramasami said he was happy to be present and to also make his first visit to IIA in the process. Of all the DST institutions, he had somehow missed visiting IIA earlier. He said astrophysics is one of a small number of scientific fields in which India is supposed to be in the forefront. He mentioned the initiative being taken currently to participate in one of the GSMT projects. A question often raised in the government circles in this connection is where are the people to use the facilities and the hardware that the government invests so much in. Dr Ramasami said that the scientific institutions must therefore attract bright young people in good numbers and infrastructure, such as a nice hostel facility, should help towards achieving this goal.

Dr Ramasami then released the IIA Brochure. A sumptuous lunch was hosted by the Director on the occasion.

The 26th Meeting of the Astronomical Society of India
February 18 - 20, 2009
Indian Institute of Astrophysics
Bangalore 560 034

The 26th Meeting of the Astronomical Society of India will be hosted by the Indian Institute of Astrophysics, Bangalore during February 18-20, 2009. The Chair of the Scientific Organising Committee (SOC) is H. C. Bhatt (IIA, Bangalore), and the Convenor of the Local Organising Committee (LOC) is G. C. Anupama (IIA, Bangalore).

The Scientific Meeting will consist of (a) invited talks, (b) contributed papers to be displayed as posters, (c) an exclusive session for oral presentations on recently submitted Ph.D theses and (d) rapporteur talks and question-and-answer sessions on the poster papers. Evening lectures by distinguished scientists will also be arranged for a larger audience.

Detailed information regarding registration, accommodation, and the scientific programme of the meeting is available at the web-site: http://www.iiap.res.in/asi2009.

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