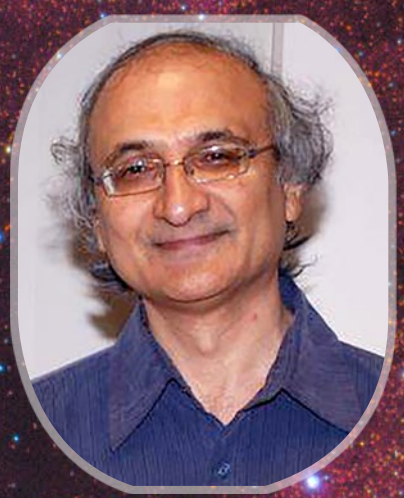
DOOT

Quarterly Magazine of the Indian Institute of Astrophysics

1971-2021 50 IIA Indian Institute of Astrophysics

Issue 04
May 2021



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Invitation for the next issue

For the next issue of DOOT, we are inviting your contributions under the following categories:

Review articles:

Scientific and technical publications (recent publications in academic journals from the IIA family, IIA technical reports, breakthroughs in Astronomy, book review, Journal club discussions, milestones of IIA projects; to be published in simple language) are invited. Project interns and summer school project students can submit an overview of their work. (Word limit: 2000 words)

Individual experiences and substation stories:

In this section, we invite stories of your personal experience, maybe with a scientific project, an experiment, attending a conference/workshop, a collaborative visit, visit to an observatory, or even a coffee break with a prominent scientist. We also invite interesting stories from our substations at Hanle, Kodaikanal, Kavalur, and Gauribidanur about the ongoing activities and valuable memories. (Word limit: 1400 words)

Physics concepts made easy:

For this section, we invite write-ups discussing interesting concepts of Physics in a very simple and enjoyable way, without using much of technical jargons. The main motive is to reach a wider audience by making it easy to understand, relate, or appreciate Physics, without having any technical background in the subject. (Word limit: 1400 words)

Alumni and retired staff/faculty stories:

IIA Alumni students and retired staff/faculty can share their experiences during their association with IIA. (Word limit: 1400 words)

Creativity corner:

Splurge on your creativity here! For this section, we invite all kinds of artworks including but not limited to paintings, poems, short stories, and graffiti. (Word limit: 800 words)

NOTE: Attach a brief bio along with the article. Submissions should be in editable text files (doc/odt).

High resolution images should be given separately with the filename same as figure numbering (eg: Fig1.jpg)

Disclaimer: *Any article received will be published only after strict screening. The chief editor's decision will be final. Submitting your article to DOOT implies your consent to edit and publish the article and the work is bonafide.*

We would like to improve the content of the magazine.

Please send your generous feedback and contibutions for next editions to

magazine.iiabengaluru@iiap.res.in

DOOT
Quarterly Magazine of the Indian Institute of Astrophysics

From the Editor

We are happy to release the 4th issue of DOOT, the quarterly e-magazine of the Indian Institute of Astrophysics. Like all our previous issues, this time too we have brought interesting articles covering from experience of seasoned astrophysicist working in the field of observational astrophysics and instrumentation for five decades, to technical details of cutting-edge instrumentation techniques for the upcoming Thirty Meter Telescope (TMT), interview with an eminent scientist at IIA associated with several space-based instruments, and many more. As our articles cover a wider prospect of both scientific research, experiences as well as conceptual knowledge in the fundamentals of astronomy and astrophysics, we are dedicated to spread the scientific temperament towards awareness and opportunities among the community, and especially in the younger generation aspiring in various fields of science and technologies. To have a better reach to the community, we are launching official pages in various social media platforms including facebook and twitter, where information regarding our upcoming issues will be posted and can easily be circulated.

As we all know, our country and the whole world is currently facing the biggest ever challenge from the pandemic known as COVID-19. Being a part of such a large community, it is our responsibility to keep ourselves safe, so that community can be saved. From the DOOT family, we urge everyone to avoid going to public places if not necessary, use masks and sanitizers when interacting with others, maintain social distancing and follow covid appropriate norms raised by the governments; and take the jab of covid vaccine if you can. If we all try together, we can defeat this pandemic before long.

Wish you all safe and a happy reading through this issue of the magazine.

Suman Saha

Chief Editor, DOOT

DOOT
Quarterly Magazine of the Indian Institute of Astrophysics

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& Pelican Nebula

The North America Nebula (aka NGC 7000) and the Pelican Nebula (aka IC 5070) are an emission nebula in the constellation Cygnus. The shape of the nebula closely resembles the continent of North America with the Gulf of Mexico represented by the bottom region of the dark clouds. The portion of the nebula resembling Mexico and Central America is known as the Cygnus Wall. This region exhibits the most concentrated star formation.

The star which ionises the two nebulae lies right in the centre of Sh2-117, with a temperature of over 40,000° K. The star is heavily obscured by the dark band of interstellar dust in the Lynds dark nebula LDN 935, a Rift cloud which appears to divide the North American and Pelican nebulae.

Equipment Used :
Camera: Nikon D7200 (Stock, Unmodified)
Telescope: WO RedCat 51 Apochromatic Refractor, 250mm, f/4.9
Tracker: iOptron Sky Guider Pro (Not Guided)
Tripod: Amazon Basics 70 inch Tripod

Acquisition Details :
Sub-Exposure: 30 seconds, ISO 4000, 250 mm, f/4.9
Lights: 312
Flats: None
Darks: None
Bias: None
Total Integration Time: 2 hr 36 mins

Software :
Stacking: Sequator V1.5.5
Processing: Adobe Photoshop CC 2019

Location :
Devasthal, Uttarakhand, India (Bortle 3)

The photographer, Dr Avinash Singh is an Assistant Professor at Hiroshima Astrophysical Science Center at Hiroshima University, Japan. He did his PhD on "Observational Investigation of Core-Collapse Supernovae" from Indian Institute of Astrophysics as a part of Joint Astronomy Programme of Indian Institute of Science. He started pursuing Astrophotography as a hobby after his exposure to the field of observational astronomy in IIA. The Witch Head Nebula - IC 2118 image used in the last page is also captured by DrAvinash from Nainital.

A Heritage Library in the Mountain Observatory

Part-I

Christina Birdie
A. Vagiswari

Nestled high in the Palani hills, the Kodaikanal Solar Observatory exists with a grandeur as depicted in the painting above, done on canvas in the year 1909 by an unknown artist, carries a testimony to the legacy it stands for. The Library in this mountain observatory is a star attraction serving the researchers and students specializing in observational astronomy. As a storehouse of information, it is very useful to historians who trace the history of colonial science, as this observatory and the library hold old instruments and collections of printed treasures in astronomy dating back to the 17th century. Kodaikanal Solar Observatory traces its origin to Madras Government Observatory established in the year 1786, (Kochhar, 2002) starting from a private observatory located in Nungambakkam. After 100 years of exceptional astronomical observations and discoveries, this observatory at Madras was shifted to Kodaikanal to serve as a mountain observatory from the year 1899 to the present (Kameswara Rao, et al. 2014). The collection of books, journals, manuscripts and observatory publications is considered a valuable asset to Indian Science as most of them date back to the 17th Century and to the early 19th century.

Residence of Charles Michie-Smith in 1901

Shifting the library books and journals from Madras to Kodaikanal in Palani hills was a challenge, especially in the ghat section. This is evident from the statement written in the annual report of 1900 by the then director Prof. Charles Michie-Smith. It says: "As it was necessary that the books and instruments which had to be transferred from Madras, should be sent up the ghat in the dry weather, packing was begun in December, and by the end of March most of the cases (more than 1000 coolie load shed) reached Kodaikanal. All the cases of books were received before the rain began, and on the whole the removal has been affected with remarkably little damage considering the difficulties that had to be overcome." When the books reached Kodaikanal, they were stored in the Director's house before shifting the collection to the current library building[1,2].

1. *"Book cases reaching from the floor to the ceiling have been erected on two sides of the library room of the Director's house but an additional case is required before the books can be properly arranged. This is now in hand and it'll soon be ready. Two hundred and eighty books and pamphlets were presented to the Observatory during the year." CMS, Kodaikanal Observatory Annual Report (1900)*

2. *"The new bookcase referred to in the last report was erected and the books have now been arranged in such a way that they can be easily consulted. The number of books and pamphlets presented to the library during the year exceeded 300. These included a complete set, up to date, of the Geographical Journal, presented by the Royal Geographical Society. The number of volumes purchased, not including periodicals, was 15." CMS, Kodaikanal observatory Annual report (1901)*

It was not an unique phenomenon to build library shelves around the walls of the building, especially those built before 20th century. The libraries located inside the old observatories those days have been uniformly designed to have racks touching the ceiling like the ones in Mount Wilson Observatory, US Naval Observatory in the USA. and the Klementinum Library Monastery cum Observatory in Prague. This facilitated easy access to the library for those astronomers who would like to consult any particular reference while observing and also mainly to maximize the use of space. To follow the tradition, Kodaikanal observatory library shelves have a similar design with racks touching the roof along the walls of the main reading hall though it is not located inside any telescope building.

Sketch of the observatory building at kodaikanal showing the proposed new building- photo record room, Library & office rooms dated 1930 drawn by Ramanarayana Aiyer.

The present library building built after 1930 (proposed plan for the library building shown in the floor plan dated 1930), the sketch of the proposed new buildings with Photo record room, Library and Office rooms drawn in the year 1930 shows the location of the present Library building. The administrative report of the Kodaikanal observatory for the year 1930 mentions that the library building plan was made as it became necessary for a bigger space to accommodate the growing collection of books and journals over the years. But

Current Library Building

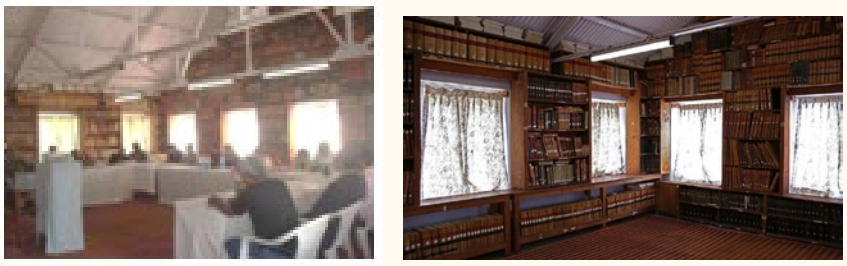
the actual execution of the building could not be undertaken in 1930 due to paucity of funds. Subsequently between the years 1930 and 1948 the library building was built with a main

Panoramic view of the library

hall with windows for natural lighting and ventilation. The administrative report for the years 1948-49 mentions that the extension to the library hall was undertaken in the year 1948. As per the report 'The present library hall is 37′ wide and 32′6″ long. The trusses have been placed on the greater width of the hall than on the length side and the spacing of trusses is roughly 6′. An extension to this hall with dimensions 37′ wide internal, and 30′ long was desired by the director within the limit of

Extension library hal and Wooden rack stacked with glassplates in acid-free envelopes

cost mentioned. He also wanted the number of windows to be reduced in the extension so as to give more wall space. Currently the library building has two main halls and a foyer which houses a small veranda at the entrance as shown in the diagram below. The main hall has a dimension of 1206 sq. ft as floor area and the wooden shelves are erected in this hall against

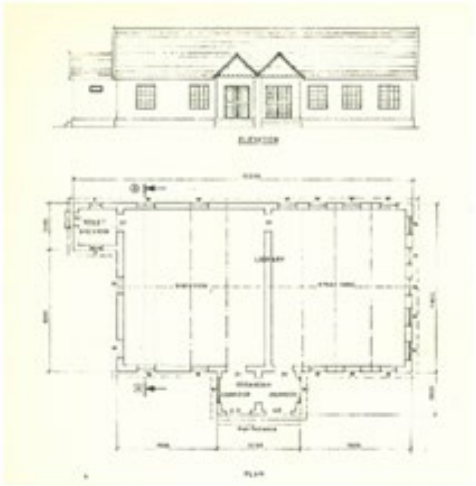


Main hall as conference room

the walls from floor to ceiling. They are aesthetically arranged around the windows to accommodate the use of windows for maximum utilisation of space. Effectively the two halls of the library were built at different times without compromising the total look of the building. The main hall of the library which exudes the smell of old books has conducive temperature to serve as a reading room. It also serves as a lecture hall and conference room where a small audience of 50 to 60 people could be accommodated (Birdie,2014).

For Prof. Bappu, the Library was the pride of the place.

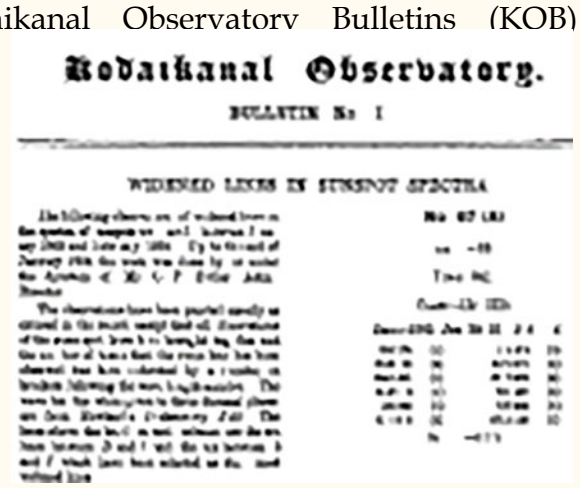
He strived hard to make it the best, at par with any library in the developed countries. He was alert to procuring new and latest titles of books, in not only Astronomy and allied subjects



Kodaikanal library structural drawing

but also on Environment and general topics of interest. In a few cases he himself purchased the books if they need to be imported from outside. All the important visitors were taken around the library and some old & rare volumes like the first hand-written annual report of the Madras observatory dated 1792, were shown to them. This library was also the custodian of the glass plates containing major discoveries and recorded observations of the Sun and other important celestial objects for more than 100 years. Plates like Evershed Effect spectrum, Observations of Comets Halley, West, Ikeya-Seki, Kohoutek, Brooks and Wilson and Solar Eclipses observed at different times were all stacked carefully in wooden cupboards, with acid-free envelopes as protecting covers.

Kodaikanal Observatory Bulletins (KOB) was an



Kodaikanal Observatory.

BULLETIN No. 1

WIDENED LINES IN SUNSPOT SPECTRA

important inhouse publication. It was started by the then Director, Charles Michie - Smith in 1904. This publication was divided into 3 parts, A) Research papers, B) Data on solar Geomagnetic observations & C) Ionospheric observations carried out in Kodaikanal. The first research paper in the series was published by Michie Smith himself. The path-breaking work by John Evershed was reported in both KOB and Monthly notices of RAS simultaneously, which increased the importance and visibility of KOB though it was an observatory publication. The library was responsible for sending KOB by post to more than 100 observatories all over the world in exchange for their own publications and reports. In addition to KOB, there was supplementary publication started in (1909) titled Memoirs of Kodaikanal Observatory Bulletins to publish large observational data. But unfortunately this was discontinued after volume 2.

This library extended its services not only to those astronomers within the observatory but also to those individuals employed in the Metrological Department of the Government of India as the observatory was administratively governed by the Metrological department of Government of India until it acquired autonomy in the year 1971.

An Erstwhile Binding section of the Kodaikanal Observatory

This binding section, as the record shows, was as old as the observatory itself and it became an integral unit of the library. Binding of the library journals and observatory publications was considered an important work as early as 1901. Initially the journals were sent to Madurai, the nearest town to get them bound, which was a difficult task. It involved a lot of physical effort to commute between the observatory and the plains down. Everytime the binder had to stay in Madurai for days to get the binding work completed, which involved expenses. To minimise the physical efforts and to economize the expenses incurred, it was decided to set up a binding section within the observatory by Michie-Smith who was the first director of the Kodaikanal observatory.

Appointment of bookbinders was done in the year 1901 as mentioned in the Annual report by Michie-smith in the year 1900-1901. "The Kodaikanal Observatory. l. Staff. -The staff remained throughout the year as recorded in last report 'During the year Government sanctioned a change in the menial staff by which the two menial assistants will be replaced by a bookbinder and a bookbinder's boy, but it has not yet been found possible to obtain a suitable bookbinder for the post'. (Report on the Kodaikanal and Madras Observatories for 1900-1901). Subsequently in the year 1903, the annual report mentions that 'A first-class book-binder from the Government Press, Madras, is attached to the establishment'. (Report on the Kodaikanal and Madras Observatories).

The image below is the cover page of a Tamil magazine published in 1973 called 'Noolagam' (means 'Library'), which has the picture of the high rising library shelf at Kodaikanal Library main hall. This issue carries an article on the Kodaikanal observatory library by M S Kalyanasundaram, where he has

mentioned about the importance of the binding section in the

Old Binding secton building

observatory, and the appointment of a generation of binders from the same family, the son taking over from father. He has added the names of them as C Krishnaswami Pillai, C K Govindaswamy Pillai and C G Veeraraghavan, all of them were technically qualified binders to continue the binding work. He has also highlighted the establishment of a binding section and the work of binding as an essential activity in the words of Harlow Shapley when he came to visit the Observatory in the year 1947 during the directorship of A K Das. (Information shared by A K Das to Mr Kalyanasundaram). Shapley congratulated the director saying that 'though the developed countries like USA are rich in their resources, the institutes and observatories did not have the luxury of an exclusive binding section, which he was happy to see in this observatory'. The image below is the photograph taken on the retirement day of C G Veeraraghavan, standing next to Prof. Bappu in the centre along with other staff at the observatory in the year 1976.

Another interesting story Mr Kalyanasundaram narrated in the article is the marriage between Mr Krishnamurthy and Ms Revathy who were appointed as qualified binders in this binding section in 1958. He adds that this binding section not only binds the papers but also the lives of individuals. When Ms Revathy joined the observatory, she was the first woman

Cover page of Noolagam Magazine

employee of the observatory as no other woman employee had joined before her. She was interviewed by Dr Ramasamy Chandrashekar (brother of Sir C V Raman) who was the Director of IMD, Madras in 1958. Mr Krishnamurthy and Ms Revathy were very diligent and hardworking throughout their career. With the limited funds available those days, they were careful to avoid the wastage of binding material. Mr Krishnamurthy and Ms Revathy continued to maintain the binding section in Bangalore until they retired in 1998.

Over the years the binding section of the Kodaikanal

Group photo of kodaikanal observatroy staff at retirement of C G Veeraraghavan

library became more important. Every year the annual report of the observatory carried the statistics of the binding work done meticulously and this information was shared with the government departments. The bound volumes in the observatory stand as a testimony to the quality, consistency and the special care taken by the binders trained under the government astronomers.

As one entered the main hall one was awestruck by the large number of colourful volumes neatly stacked on the wooden shelves. The colour coding followed and the material used for a particular journal while binding, was distinct and unique. This made it easy to recognise the journal on the shelf, an additional visible aid and also to maintain the uniformity. The journal "Solar Physics " had a bright orange color binding. The 'Astrophysical journal' was bound in beige leather and brown rexine and so on. Binding was professionally done to include the contents and index for each volume. All the

Ms Revathy & Mr Krishnamurthy

issues of a particular volume were checked for completion of a volume before commencing the final binding. Krishnamurthy, the binder, would make several trips to Madras to source binding material. like the leather, rexine and genuine gold leaf for embossing letters of the titles on the spine. Though one

Binding section @Bangalore

could get leather in Dindigul which was close by one had to go to Madras to get good quality leather. Leather was purchased from Periamedu, which was the wholesale market for leather in Madras, and gold leaf and rexine were also sourced from nearby shops. The tradition of resourcing good quality material for binding continued even after the binding section was shifted to Bangalore.

In addition to binding the library material all the PhD theses, technical reports and several administrative papers and reports were stitched and bound in the binding section as value-added service. After the binding section was shifted to Bangalore it became an essential unit of the archives as the conservative procedures for preserving the archival material were done with the help of the binders.

We thank Mr Krishnamurthy and Ms Revathy for sharing

IIA library & Binding section staff at retirement of Dr Vagiswari

their experiences while they were working in the observatory. We also thank Mr Krishnamurthy for providing us with a copy of the Tamil magazine 'Noolagam'.

At the time of compiling the write up on Binding section we learnt that Ms Revathy, our binder has passed away on 20th April in Bangalore due to sudden illness. We dedicate this write up to Ms Revathy.

References:

1. *Kameswara Rao, N, Vagiswari, A, and Christina Birdie, Charles Michie Smith - founder of the Kodaikanal (Solar Physics) Observatory and beginnings of physical astronomy in India, Current Sci., vol. 106, no. 3, 10 February, 2014, pp.447-467*
2. *Christina Birdie, Blending New with Old – A heritage library re-lived, proc. of International Conference on 'Library Space and Content Management for Networked Society' (ICLISCOM-2014), 18-20 Oct. 2014 at DVK Central Library, Dharmaram Vidya Kshetram, Bangalore.*
3. *Kochhar, R K, Madras and Kodaikanal Observatories: A brief history, Resonance, August 2002, pp.16-28*
4. *India Meteorological Dept., Pune, Report on the administration of the meteorological dept. of the govt. of India, 1930-31.*
5. *Administrative reports of the Madras and Kodaikanal observatories for the years 1929-46, 1948-49*

Christina joined IIA as an assistant librarian and after 36 years of service retired as the librarian in 2014. She has a PhD in Library and Information Science. She was a key player in introducing many services in the IIA library to make it one of the premier state-of-the-art Astronomy libraries in India. She has organized and established the archives at IIA and was a member of many national and international committees in coordinating library activities and has received many international professional awards.

A.Vagiswari joined the IIA library in the year 1974 and worked as an assistant librarian and later as a librarian for 30 years. She has a masters and a PhD in library and information sciences. She was awarded the Fulbright Fellowship in 1988. After retirement, she continued as a consultant in a DST project. Her main interests are in the field of history of Astronomy in India and the Madras and Kodaikanal observatories.

Sky-Chart
May 2021

Location: Bengaluru, 12.9791°N, 77.5913°E
Time: 15 May 2021 20:00 (UTC +05:30)

Watchout for:

May 6, 7 - Eta Aquarids Meteor Shower. The Eta Aquarids is an above average shower, capable of producing up to 60 meteors per hour at its peak. Most of the activity is seen in the Southern Hemisphere. In the Northern Hemisphere, the rate can reach about 30 meteors per hour. It is produced by dust particles left behind by comet Halley, which has been observed since ancient times. The shower runs annually from April 19 to May 28. It peaks this year on the night of May 6 and the morning of the May 7. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Aquarius, but can appear anywhere in the sky.

May 17 - Mercury at Greatest Eastern Elongation. The planet Mercury reaches greatest eastern elongation of 22 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the evening sky. Look for the planet low in the western sky just after sunset.

May 26 - Full Moon, Supermoon. The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This is also the second of three supermoons for 2021. The Moon will be near its closest approach to the Earth and may look slightly larger and brighter than usual.

May 26 - Total Lunar Eclipse. A total lunar eclipse occurs when the Moon passes completely through the Earth's dark shadow, or umbra. During this type of eclipse, the Moon will gradually get darker and then take on a rusty or blood red color. Eclipse will be visible throughout the Pacific Ocean and parts of eastern Asia, Japan, Australia, and western North America. The Penumbral Eclipse phase will be visible from India.

Thirty Meter Telescope:
How to achieve a high surface accuracy primary mirror segment

Mirror Segment Polishing processes carried out at ITOFF, CREST Campus, Hosakote

Janani Varadachari
S. Sriram

Introduction

In the earlier editions of DOOT, we skimmed through the Thirty Meter Telescope Project, its First light instrument, WFOS, and the importance of one of the Primary mirror control systems – the Actuator. In this edition of DOOT, let us take a bird's eye view of the activities planned at the India-TMT Optics Fabrication Facility (ITOFF), CREST, IIA and take a quick peek at how to make a primary mirror segment having a 2 µm surface accuracy.

The Thirty Meter Telescope project, partnered by the California Institute of Technology, Universities of California, Canada, Japan, China and India, proposes to build a 30 m diameter optical–infra-red telescope at Maunakea in Hawaii, USA. The TMT optical design is based on the Ritchey Chrétien system. Both the primary (M1) and the secondary mirrors (M2) are hyperboloids. The focal length of the primary mirror is 30 m and the final f-ratio of the telescope system is f/15. A flat tertiary mirror (M3) is used to fold and steer the light beam to any of the eight instruments that will be mounted on the two main Nasmyth platforms. The telescope has an unvignetted field of view of 15 arcmins. The M1 is a segmented hyperboloid (paraxial ROC = –60.0 m, k = –1.000953, sag = 1.8 m, asphericity = 29.3 mm) of an effective diameter 30 m. The secondary is a single piece convex hyperboloid (paraxial Radius of Curvature (ROC) = –6.228 m, k = –1.31823, sag = 196 mm, asphericity = 850 µm) with 3.1 m diameter. The diffraction limited resolution

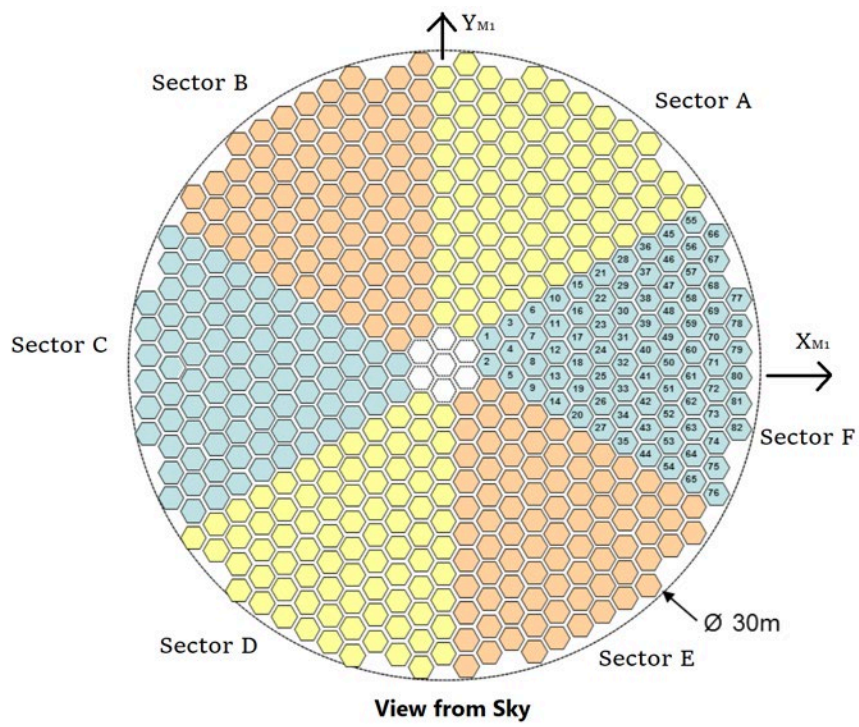


Figure 1. Primary Mirror (M1) Segmentation

of TMT will be three times better than the existing 10m class telescopes, and wavelength coverage would range from 310 nm to 28 µm. To achieve the desired performance, the surface finish of each segment has to be λ/20 or better at the specified wavelength.

The TMT primary mirror comprises 492 hexagonal segments made of low expansion glass material, each having a size of 1.44 m across corners. Figure 1 shows the top view of the M1 segmentation pattern. The entire M1 is divided into 6 identical sectors (A-F). There are 82 hexagonal segments, the

innermost segment is Type-2, and the outermost segment is Type-82, in each sector. The segment arrangement pattern has six-fold symmetry about the vertical axis. That is, the entire M1 can be obtained by rotating any of the sectors in 60 degree steps about the optical axis. Since an array of identical regular hexagons cannot uniformly fill a curved surface, the shape and asphericity for each of the 82 segments are uniquely defined. For example, the Type-82 segment has the largest aspheric departure (~226 µm PV (Peak-to-Valley)) while the Type-2 segment has only ~6 µm PV.

As part of India's contribution to the TMT project, ITCC (India TMT Coordination Centre) intends to deliver a portion of polished M1 segments. The TMT project prefers to utilize segment production methods used successfully on segmented mirror telescopes, such as that employed for the Keck telescope primary mirror segments. This process includes Stressed Mirror Polishing (SMP) of circular mirror blanks followed by hex-cutting, mounting onto a support system, and finally, Ion Beam Figuring (IBF).

SMP method is preferred as (a) it uses full tool to control mid and high-frequency requirements on the mirror surface, (b) fast material removal rate to meet the rate of production of segments, (c) has faster convergence towards the surface specifications needed for IBF, and (d) gives the finish with

Figure 2. The flow of Processes for Segment Production

no edge roll-off. ITCC, through IIA, proposes to acquire the necessary technology for the Full Tool Polishing (FTP) technique and metrology (excluding IBF) for the delivery of polished segments to the TMT Project.

Inspection of Glass Blanks

The production workflow at India TMT Optics Fabrication Facility (ITOFF) involves activities like Glass Blank Inspection, Etching, Bonding, Grind & Polish, Hexing & Pocketing, and PMA Integration.

The mirror blanks are received from OHARA, Japan, for production. The first step in the production of the mirror segments is the inspection of these blanks. The inspection is basically done on two levels. One is the initial incoming blank inspection to ensure that the blanks are not damaged while in

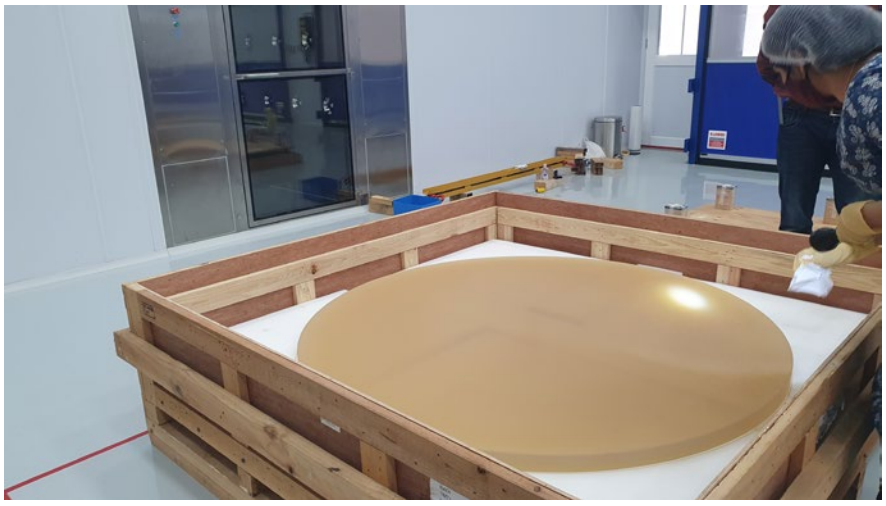


Figure 3a. Initial Incoming Blank Inspection

Figure 3b. Pre-Production Blank Inspection

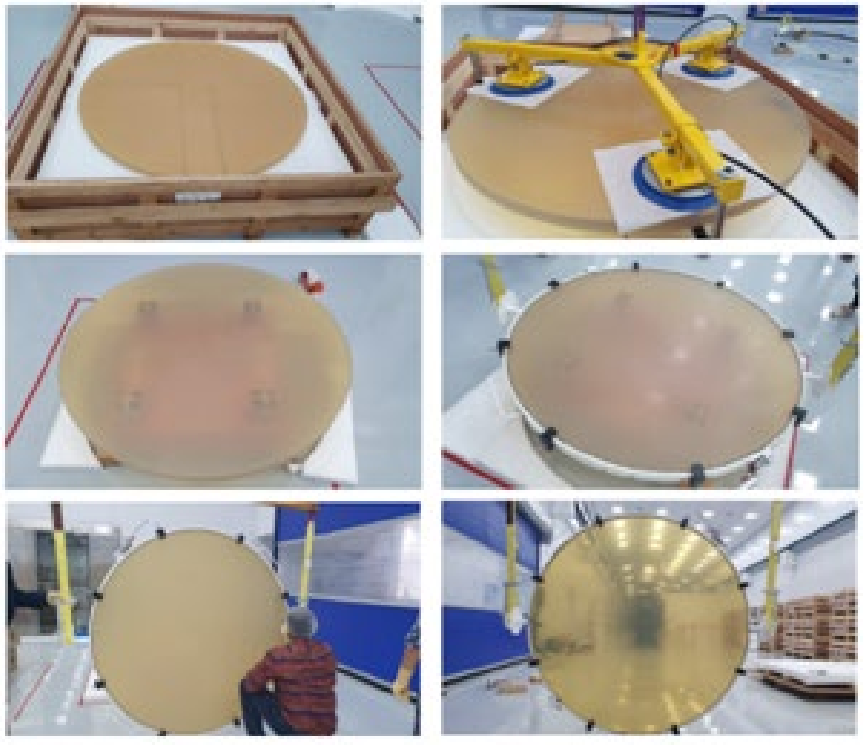


Figure 3c. Blank Inspection at ITOFF

transit from Japan or otherwise.

The second round of inspection is the pre-production blank inspection, where the blank is inspected for subsurface level damages (on both S1 and S2 surfaces). Here S1 is the concave and S2 is the convex side. If there are no damages or inclusions, then the mirror is moved to the next level in the production, i.e., Etching and Bonding.

Etching and Bonding

Etching of the blank is done to bond the components to

Figure 4. Bonding

grind and polish the segment. To initiate the polishing process, the roundel blank edges need to be connected with the 24 warping arms around its cylindrical edges. To achieve this, bond pads are connected to the cylindrical edges using epoxy after etching and bonding.

Grind and Polish

Once the bonding is completed successfully, the mirror segment is now moved to the process of grinding and polishing.

Figure 5. Grinding of the mirror segment

Grinding is a process carried out on the mirror surface to achieve the desired Radius of Curvature of 60 m. Post grinding, metrology is carried out on the surface. For the polishing, we will be adopting the method of Stress Mirror Polishing (SMP), where Stresses are applied to a mirror blank through the 24 lever arms that has an effect of elastically deforming the blank and bringing the surface to the complement of the desired surface. A sphere is then polished into the blank, and on releasing the applied stress, the spherical surface deforms into the desired one. For this purpose, 24 warping arms will be used that will hold the mirror while stresses are being applied and then will be released for the blank to get to its desired shape.

Hexing and Pocketing

Figure 6. Hexing and Pocketing of the mirror segment

Post the process of grinding and polishing, the segment is now moved to the stage of hexing and pocketing. The polished roundel is hex-cut and pockets are milled into it for the central diaphragm and other sensors used for segments alignment in the telescope. These hexagons are irregular in shape and of size 1.44 m measured across the corners.

The surface figure errors relative to the theoretical surface shape for each roundel shall be less than 1.73 µm PV.

The segments shall have individual theoretical surface shapes described by corresponding Zernike ters The maximum error allowed is 1 µm PV, due to change in shape due to hexagonal machining. The surface edge finish is 0.4 µm Ra and no roll-off is allowed at the edges. The chip size on S1 < 0.2 mm and that on S2 < 0.4 mm. Scratch-dig specification for the Optical Surface is 60-40.

Metrology

Post hexing and pocketing, metrology will be carried out on the segment to ensure required specifications.

For the purpose of metrology, we will be using the equipment as stated below.

- Spherometer for Radius of Curvature (RoC) measurement
- 2D Profilometer for low-frequency error measurement
- Sub-aperture Interferometer for low and mid-frequency error measurement
- Phase measuring microscope (PMM) for mid and high-frequency error measurement

PMA Integration and Shipping

After the metrology test, the polished and hexed segments are ready to be integrated with the SSA. This stage is called the PMA integration.

Figure 7. PMA Integration

Finally, the PMA will be packed in the PMA container and sent to TMT for Ion Beam Figuring (IBF). Later on, the PMA will be installed on the telescope.

Figure 8. Packing of the Primary Mirror Assembly (PMA)

(To be Continued...)

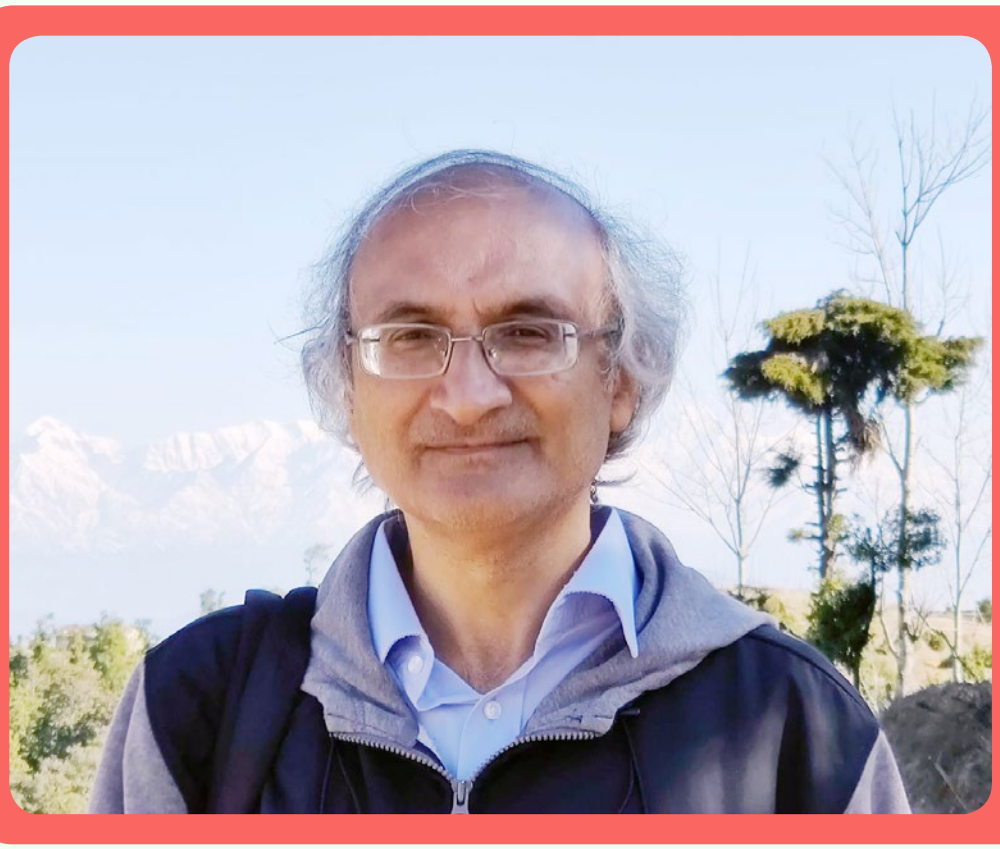
[India-TMT Segment Polishing Team: S. Sriram, Alikhan Basheer, Janani Varadachari, G. Manoj, G. C. Anupama]

Janani Varadachari is a Project Engineer-II at ITCC; primarily working with the IIA-ITCC Optics team and involved in the Quality aspects for production of segments and Metrology for optical equipment.

S. Sriram is the Head of the Optics Division, IIA and work package manager for the Segment Polishing workshare. His area of expertise includes optical design, astronomical instrumentation and optical metrology. He has a vast range of work experience from design and building of fiber-fed high-resolution spectrographs to design, integration, testing and calibration of UV payloads for space astronomy. He has also immensely contributed to the TMT/WFOS optical design simulations of distortion and modelling of the instrument flexure in the WFOS optical design.

'Asimov, Basket Ball, Satellites & Dust'

Prof. Jayant Murthy speaks about his career, exciting life stories and his perspectives on various science and social issues.



Prof. Jayant Murthy is a Senior Professor and the former Director of the Indian Institute of Astrophysics. He obtained his PhD from Johns Hopkins University in 1987. He went to NASA/GSFC for two years as a NAS/NRC Research Associate and then back to JHU as a Research Scientist. Prof. Murthy joined IIA in 1999 and has done works on the topics in UV astronomy, the interstellar medium, and payloads intended for space flight. He is now working on an instrument scheduled for flight on the Chinese Space Station as part of a UNOOSA program.

For DOOT magazine, Prof. Jayant Murthy speaks about his career, exciting life stories and his perspectives on various science and social issues.

You started your university education at Johns Hopkins University (JHU) in the United States. After your graduation, you were at GSFC, NASA and spent a significant portion of your research life at JHU. How did you end up doing your university education in the US?

I did my high school in Zambia (The International School of Lusaka) and was too young (14 years of age) to write the IIT exams, so I wrote the SAT and Johns Hopkins offered me a scholarship for my BA. When I finished my undergraduate degree, it was decided to locate STScI (Space Telescope Science Institute) at JHU, and I thought it would be a good thing to work with them. As it turned out, it took longer than one might think to get ST (Space Telescope) off the ground, and I was never really associated with them.

In general, I would recommend an American education because they give you a much different experience than anywhere else, at least if you go to a top-tier college. The breadth and the depth of the research are so much greater. It becomes hard to measure yourself in India because your peer group is so much smaller.

What was your PhD thesis on? We would like to know more about the later projects you were involved in at Johns Hopkins.

I first worked on a spectrograph to go on the Space Shuttle called UVX - Ultraviolet Experiment. Our instrument included two spectrographs that measured the diffuse sky background in the UV, collaborating with a similar instrument from UCB (University of California at Berkeley). We built the instrument and mounted it in a GAS (Get Away Special). At the time, NASA had thought that the Space Shuttle would provide a platform for regular science experiments. Unfortunately, the Challenger exploded just a few months after our launch (on Atlantis), and science on the Shuttle was deemphasised. I was playing basketball when the Challenger exploded, and it

wasn't until I went back to the Department that I heard. It was like a cliff. Before the explosion, there were several new jobs every week. That dropped to a few a year.

Although UVX was supposed to be my thesis project, it was delayed by two years - as is common in space projects and I got onto a project to search for hydrogen in the local interstellar medium by looking at Ly-alpha absorption against the chromospheric emission of nearby stars. I think my experience here was pretty standard by American standards. My predecessor (Wayne Landsman) handed me a program (if I remember a printout) and a stack of 8 track tapes and left for his postdoc at NASA. You get thrown in the deep end, but you learn to survive.

I spent one more year as a PDF at JHU, where I completed my analysis of the UVX data and then spent two years as a NAS/NRC Research Associate at NASA/GSFC. My prospective advisor had left, and I worked more or less independently my two years there before going back to JHU to work on a 'Phase A' study for a SMEX mission. This is where I became intimately involved with APL (Applied Physics Laboratory) and worked closely with the spacecraft groups there.

We then got the opportunity to be involved with a Defense Department project (MSX). This was a part of Reagan's Star Wars, where the goal was to detect 90% of incoming Russian missiles. After the collapse of the Soviet Union, the goal changed to detect 100% of all North Korean missiles. Our part was only astronomy, and, except for the few times they observed military targets, we got to do astronomy. Unfortunately, the instrument was soon superseded by GALEX, and much of the data from the UV instruments are sitting unused.

The last project I worked on was FUSE, where I was part of the software pipeline. I also worked on several individual science projects. The most productive was working with Voyager observations and data in which I derived the UV background based on observations from 1 AU to 50 AU.

Can you share some memories as a PhD student and later on as a research scientist at Johns Hopkins?

I enjoyed my time at Hopkins much more than at any other place. We had a beautiful campus that felt academic. There were always students around but in an urban environment where you had to be part of the city. I lived in some pretty bad places off-campus and would sometimes hear gunshots just outside my apartment. I had pretty much the same routine. Go into work by 9, play basketball at lunch, go home at 5, make dinner and then go back to the office until about 10.

When I started grad school, we had a communal office with the 25 of us (only 8 got their PhDs), from which we were ejected when the Space Telescope came. In the luck of the draw, I got an office in the basement with no windows. When I came back to Hopkins after NASA, we had moved to Bloomberg, and I had a nice office with a window.

My life was devoted to basketball which I played twice or thrice a week, and then to ultimate frisbee twice a week. Basketball at lunch and frisbee at 5, usually not on the same day.

You have done wonderful work in interstellar dust and diffuse UV radiation. Can you shed more light on your work and the recent developments in these fields?

The interstellar medium has been a niche area in astronomy that has its pluses and minuses. On the plus side, there is time to think, and you don't have to worry about other people working on the same problems. On the minus side, you don't nearly get the citations that other people get.

I started with working on the gas, mainly hydrogen and deuterium, in the local interstellar medium and calculated the D/H ratio, which sheds light on the conditions in the Big Bang. Since then, I have done some absorption line work to look at the role of carbon in the ISM but not much more. I have worked much more on diffuse radiation, particularly after the launch of GALEX, including publishing the first UV maps of the diffuse radiation in the sky. We always make incremental advances, and we are still in the early stages of our work. One of the more exciting developments is that we have found a new component of diffuse radiation, which we are still trying to pin down.

You have been a part of various space-based payloads, both in the US and in India. You also lead the High Altitude Balloon group at the IIA. We are excited to know more about your experiences with these missions.

The difference between the US and India is the size and the professionalism of the team. We had 5 PhD scientists just writing the software pipeline for FUSE. I felt that the team in

charge of UVIT lacked enough expertise in UV astronomy. This is one reason that I started the balloon group. We are now working on small projects which a small number of people can do. Each of the instruments we have built to date was done by one student who was responsible for all aspects of the mission (Joice for LUCI, Mayuresh for StarSense, Ambily for NUTS, Nirmal for SHS - Sreejith started the whole process but did not have a payload of his own). This has been excellent training for the students, and they are now all doing very well in their new jobs around the world.

What are your expectations about your upcoming projects like SING and TINI? Could you give us an update on their current status?

SING and TINI are both related in that they are spectrographs to look for diffuse line and continuum emission. SING has a launch on the Chinese Space Station, and we have to deliver by the end of 2022, a challenging goal. We have most of the items needed and have completed much of the design. The team (Rekhesh, Rita, Binu, Richa, Shanti, Bharat) is good but will have to pick up the pace. As I said earlier, we never have enough people.

Science payload for High Altitude UV Observation launching from IIA CREST Campus, Hosakote (Image credit: Jayant Murthy)

TINI is a collaboration with people at Tubingen for which we are asking for a secondary launch on an ISRO mission. We have submitted the proposal to ISRO, but given the pandemic and ISRO's reorganisation, we are unsure what the status is. The priority is SING, but we can reuse much of the SING development to speed up TINI.

We have another payload that we hope to have launched before the end of the year on the ISRO PS4 - our star tracker. It will not do much science, but it will be good to get data and prove our concepts and builds.

CubeSats are a popular concept for modular payloads with minimum development time. But how suitable are they for science-oriented missions? Do you think they might play a crucial part in future space missions?

CubeSats are interesting but challenging. They have to be treated just like any other space mission, with realistic and achievable goals. Their science will always be limited just by sheer size. But they can make contributions in specific areas, and it is not so difficult to think of use cases. For instance, our NUTS payload is close to as sensitive as UVIT but was built for under 20 lakhs. One could easily launch 10 of them or even 100 for less than the cost of UVIT for continuous monitoring of the sky - an LSST in space. Another possibility might be to launch a telescope to monitor Proxima Centauri for six months looking for flares with a cadence of seconds. So, with appropriate science cases, we can build payloads for a relatively low cost and all done by students.

Public speaking is an important skill every scientist should nurture. It's tricky to convey information in a simplified manner while keeping facts intact. You are an excellent public speaker and give a variety of scientific seminars. Can you highlight the major points to keep in mind while giving a popular science talk?

Over the last two decades, I have averaged about 20 talks per year, all online this last year, of course. These talks have

Prof. Jayant Murthy interacting with kids at Space Camp, 2017 at Lawrence High School, Bangalore (Image credit: Jayant Murthy)

been at all levels, from a first grade class in Pakistan to college students, but the key is to talk in ordinary English with no buzzwords. (Unfortunately, my skills are not good enough for science talks in other languages.) I do have slides, but really all I do is to tell a story. It is odd because I am an introvert, but I enjoy telling science stories. My proudest moment was when I gave a talk in Mysore as part of a "Frontiers in Science" session, just after the LIGO observation of gravitational waves. Everyone else had prepared talks in their own areas, as had I, but when it came to my time, I told the audience that I would throw away my presentation and just talk about LIGO. It went great. The key to give talks is to speak slowly and conversationally. Keep it simple without condescending, whatever the level. It all depends on the individual, of course, but I never practice. It's always a stream of thought. I do find, though, and this is difficult in online talks, that I do better if I can see the audience and how they are reacting. I do the worst when it is clear that the audience doesn't care and almost put myself to sleep.

You are very active on Facebook, engaging in various discussions on social issues. What made you come to social media, and what makes you stay?

In social media, I enjoy Facebook but don't do anything else. I have a wide range of interests, and I post what I think on many different ideas. I'm pretty far over on the liberal side, socially and economically, and I see FB as a way not to let my voice be lost. I wish I could be a true activist and actively increase change in society; this is my way of doing so while continuing my science.

Having spent ample time in both US and Indian academia, what are some of the features you think we could adapt from the US to help improve the research environment in India?

Every system has advantages and disadvantages, but it is better to just talk about improving our own system. The two biggest problems that I see are the hierarchy and the mistrust. Because of the mistrust, only Directors are allowed to make decisions. As a result, the initiative is lost. Everyone looks to only doing things the Director would approve of. This is not true in the US. No one even sees the President or any of the Deans or even the Department Chairman. You do things and assume the University will back you up if needed. I would advocate a system where people do things as they want and are given support to the level required.

What do you think about the condition of space research in India? How does the future of Indian space research look to you?

The ISRO missions are not science-oriented. They are technical missions that have done well, technically. But science is reflected by publications, and we have not done well there. We have also failed in setting up groups that will have a continuing series of missions, as it was at JHU in my time. I believe this is because of the mission-oriented system rather than a people-oriented system. My recommendation would have been to fund groups for less ambitious projects and support them through fruition. In time, this would have grown into a robust space community able to participate at par in international missions. Our science community has lacked long-term vision.

What is your take on the private space industry in India? Do you think private players are essential to foster the growth of science and technology? How do you see private-public partnerships in space research?

There is a healthy private ecosystem with large companies such as Godrej and L&T, but they work in limited areas. When I was putting together missions in the US, we would work with spacecraft contractors like Ball Aerospace, but this is not possible in India because ISRO does so much. The new vision is that ISRO will focus on research, and we will see if this makes a difference.

There is an enthusiastic crowd of small companies who have hopes of making it big. I think they have overestimated the size of the market and are not realistic in their goals, but, no doubt, some will survive and do well.

You have been associated with IIA for over two decades and have acted as the institute's Director. We would like to hear about your life at IIA. Can you tell us how the institute has evolved over the last 20 years?

When I joined IIA, many of the people had been hired by Bappu when the Institute had a focused goal. Cowsik brought in a more diverse group of scientists without the same emotional attachment to the old observatories, and it has shown in the overall decline of VBO and Kodaikanal as productive scientific facilities. The Institute hires top-notch scientists but, inevitably, no longer has institutional goals other than maximising the science output. Whether this is good or bad is a matter of

opinion.

I would like to say with gratitude that IIA has never tried to interfere with my work. I have never asked for permission and have never been told not to do something. On the other hand, I have never had active, or even passive, encouragement.

As a voracious reader who does not limit himself to scientific books, could you tell us how it has helped in shaping your worldview?

The main reason I became a scientist is because I want to know how the world works, not just astronomy or physics or even just science, but history or politics as well. So I read a lot and synthesise it. You learn so much about the diversity of people and the troubles they face just by being born in the wrong place at the wrong time. I just cannot understand bigotry and prejudice when, but for the grace of God, there go I.

A view of Jayant's book shelf (Image credit: Jayant Murthy)

Are you a big fan of science fiction? Can you tell us some of your favourite titles? Given Star Wars and Star Trek, which would you prefer?

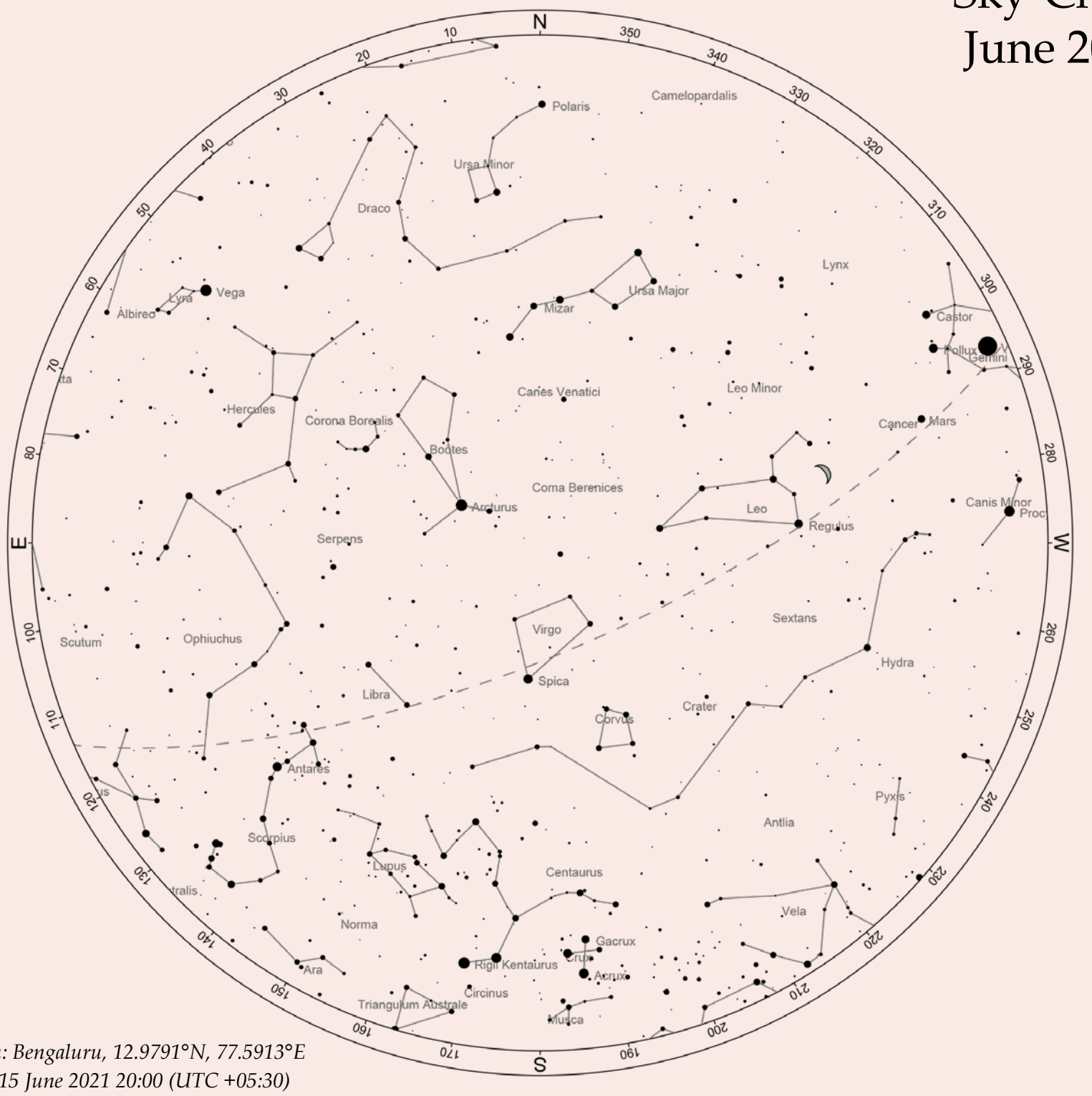
I grew up in either the Golden Age of SF (or the Silver Age, depending on who you talk to), reading Asimov and Clarke. This was a time when science was triumphant, and there was no doubt that we would go far and fast on the wings of science. Science fiction has changed since those days and has become less focused on science and space opera and more on humans and their interactions. Many might say it has matured, but I miss the innocence of those days. On the other hand, we are also more aware of the dangers of a technocratic view of the world in which we solve every problem with engineering. We know that dams can cause ecological stress, that the interlinking of rivers will introduce unforeseen problems. Nature is too complex for us to mess with randomly. So, now, I read less science fiction and more fantasy.

I much prefer Star Wars to Star Trek. There were a few exceptional Star Trek episodes (Mirror, Mirror; the Trouble with Tribbles; Khan), but, on the whole, it has not aged well. Star Wars came out in 1977, and I saw that in the theater. What an experience that was, seeing it in 70 mm. It's still my favourite movie, although it is not the best. I then followed along with the entire series. Even with those ridiculous Ewoks, Return of the Jedi was a great movie with the redemption of Darth Vader. Then came the three Abominations whose names I will not utter. Like the entire Star Wars fraternity, I waited for TFA with trepidation, not helped by the two weeks of delay in India because of some Salman movie or other. It turned out that getting rid of George was the best thing that could happen to Star Wars. The Last Jedi is, in my opinion, the best of the entire set with a new vision of the Universe, and it was a shame that Rian Johnson did not direct The Rise of Skywalker, which was almost as bad as the Abominations. Of all the Star Wars movies, though, my favourite is Rogue One.

Interview team

Vishnu Madhu, Fazlu Rahman, Raveena Khan, Rishabh Teja and Suman Saha

Sky-Chart
June 2021



Location: Bengaluru, 12.9791°N, 77.5913°E
Time: 15 June 2021 20:00 (UTC +05:30)

Watchout for:

June 10 - Annular Solar Eclipse. An annular solar eclipse occurs when the Moon is too far away from the Earth to completely cover the Sun. This results in a ring of light around the darkened Moon. The Sun's corona is not visible during an annular eclipse. The path of this eclipse will be confined to extreme eastern Russia, the Arctic Ocean, western Greenland, and Canada. A partial eclipse will be visible in the northeastern United States, Europe, and most of Russia. This Eclipse is not visible from India.

June 21 - June Solstice. The June solstice occurs at 08:51 IST. The North Pole of the earth will be tilted toward the Sun, which will have reached its northernmost position in the sky and will be directly over the Tropic of Cancer at 23.44 degrees north latitude. This is the first day of summer (summer solstice) in the Northern Hemisphere and the first day of winter (winter solstice) in the Southern Hemisphere.

June 24 - Full Moon, Supermoon. The Moon will be located on the opposite side of the Earth as the Sun and its face will be will be fully illuminated. This is also the last of three supermoons for 2021. The Moon will be near its closest approach to the Earth and may look slightly larger and brighter than usual.

In retrospection: *My five decades in Astrophysics!*

Part-I

Ram Sagar

Preamble

During my five decades of journey in observational sciences, I was mostly associated with two premier research institutions of the country, located in Bangalore and Nainital. Memories regarding the start of my career in Astrophysics and joining of the Indian Institute of Astrophysics are narrated in this first part of the article; while its second part details my participation in the establishment of major observational facilities in India along with other relevant information.

The IIA, an autonomous research institution under the Department of Science and Technology (DST), Government of India (GoI) has completed 50 years of its formation on April 1, 2021. Prof. M.K. Vainu Bappu, the founding Director, started establishing a number of modern Astrophysical observational facilities in the country. So, in the early 1970s, becoming a part of IIA was a dream for youngsters like me, and how it happened in my case is briefly described below.

Anecdotes

Born and raised in a remote village of the state of Uttar Pradesh (UP), and being the first from the family to step out for education, I never thought that research in astrophysics would be my career. I opted for science stream in my higher education because in both high school and intermediate UP board examinations, my marks were very good (97 %) in Mathematics. My journey in Astrophysics started in MSc Physics during 1972 -1973. Dr S. D. Sinvhal, ex-Director, Uttar Pradesh State Observatory (UPSO), Nainital (see Figure 1) was an external examiner for our Astrophysics specialization. After the viva-voce examination in June 1973, Dr Sinvhal indicated that UPSO might offer a research fellowship, if I am interested.

By the time I completed the MSc final examination, there was an expectation for earning as a support to my family. I, therefore, started looking for employment. People in my village used to think that I can get a job easily due to my good academic records. But it was not the case even in those days. My father was of the view that I should take any teaching job in a nearby Intermediate/High school and stay in the village. However, my mother used to say that for a job, one has to move out of the house as it cannot be inside your house. If a place of work is nearby, one can visit family frequently otherwise visit to family becomes rare and she was not very supportive of my father's views. During the summer of 1973, while waiting for my MSc final result, I was very frustrated as every day I was confronted with a question, "have you got a job?", by our well-wishers. I, therefore, decided to move out of the village at the first available opportunity. In this endeavor, my mother supported me strongly.

First-time travel to Nainital

As soon as our MSc final result was announced in the 2nd week of July 1973, I collected the marksheet from the University of Gorakhpur and also took a reference letter from Prof. D. Sharma, Head of Physics Department, so that the offer of a UPSO research fellowship can be utilized. In this process, Dr J. P. Chaturvedi, our Astrophysics teacher, helped me a lot. He explained to me how to travel to Nainital. I headed to Nainital in the 3rd week of July 1973. After about 8 hours of Bus journey from Azamgarh, I arrived Lucknow around 4 pm and went to the ticket counter of Charbagh Railway station to buy a ticket for Nainital express train starting around 8 pm. At

that time, I realized that the distance to Kathgodam, Nainital from Lucknow is more than the distance from my native place to Lucknow. So, I became very nervous as I was travelling such a long distance for the first time. However, remembering the questions asked in my village about any job, I decided to go to Nainital and bought a train ticket. Next day morning, the train arrived at Kathgodam on scheduled time. It was raining heavily since it was the peak of the rainy season in that part of the country. Kathgodam to Nainital bus journey was very scary due to heavy rains as well as sharp turns on the hilly climbing roads. From Nainital, I walked to the Observatory, Manora peak, via Hanuman Garhi. There, I met Dr K. Sinha and handed over the letter given by Dr Chaturvedi. Dr Sinha arranged my lunch. After an interview by Dr M.C. Pande (Figure 1), research fellowship amounting Rs. 250/pm was offered to me. I was very happy since a job, which I was waiting for all through June-July 1973, has been finally offered. That's how Astrophysics became my research career and UPSO became my first place of learning. I returned to my native place to take necessary items before joining UPSO. My mother was very happy and excited. She prepared a quilt and other essential

Figure 1. In the photograph, the author is with founding pillars of the UPSO (from left to right) namely Dr H. S. Mahra, Dr S. D. Sinvhal and Dr M. C. Pande

clothes for my stay in Nainital. However, my father was not very enthusiastic about it though he reluctantly agreed that I should go to Nainital as a scholarship has been offered.

I started my research activities in Astrophysical sciences at UPSO, Nainital, on August 6, 1973. Within a week, the Director advised me to start research work on star clusters using the newly installed 104-cm optical telescope. It was supplied and installed by M/S VEB Carl Zeiss, Jena in 1972. Within a few months of its installation, the telescope was dedicated to the nation by Prof. M.G.K. Menon, Ex-Director, Tata Institute of Fundamental Research (TIFR), Mumbai. His Excellency Sri Akbar Ali Khan, the then Governor of UP presided over the inaugural function. It was named after late Dr Sampurnanand who established the institution on April 20, 1954. A group photo taken during its silver jubilee function is shown below.

My PhD thesis entitled "Studies in star clusters", based mainly on observations taken with the UPSO 104cm Sampurnanand telescope, was submitted to the DDU University of Gorakhpur in August 1979 but was awarded in March 1981.

Figure 2. It shows a group photograph taken in the year 1997 at the administrative training institute (ATI), Nainital during silver jubilee function of the 104-cm telescope.

Physics Lecturer in Kumaon University, Nainital

I was also interested in teaching and was fortunate to get an opportunity at Kumaun University (KU), Nainital just after submitting my PhD thesis. I joined the DSB Campus of KU, Nainital as a Lecturer in the Department of Physics on September 1, 1979. There, I met Profs. A.L. Sharma (ALS) and Ramesh C. Verma (RCV) who joined the department like me. With RCV, I learned high energy physics and published a few research papers. ALS, RCV and myself became close friends. To learn the concepts of physics better, we three used to change our teaching assignment amongst ourselves. In fact, I taught Mathematical Physics, Classical Mechanics, Quantum Physics and Nuclear Physics along with my special paper Astrophysics to the MSc students. I enjoyed teaching and learned concepts of physics because teaching is the best way of learning. One day in the evening, families of both ALS and RCV visited the UPSO located at Manora Peak to see the moon, Jupiter and other interesting celestial objects through 104-cm telescope. I explained various aspects of telescope and astrophysical research work done by our group before moving to the KU. After this visit, RCV convinced me that I should return to Astrophysical research as I have attachment with the subject. He also persuaded me to try for a post-doctoral fellowship (PDF) abroad. Fortunately, our efforts yielded positive results and my first visit abroad was to the Institute of Astronomy, Moscow, USSR for a period of 3 months (August 1983 to November 1983) under Indo-USSR cultural exchange visits of scientists. From Moscow, went to the Royal Observatory Edinburgh (ROE), Edinburgh, Scotland, UK to avail Commonwealth Bursary post-doctoral fellowship offered by the Royal Society for a year and academic consultant at ROE for ~ 4 months. In the last week of March 1985, returned to India from ROE, UK. Both

visits were academically rewarding. I remember, when I met Prof. Malcom Longair, then Director of ROE, a few days before my departure, he said "Ram, our collaboration has just started, not ended". This was a very encouraging conversation and in fact, our collaboration with my host Professor, Dr R.D. Cannon continued for a few decades. Figure 3 shows a group photo of Dr Cannon taken during his visits to IIA in December 1992.

Figure 3. Photograph of Dr R. D. Cannon, Ex-Director, Anglo-Australian Observatory, Australia during his visit to IIA in December 1992. Profs. J. C. Bhattacharya and R. Cowsik, Ex-Director, IIA; Prof. B.V. Sreekantan, Chairman, GC, IIA and myself are also seen.

At ROE, in the year 1984, I met two IIA visitors namely Dr S. K. Jain and Prof. N. K. Rao and discussed with them my ongoing research work. Both encouraged me to join IIA, so that the digital image processing techniques which I have learned at ROE can be utilized since the institution was in the processes of installing CCD imager systems. In January 1985, a few months before my departure from the UK, I applied for a position in IIA. After returning to India, my mentor, Dr S.D. Sinvhal also advised me to join IIA, if selected. I remember, he said that IIA is the best research organization in India for carrying out research in optical astronomy. Prof. J. C. Bhattachraya, then Director IIA, interviewed me in May 1985 at Indian National Science Academy (INSA), New Delhi. After the interview, he asked to send my salary details of KU, Nainital and also guided about schooling of my children. He said that a faculty position may be offered only if my application is approved by the Governing Council (GC) of IIA chaired by Prof. M. G. K. Menon which happened in November 1985. I received an IIA offer letter on January 6, 1986. Incidentally, the same day 2.34-meter Vainu Bappu telescope (VBT) was inaugurated by the then Prime Minister of India, late Shri Rajeev Gandhi. I was very happy as my dream became reality and I joined IIA on 11 February 1986.

Figure 4. Prof. R. Cowsik introducing author to Prof. S. Chandrasekhar, noble laureate in Physics taken on January 11, 1993 during one of his visits to IIA.

Participation in developmental activities at IIA

At IIA, I actively participated in installation of CCD camera system at 1.02-m and 2.34-m VBT and photometric data reduction packages like DAOPHOT etc., at the VAX 11/780 system of Vainu Bappu Observatory (VBO) as well as for displaying and analyzing CCD images on the COMPTAL image display station. I was also (i) a member of library committee (1986 to 1988); time allocation committee for telescopes at VBO, Kavalur (1987 to 1989 and 1995 to 1996) and in a few administrative committees; (ii) Chairman/Coordinator of computer committee (1991 to 1992); Student Affairs Committee, now BGS (1991 to 1996); time allocation committee for telescopes at VBO (November 1992 to March 1995) and a few Himalayan Infrared Optical telescope committees (1995 to 1996); (iii) Administrative in-charge of VBO for a year during 1991 to 1992 and (iv) Scientist in-charge of the national facility, PDS microdensitometer (1987 to 1996).

Fig. 5. Photograph shows author's interaction with members of the Parliamentary committee during their visit to IIA on July 15, 1994.

After a decade of my association with IIA as a faculty member, I joined UPSO, Nainital on 12 July 1996 as Director on lien from IIA and continued collaboration with the IIA. Further description of my journey in Astrophysics is provided in part two of this article appearing in the next volume.

Polarized Light - *Ubiquitous but Incognizable to human eye*

Raveena Khan

It was around 1669 when Erasmus Bartholin first reported on the existence of polarized light. He discovered that Icelandic crystals (a transparent, colorless variety of calcite) produce a double image when objects are viewed through the crystals in transmitted light (Figure 1). It was then that he observed this unusual phenomenon of refraction taking place and wrote a report entitled "Experiments on Double-refracting Iceland crystals", which led to the marvellous discovery of double refraction or birefringence.

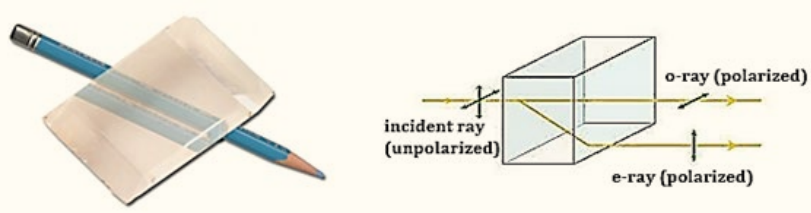


Figure 1: Double refraction in a calcite crystal.
(Image source: microscopyu.com)

Polarization is an interesting property of light. To understand more, we consider light as a wave which always oscillates perpendicular to its direction of propagation. Such a wave is called a transverse wave. Say, we have a taut wire whose one end is fixed on the table while the other end is held by us and we prick in the middle of the wire. We see it starts vibrating and the direction of vibration/oscillation is perpendicular to the length of the wire. This means the wave is travelling along the length of the wire, while it is oscillating perpendicularly. Now, light is an electro-magnetic wave, i.e. it consists of oscillating electric and magnetic fields (as shown in Figure 2). In Figure 2, we can see the electric field(E) vector along X-axis, magnetic field vector along Y-axis and direction of propagation along Z-axis.

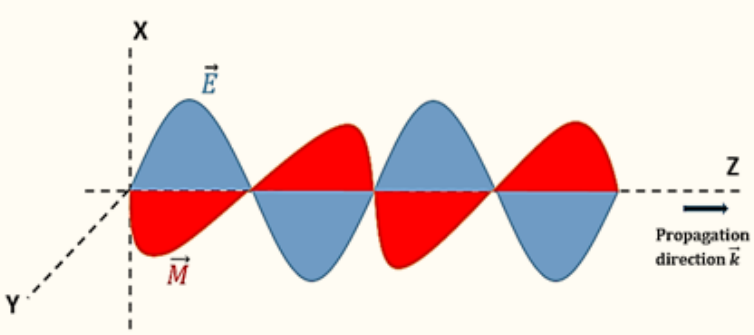


Figure 2: Electromagnetic wave

When we say light is polarized, we consider only the E-vector. In Figure 2, the E-vector is directed along the X-axis, so light is said to be plane polarized along the X-axis. That means looking at the direction of the E-vector, we can state the direction in which light

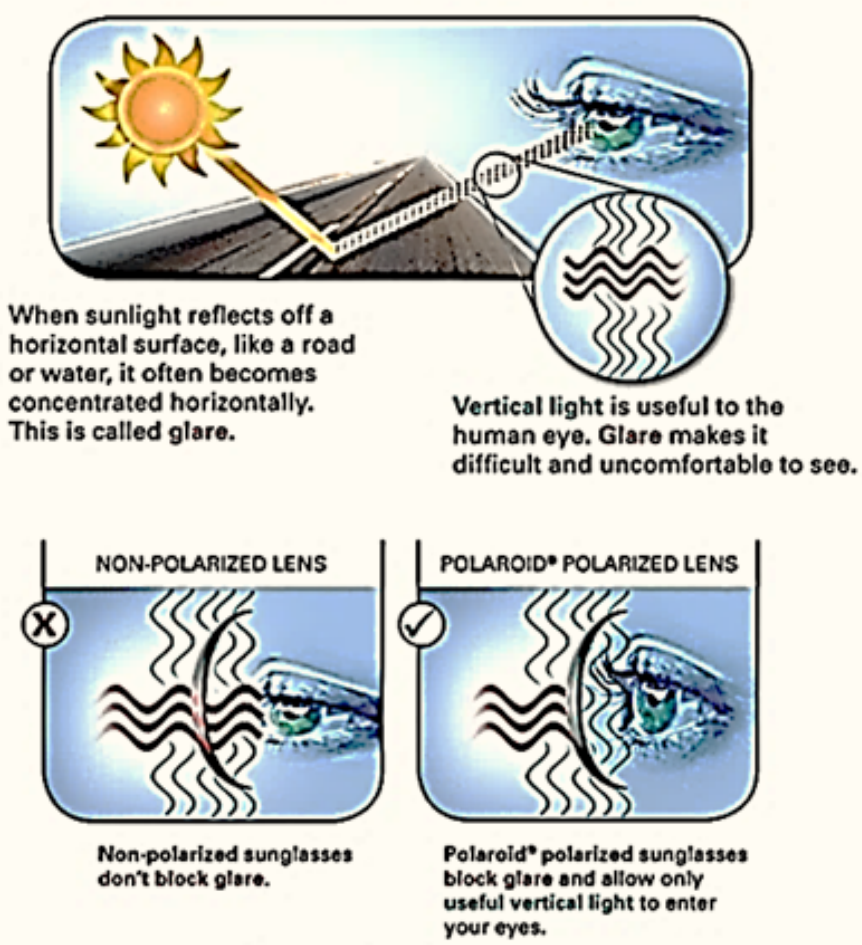


Figure 3: Action of polarized sunglass
(Image source: Quora)

is polarized. But it is not always necessary that the E-vector will be confined to a particular direction (say, X-axis). The most common and ubiquitous light is sunlight. Sunlight produces transverse light waves whose E-vectors oscillate/vibrate in all possible planes. So sunlight is said to be randomly polarized. But naked human eye is not capable of recognizing this property of light. In fact, polarized light can be detected through color effect. For example, when we wear polarized sunglasses, it blocks the horizontal wave called glare, hence improving visual comfort (Figure 3).

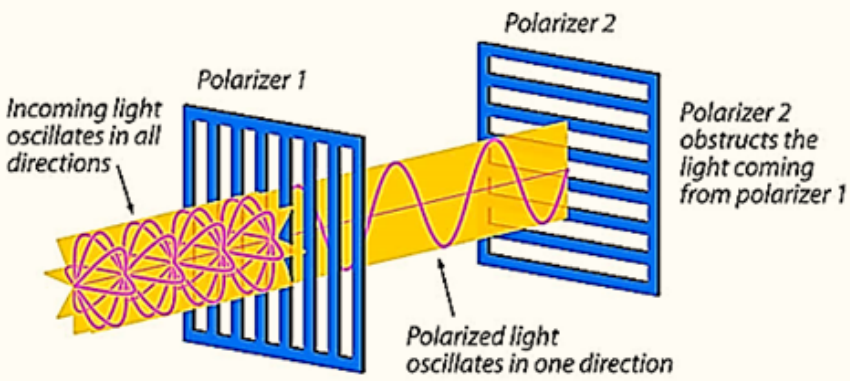


Figure 4: Action of crossed polarizers. (Image source: vitensenteret.com)

Polarizers are basically filters which have long polymer molecules oriented in a single direction. So these molecules allow only the incoming light waves vibrating perpendicular to the direction of molecule orientation, while absorbing the waves vibrating parallel to the molecules. Such polarizing filters are also used in camera lenses, in room and stage lighting to reduce glare and provide an increased uniformity in illumination. Now if we hold two such filters at right angles to each other, we get a crossed polarizer. Crossed polarizers are used in space suits to block the intense sunlight from entering the astronaut's eyes. We can understand it better from Figure 4. In our day-to-day life, we also come across numerous applications of polarization like liquid crystal displays (LCDs) used in wrist watches, computer screens, clocks etc.

Raveena is Junior Research Fellow at IIA, working in the field of Solar spectro-polarimetry.

In my view, Science had turned human history upside down by demystifying the hitherto unknown mysteries of the world. Science helps to seek true knowledge by removing the superstitions and religious dogmas of society, just like a light burst eliminating darkness. I have tried to depict the very nature of Science in the painting. I have painted some of the symbols of superstitions, black magic, and satanism near the canvas's edges with a darker background. In the central part of the art, a few (randomly chosen) of the important scientific inventions and achievements (Fire, Wheel, Light bulb, DNA, Nuclear energy, Hubble Space Telescope), which changed human life perspectives, are shown in place of electrons in an imaginary atomic structure. The recently captured Black Hole image is drawn as the nucleus of the imaginary atom.

Partha Prathim Goswamy

My Journey with Chess

Through the eyes of an IXth standard kid …

Manjunath Bestha

My name is Manjunath. I'm the class representative of IX-A. I have to go to school early than other students – to collect chalk pieces, clean the board, and arrange the desk before the teachers come in. It is very important work and the duty of the class representative. And I'm proud of it.

The chalk pieces have to be collected from the headmaster's room. One day, as usual, I went there to collect them. The headmaster was in his chair, reading his morning paper.

Me: Good morning sir, shall I come in?

Head: Good morning Manju, come in.

Me: The chalk pieces ...

Head: Sure.. sure..

Next to the boxes of chalk, there was a chessboard. I had started playing chess a month back, and I had always beaten my friends at it. I had also seen the headmaster playing with other teachers in the staff room. Maybe, I should ask him for a game?

I was a bit nervous, but since I'm unbeaten among my friends, and being a class representative, I felt entitled to challenge the headmaster to a game. So I asked him. He lowered his paper, smiled at me, and nodded his head.

We started the game, and I played confidently and quickly. After a while, the headmaster leaned back in his chair, and again with a smile, announced that I had won!

Me: Oh! Is it? Really?

Head: (smiling) Yes, you won! You played very well. Keep playing!

Well, I can't say I was very surprised. After all, I had always won whenever I played with my friends. I happily went ahead and told my classmates that I had beaten the headmaster in chess. I enjoyed that feeling, and from that day onwards, I started playing chess regularly.

Looking back as an adult …

Chess became a passion for me. I continued playing the game through junior college and engineering. I strongly believe that it all started from beating my headmaster at chess that day. And I strongly believe that he had allowed me to win that day.

He was a teacher who always wanted the best for his students. He must have been playing chess for ages, but still hadn't let winning a game take control of him; instead, he orchestrated my win that day, knowing that it might cause me to pursue the game. He was a man who understood that you don't always have to win; you needn't flaunt your strength in front of people weaker than you.

I have, by no means, reached anywhere in chess, but playing chess has improved me personally and academically. It has had a profound influence in calming my hot-headedness. It has also helped me to better understand people and their responses. I have become better at making decisions, accepting challenges and solving problems.

I would suggest everyone to play chess, not to win, but to learn. Every game we lose will boost us to learn more and to win in the future.

I would like to acknowledge Vishnu Madhu for motivating and helping to write the article.

Manjunath Bestha is doing his 2nd year Integrated MTech-Phd at IIA. He is working on the Design and Development of Atmospheric Dispersion Corrector for HROS - TMT under the guidance of Prof. Sivarani Thirupathi.

Moon-Mars Occultation

On the evening of April 17, 2021, Moon occulted (eclipsed) the red planet Mars between 17:49 pm and 19:33 pm Indian Time for observers from Bengaluru. This event was visible from many parts of India, but the view was obstructed by cloudy weather. From Bengaluru, the reappearance of Mars from behind the Moon was seen after sunset at 19:33 pm. The above image is taken from Bengaluru 30min after the reappearance of Mars by DrPrasanna Deshmukh, Engineer-C, IIA.

Location: Bengaluru, India.

Date: 17-04-2021, 20:09 IST

Camera: NIKON D5300

Focal Length: 300mm, f/6.3

Exposure: 1/2 sec.

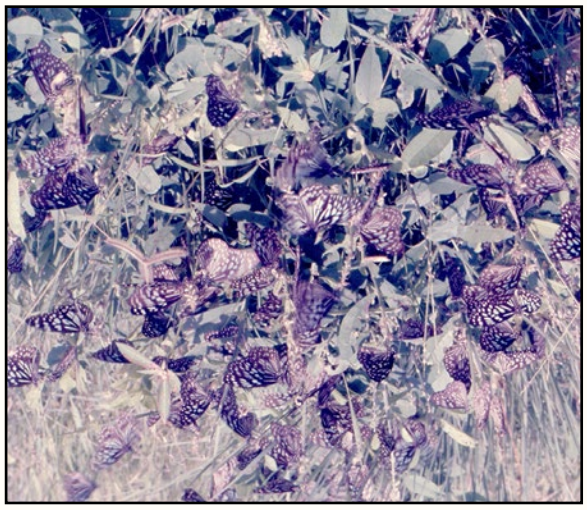
ISO: 250

Kavalur Early Days : Flora & Fauna

Conclusion

KAVALUR Flora & Fauna

Peahen, Kavalur



Butterflies at Kavalur,

Bongainvilla near roll off roof, Kavalur

Kavalur garden

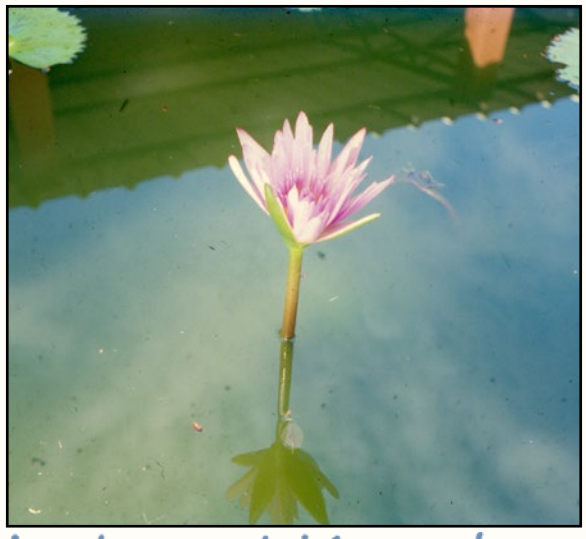
Rose Garden, Kavalur

Lizard, Kavalur

Dual Pineapple

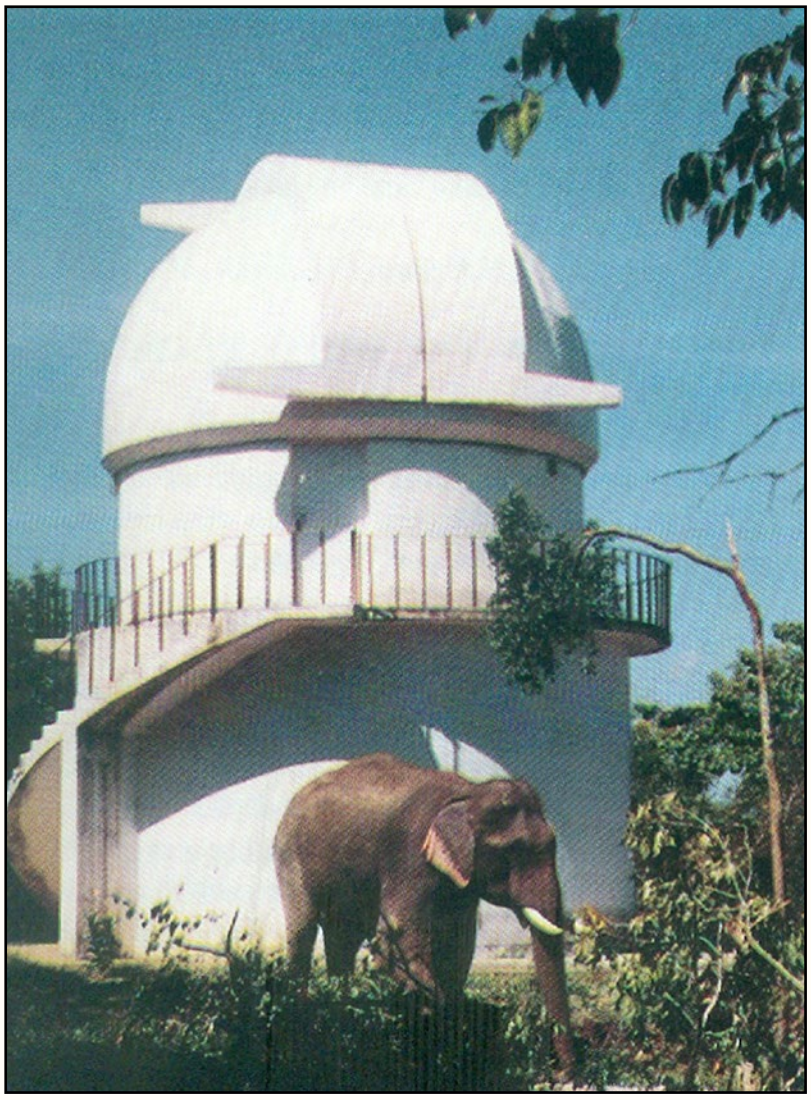

Jacaranda, Kavalur


Squash at Kavalur


Lotus at Kavalur


Water Lillies in 40inch tank


Sivashanmugam at Kavalur, July 1972

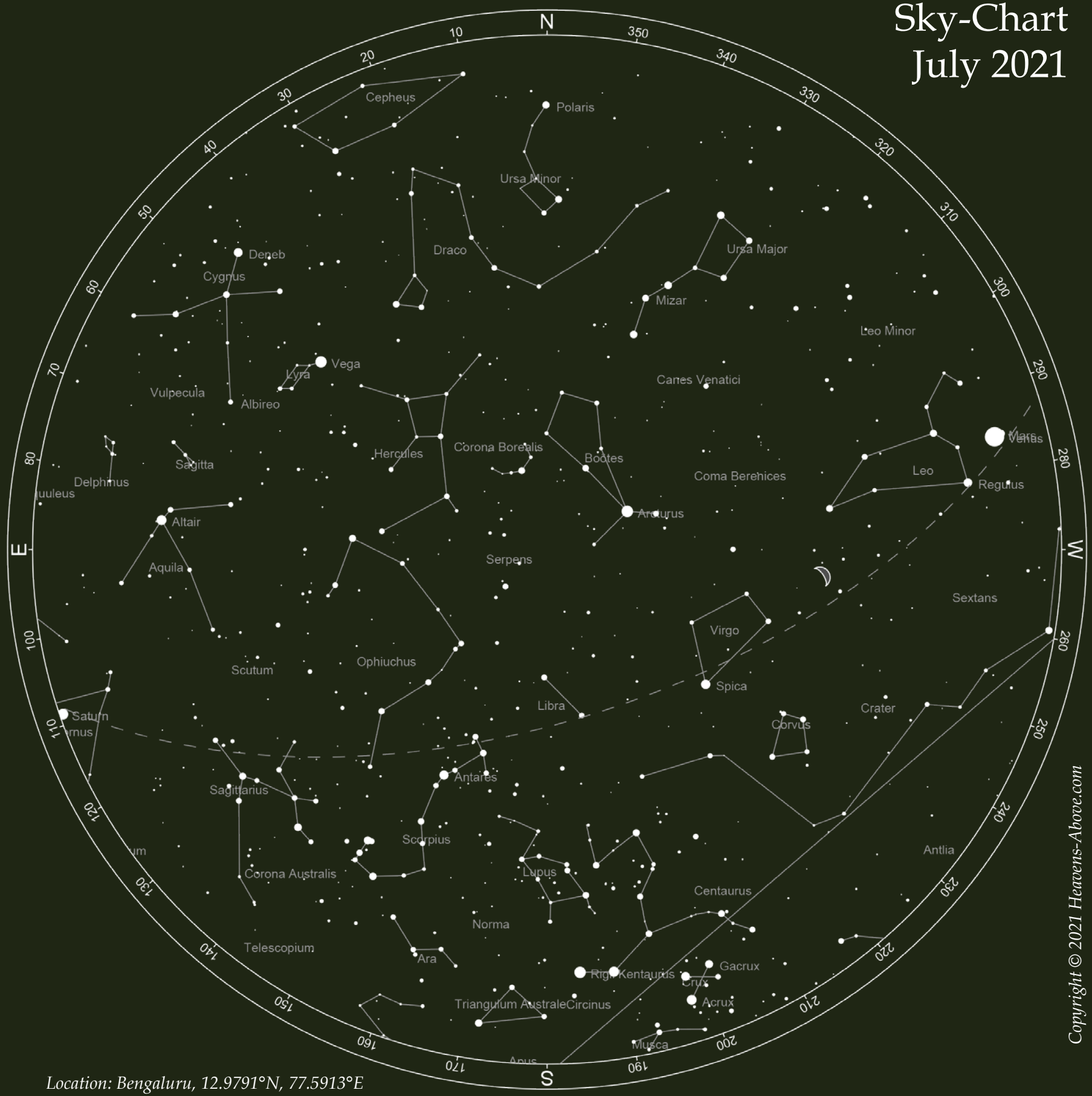

The 45cm Schmidt – an additional tusk to blink1


Lotus Pond, Kavalur


Chameleon at kavalur


Frog on Lotus Leaf

Sky-Chart
July 2021



Location: Bengaluru, 12.9791°N, 77.5913°E
Time: 15 April 2021 20:00 (UTC +05:30)

Watch-out for:

July 4 - Mercury at Greatest Western Elongation. The planet Mercury reaches greatest western elongation of 21.6 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the morning sky. Look for the planet low in the eastern sky just before sunrise.

July 28, 29 - Delta Aquarids Meteor Shower. The Delta Aquarids is an average shower that can produce up to 20 meteors per hour at its peak. It is produced by debris left behind by comets Marsden and Kracht. The shower runs annually from July 12 to August 23. It peaks this year on the night of July 28 and morning of July 29. The nearly full moon will be a problem this year. It's glare will block block most of the faintest meteors. But if you are patient, you should still be able to catch a few good ones. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Aquarius, but can appear anywhere in the sky.

IIA Memory Tree : *Branches full of lush green leaves*

Sandeep Kataria

Whenever I remember my student life at IIA, it brings a whole tree of memories with every branch full of lush green leaves. One of the branches reminds me of the JAP course work, which was quite exciting, although a brief journey through Astronomy and Astrophysics. For me and my batchmates, during this coursework, the hectic travel schedules bore the sweet fruits of discussions with many faculties at IISc, RRI and IIA. Given my interest in Galaxy Dynamics, I chose to work with Dr Mousumi Das. It was the beginning of a very fruitful journey.

This takes me to another branch of the IIA memory tree which involves the most essential aspect of a PhD: conducting the best quality research and sharing it with the research community. In the beginning, I had to learn the basic tools for my research and apply them to the problem at hand. This part of the branch reminds me of the struggles to make progress given the enormous challenges. Despite the challenges, the path was made smooth by various stress-relieving activities. When I look back at these struggles, I realize how they shaped me as I am today.

Another beautiful branch of the IIA memory tree involves insightful scientific discussions that happened during my PhD journey. The main channels for these interactions were group meetings, seminars, colloquiums and journal clubs. Weekly group meetings and journal clubs were beneficial in strengthening basic concepts, which keep on fading as we narrow down into our own research. I also remember that some of us made quite a few failed attempts to enhance casual science discussions during tea/coffee time, in the spirit to have elementary science discussions. Now I realize that apart from regular research work, these discussions help build future research directions and definitely contribute to being an independent researcher.

A principal part of the memory tree was my involvement with IIA outreach activities. Outreach allowed me to interact actively with school children, college students, and society as a whole. The activities aimed to enhance scientific temper in the community, given the prevailing amount of pseudoscience. We took various initiatives to improve the productivity for outreaches like Teacher Training Programs, which teachers and student volunteers appreciated.

Yet another branch of the IIA memory tree was my stay at the Bhaskara Hostel and Guest House. It was like a home hundreds of kilometres away from the real home. I enjoyed my stay at Bhaskara, and we had a lot of activities there. In times of sudden illness or injury, we students remained united to help and support each other. We also celebrated most of the festivals around the country, given the diversity of students at Bhaskara. These celebrations were followed by cultural and art performances like music, dance, drama, fun games, etc. We also planned many adventurous activities like trekking, cycling, picnics, which were quite refreshing given the hectic working schedules. I also appreciated the involvement of student volunteers in the collective donation drive of waste generated by the whole Bhaskara family and also as a response to natural disasters across the country in the time of need.

The vibrant life at IIA was full of academic and extra-curricular activities that built my IIA memory tree. Apart from the best academic environment, I really thank IIA for providing the support to visit various national and international conferences/workshops. These gave me a chance to discuss my research work with leading scientists across the globe. The inevitable stress due to research was managed through extra-curricular activities. These activities involved running, cycling, volleyball, music, etc. PhD life allowed me to learn several essential skills which are imperative to a successful academic career. My advice to younger colleagues will be to dedicate time for learning skills that enhance your values for the current academic environment, apart from your regular research. IIA provides a platform to connect with leading researchers across the world in your respective fields; just grab this opportunity and give your best to bring exciting insights in your field.

Sandeep Kumar Kataria is a postdoctoral fellow at the School of Physics and Astronomy at Shanghai Jiao Tong University, Shanghai. He works in the field of Galaxy Dynamics using N body simulations as well as observations.

"Walk into the swirl"

Maya Prabhakar

"Nothing behind me, everything ahead of me, as is ever so on the road - Jack Kerouac"

Maya Prabhakar

The Witch Head Nebula

Witch Head Nebula (IC 2118) is an extremely faint reflection nebula which is the result of an ancient supernova remnant or a gas cloud illuminated by a nearby supergiant star Rigel in the constellation of Orion. Its appearance resembles the side profile of a Witch face, complete with a long nose and pointy chin! The color of this blue nebula is primarily due to the intense blue light of Rigel and the dust grains that reflect blue light more efficiently than red.

Equipment Used :

Camera: Nikon D7200 (Stock, Unmodified)
Telescope: WO RedCat 51 Apochromatic Refractor, 250mm, f/4.9
Tracker: iOptron Sky Guider Pro (Not Guided)
Tripod: Amazon Basics 70 inch Tripod
Intervalometer: Neewer Digital Timer Remote Shutter Release Trigger

Acquisition Details :

Sub-Exposure: 60 seconds, ISO 4000, 250mm, f/4.9
Lights: 207, Flats: 61, Darks: 12, Bias: None
Total Integration Time: 3 hrs 27 mins

Software :

Stacking: Deep Sky Stacker V4.2.5
Processing: Adobe Photoshop CC 2019 & Pixinsight

Location:

Nainital, Uttarakhand, India (Bortle 4)