Celebrating 125 Years
Kodaikanal Solar Observatory

June 2025

Issue 10

DOOT

A students' initiative from the Indian Institute of Astrophysics

Solar Frontiers: A Conversation on Space Weather and Scientific Growth with Prof. Dibyendu Nandi

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Pen to Paper: Invitation call for articles

We invite your insightful contributions for DOOT, under the following categories:

Review:

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)

Experiences:

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 an eminent 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)

Science made easy:

For this section, we invite write-ups discussing interesting concepts of Science and technology (S&T) in a very simple and enjoyable way, without using much of technical jargons. The main motive is to make S&T more accessible to a wider audience, presenting complex ideas in a way that anyone regardless of any technical background in the subject—can understand, connect with, and appreciate the significance of S&T (Word limit: 1400 words)

Alumni:

In this section, we warmly invite our former students and retired staff/faculty to share your invaluable experiences duringyour time at IIA. We hope that this column offers an opportunity to reflect nostalgically on your journey here. We are also very interested in hearing about your career path after IIA, the challenges you would have faced, and the impact IIA had on your life. (Word limit: 1400 words)

Creative 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 doot@iiap.res.in

From the Editor

In the year 2020, a group of enthusiastic young astronomers initiated an idea of connecting the IIA community by sharing their research articles among themselves and with the general audience, which would also aid in improving the writing skills of the students. With the idea of creating a messenger (DOOT, in Sanskrit: दूत [dūta]) of science, under the remarkable Chief Editorship of Dr. Sandeep Kataria, we began the journey towards publishing the first issue of the IIA e-Magazine. Amidst the outbreak of COVID, the initial meetings started online where the team members put forward each other's ideas. Since its inception, DOOT has experienced remarkable growth and featured nine issues with over 130 articles. With unwavering support from the Dean and the Director of IIA, and the Faculty Advisors of DOOT, our magazine has achieved global recognition, representing at the meetings of the Astronomical Society of India and other conferences.

I am excited to announce the publication of the tenth issue of DOOT, as a special edition to commemorate the completion of 125 years of the Kodaikanal Solar Observatory (formerly called the Madras Observatory). This issue brings forth contributions in the form of research-based review articles, hobbies that include art and philately, interesting conversation with eminent solar physicist Dr. Dibyendu Nandi, simplified explanations of scientific principles, experiences and memories from the IIA fraternity, career guidance from our distinguished alumni, experience of the students' collaborative visits abroad and stunning astrophotography. Expanding our horizon, the team has recently launched DOOT YouTube channel (@DOOT_IIA) to provide a lively experience for our general audience. On this channel, we have featured our first interview with Emeritus scientist, Dr. Seetha Somasundaram, and videos capturing National Science Day activities. The latest initiative on the channel is the launch of a students' podcast series, formulated to enrich the young aspiring minds by providing first-hand insights into the lives and careers of Ph.D students.

We are eager to bring forth more excited videos and articles for our audience. We seek to continually grow and improve the content of the magazine through your magnanimous feedback and suggestions.

Dr. Raveena Khan (डॉ. रवीना खाँ)
Chief editor, DOOT

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The cover picture

C/2023 A3 (Tsuchinshan–ATLAS)

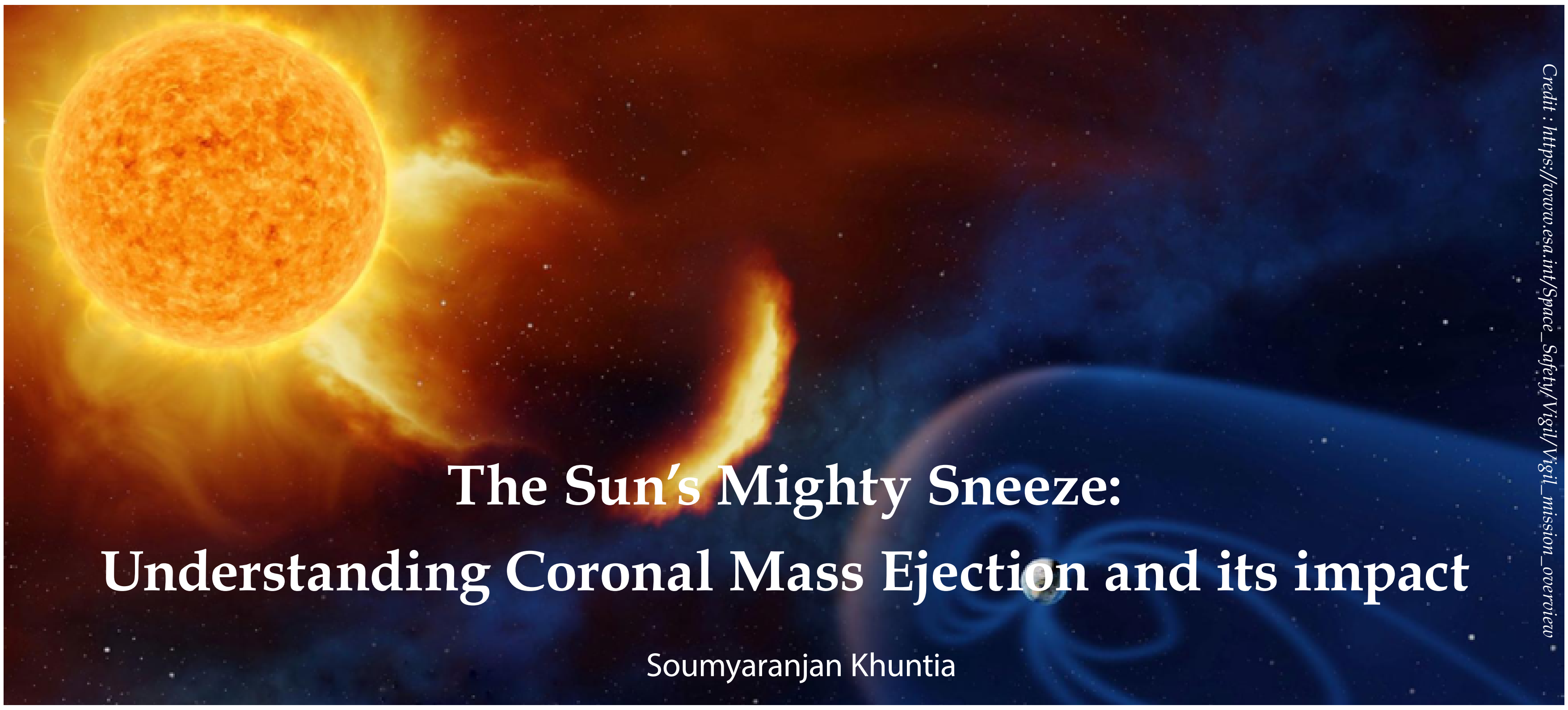
Comet C/2023 A3 (Tsuchinshan–ATLAS) is a long-period comet that became visible to the naked eye in the western sky during the evenings of October 2024. I captured this on one such evening—October 17, 2024—from the rooftop of the old magnetogram building at the Kodaikanal Solar Observatory.

The warm lighting around the Miche Smith building (now the museum) beautifully illuminated the foreground, adding a dramatic orange glow that brought a magical atmosphere to the image. As a regular astrophotographer, I initially intended to have all the surrounding lights turned off. However, I couldn't wait for that to happen and decided to shoot anyway. Later, I realized that sometimes, these lights can create an unexpectedly enchanting effect.

I'm grateful to Michie Smith and his team for constructing such a picturesque, almost haunting bungalow, the KSO electrical team for the warm ambient lighting, and the security staff, whose presence ensured access to this unique vantage point.

(Credits to en.wikipedia.org and Kodaikanaltourism.co.in for the details).

Camera	:	Nikon D7500	Focal Length	:	18mm @ f/3.5
Lens	:	Nikon 18–140mm, f/3.5–5.6	Location	:	KSO Museum, Kodaikanal
ISO	:	400	Post-processing	:	Adobe Photoshop & Lightroom Classic
Exp	:	10sec	Image credit	:	Anand M N, IIA



Credit : https://www.esa.int/Space_Safety/Vigil/Vigil_mission_overview

The Sun's Mighty Sneeze:
Understanding Coronal Mass Ejection and its impact

Soumyaranjan Khuntia

What Exactly is a CME?

The Sun! That big ball of fire in the sky, lighting up our days and, occasionally, causing a bit of cosmic chaos. Imagine the Sun as a cosmic pot, constantly brewing with hot plasma, magnetic fields, and immense energy. A coronal mass ejection (CME) is like the Sun's version of an epic sneeze, except instead of spreading germs, it spreads billions of tons of plasma, magnetic fields, and high-energy particles across the solar system. These ejections are made of solar plasma—a soup of mainly protons, electrons, and a small amount of heavier ions—carried within a tangled web of magnetic fields. The mass of a CME can be around 10^{12} to 10^{14} kg. A CME can evolve into an enormous plasma structure — larger than the Sun itself! (see Figure 1). It can travel from a leisurely 100 km/s to a jaw-dropping 3,000 km/s (the speed of passenger airplanes is around 0.3 km/s [2]). At this high speed, a CME could travel from the Earth to the Moon in about 2 minutes! Observation of CMEs in white light involves using specialized instruments, called coronagraphs, to block the bright light of the Sun's surface and capture the faint corona. Coronagraphs on spacecraft like the Solar and Heliospheric Observatory (SOHO) and Solar TErrestrial RElations Observatory (STEREO) have provided invaluable data for monitoring and predicting these solar phenomena.

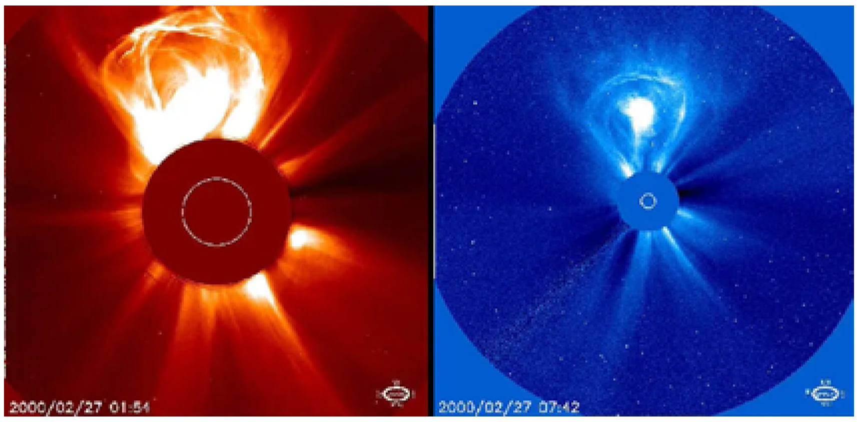


Figure 1: A coronal mass ejection was taken on 27 February 2000 by two coronagraphs, C2 and C3, in SOHO spacecraft [5].

The Impact on Earth

When a CME heads toward Earth, the effects can be significant—it's like the Sun's way of sending a message saying, "Hey, pay attention to me!" Here's where things get pretty! After the CME rattles the magnetosphere, many energetic charged particles get funneled toward Earth's poles. These particles slam into atoms in the atmosphere, mainly oxygen and nitrogen, giving them a little extra energy. When those atoms return to their normal state, they release the energy as light. And boom—auroras! You've got yourself a natural light show in the sky (see Figure 2). The aurora occurs generally in the polar region or higher latitude regions.

Figure 2: Beautiful northern lights on 10th May 2024 in Stockholm, Sweden [6])

But wait, there's more: CMEs cause temporary disturbances in the Earth's magnetosphere (the protective magnetic bubble surrounding our planet), what we call a geomagnetic storm. A strong geomagnetic disturbance can interfere with the working of satellites, global positioning system (GPS), and even ground power grids (see Figure 3). Remember the March 1989 geomagnetic storm? It was like the Sun's April Fool's joke—except it knocked out the entire power grid in Quebec (a city in Canada) for nine hours and resulted in a loss of $13.2 million worth to Hydro-Quebec's electrical transmission system [10]. No electricity, no heat, and probably no coffee! (for more details, refer to [7,8])

For astronauts aboard the International Space Station (ISS), a CME means more than just a cool light show. These solar storms can expose them to increased levels of radiation. Imagine being in space and suddenly feeling like you're in the middle of a cosmic laser tag game—not exactly the fun you could sign up for! CMEs also keep airlines on their toes. When solar storms are strong, flights that travel near the poles might have to take a detour. So, if your New York to Tokyo flight suddenly seems to be making an unexpected pit stop in Los Angeles, you can blame the Sun for throwing a plasma ball.

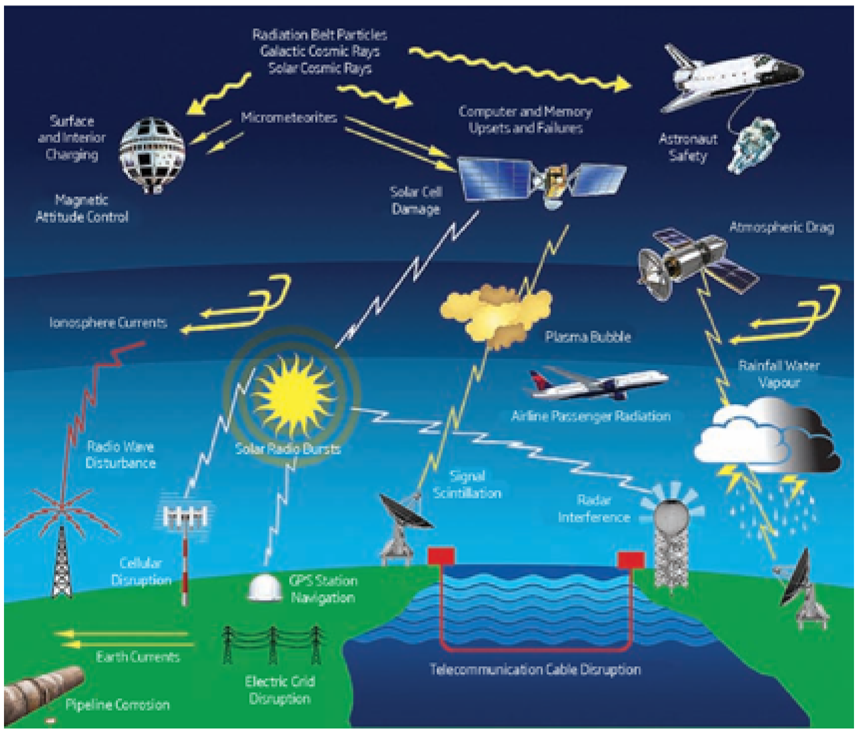


Figure 3: Probable effects of a geomagnetic storm on terrestrial and space technologies [9]

The Carrington Event of 1859, named after the British astronomer Richard Carrington who first observed it, is the most intense geomagnetic storm ever recorded. Telegraph systems around the world went haywire—sparks flew from the equipment, shocking operators and setting telegraph papers on fire. The intensity of this storm, measured using detailed magnetic records from India's Colaba-Alibag observatory, was roughly three times more powerful than the most intense storm recorded by modern instruments. And all this was between the 18th to 19th centuries when electricity was just starting to power communication. Imagine what would happen today with our interconnected, tech-reliant world. More recently, we've seen the Sun flex its muscles again. In February 2022, SpaceX lost 38 of its Starlink satellites due to a geomagnetic storm triggered by a CME. It was a multi-million-dollar reminder that the Sun's space weather can have serious consequences—even in modern times!

Interesting fact: The Sun's corona, its outermost atmosphere, is not only a million times dimmer than its surface but also much hotter than its surface, reaching about a million K, compared to the surface temperature of around 5,800 K, despite being farther from the Sun's core [3,4]. What!!

In short, while auroras are a beautiful gift from the cosmos, the larger impacts can ripple through various sectors—power, communications, and space exploration—making it a crucial event to monitor.

The Science Behind It

Alright, let's sprinkle in a bit of science here.

What causes these massive outbursts? The Sun generates an ever-changing magnetic field extending far out into space, creating the heliosphere—a giant bubble that protects our solar system from interstellar plasma and radiation. The story begins in the Sun's corona, where magnetic field lines twist and tangle like spaghetti in a bowl. Over time, these magnetic field lines stretch and become tightly wound, storing immense energy. A key feature in this process is the formation of a flux rope—a twisted bundle of magnetic field lines filled with plasma. This structure is integral to the eruption, as it can become unstable and act as a trigger. When the stored energy surpasses a critical threshold, the magnetic structure destabilizes and undergoes magnetic reconnection, reconfiguring itself and releasing enormous amounts of plasma (electrons, protons, and heavier ions) and magnetic fields into space (see Figure 4).

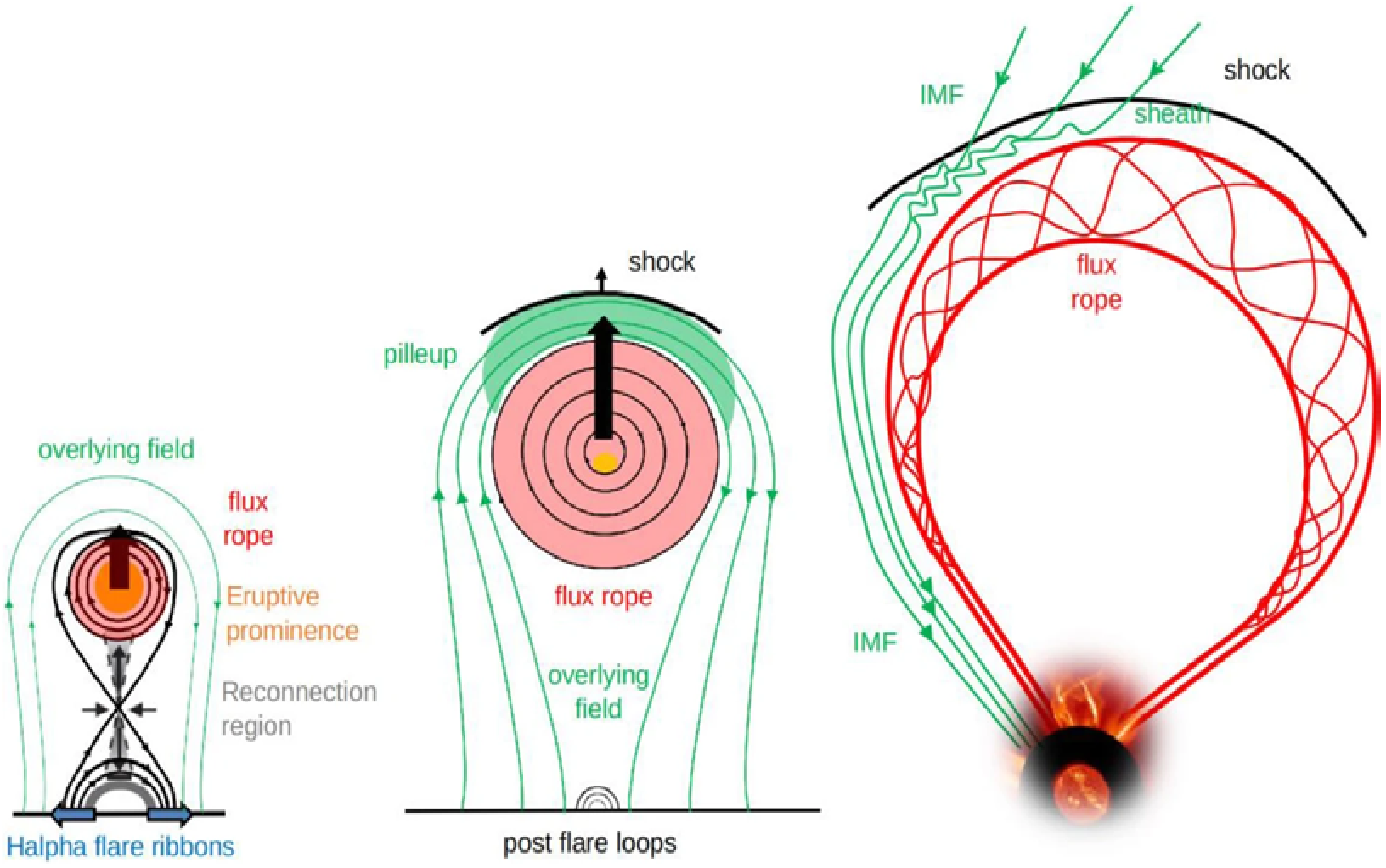


Figure 4: Schematic showing various stages of CME evolution: onset, post-eruption phase, and interplanetary propagation (from left to right) [11]

During the CME's interplanetary road trip, we call it interplanetary coronal mass ejection (ICME). An ICME evolves as it moves through space, interacting with the interplanetary magnetic field (IMF) and other solar wind structures. Its size, speed, and orientation can change, affecting how it will interact with planetary magnetic fields when it reaches them.

When this massive bubble of plasma reaches Earth, it pushes against our magnetosphere, compressing it on the dayside and elongating it on the nightside, forming a long "magnetotail." This distorted shape sets off a chain of reactions that can cause magnetic reconnections in the magnetotail. These reconnections are explosive releases of energy that can create strong currents flowing through the ionosphere—the layer of Earth's atmosphere that contains charged particles. These currents can generate a magnetic field opposite the Earth's magnetic field, creating a temporary disturbance in the Earth's magnetosphere, hence named as geomagnetic storm (see Figure 5). The crucial factor determining how an ICME will impact Earth lies in its magnetic field direction. Think of it as a cosmic handshake: if the magnetic field of the CME is aligned southward (opposite to Earth's northward magnetic field), it's like a bad handshake that opens the door for trouble. This alignment allows a more direct and intense interaction through magnetic reconnection, leading to stronger geomagnetic storms. When the magnetic field of the CME is aligned northward, the impact is much less severe. Apart from the magnetic direction, other factors—such as the speed, temperature, density, and strength of the magnetic field in the CME plasma—also play a major role. A fast-moving CME carries more energy, which increases the intensity of any geomagnetic storm it causes. Similarly, if the plasma density is high, more particles will collide with Earth's magnetosphere, causing greater disruption. It's like having a larger crowd at a party—the more people, the bigger the mess.

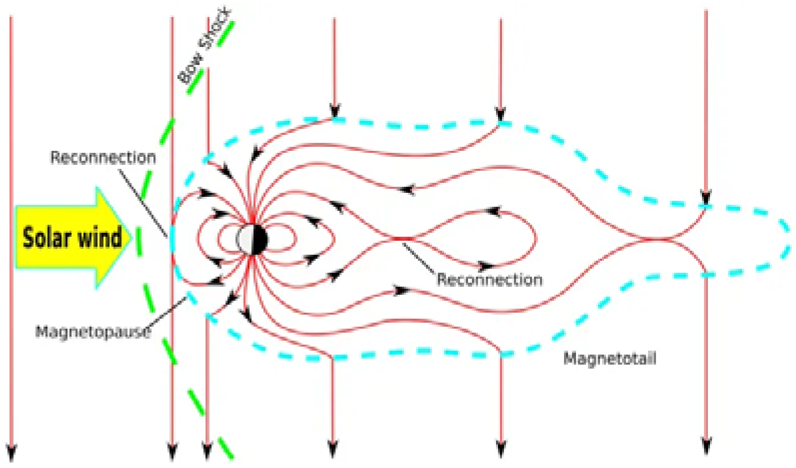


Figure 5: Schematic showing the interaction of Earth's magnetic field lines with oppositely aligned solar wind magnetic field lines [12].

You may be wondering, "Should I be worried?" Well, not really. The most important factor protecting us from the full brunt of a CME is Earth's magnetosphere, our cosmic bodyguard, which works like a giant shield, deflecting most of the solar wind and CMEs. Without this protection, our atmosphere could be gradually stripped away by the solar wind, as scientists believe happened to the planet Mars.

In short, the combination of the CME's magnetic field direction, speed, density, temperature, and plasma composition—along with the resilience of Earth's magnetosphere—determines how much of an impact a CME will have. This is why scientists use space weather models to predict these parameters as accurately as possible, helping us prepare for the space weather effects caused by these solar outbursts.

The Bigger Picture: Philosophical Thoughts

CMEs travel vast distances, impacting space far from their origin. In life, our actions, thoughts, and intentions ripple outwards, affecting others in ways we may never see, reminding us to act with mindfulness and kindness.

The beauty of auroras following a storm shows that out of disruption, beauty and wonder can emerge. Perhaps life's struggles, like solar outbursts, shape us, revealing our hidden brilliance when we allow our inner light to shine through the turbulence.

CMEs remind us of the delicate balance between our planet and the star that sustains life. So, the next time the Sun sneezes, just grab some popcorn, sit back, and enjoy the cosmic show!

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Soumyaranjan Khuntia is a Senior Research Fellow (SRF) at the Indian Institute of Astrophysics (IIA). His research focuses on the kinematics and thermodynamics of solar coronal mass ejections (CMEs), solar wind dynamics, and space weather phenomena.

IIA students pose for a group photo at the DOOT stall on National Science Day 2025.

Chasing Dreams: My First International Journey to Heidelberg

Payel Nandi

As human beings, we constantly dream of exploring new places, experiencing different cultures, and seeking opportunities to broaden our academic horizons. For many Indian students, the allure of studying or collaborating abroad, especially in Western countries, is particularly strong. This dream, however, often comes with its own set of challenges. I, too, nurtured this aspiration when I began my Ph.D. journey.

My dream materialized when my supervisor, Prof. C. S. Stalin, introduced me to a program offering an opportunity to visit a European institution. To participate, I had to prove my academic capabilities, which added a layer of determination to my already ambitious Ph.D. journey. When I was officially registered for the program, I was thrilled at the prospect of visiting the prestigious University of Heidelberg, nestled in the charming city of Heidelberg - a popular tourist destination, especially in winter.

However, as reality often proves, dreams come with hurdles. The process of obtaining a visa, securing accommodation, and preparing for international travel was daunting. Despite these challenges, I managed to overcome them and embarked on my first-ever international journey to Germany.

Upon arriving at Frankfurt Airport (Flughafen Frankfurt Main, Germany) after a long 10.5-hour flight, things took an unexpected turn. A technical delay had caused me to miss my pre-booked bus to Heidelberg from the airport. With more than 30 kg of luggage and a growing sense of anxiety, I struggled to find the next available bus. My limited English and cultural unfamiliarity didn't help, but after some trial and error, I encountered a kind stranger, who guided me to a digital screen. There, after pressing some random buttons, I connected with a virtual assistant who helped me locate the next bus and provided guidance on purchasing a new ticket. Finally, after much effort, I reached Heidelberg.

The following day marked the beginning of my experience at the host institute, the culmination of all the groundwork and preparations. The experience was overwhelming, a new environment, new people, and an entirely new work culture. The warm welcome from everyone, including my officemates, my host, and the group members, was truly remarkable.

Picture: (Left) A stunning view of Mannheim water tank. (Center) Panoramic view of Heidelberg and the Neckar River from the hillside.(Right) The open-air amphitheater "Heidelberg Thingstätte" radiating its historic charm on a bright sunny day.

Meetings and discussions over tea or coffee were incredibly engaging and productive, offering me a fresh perspective.

During non-scientific conversations, I often found myself quiet, speaking only a few words while my mind raced with countless thoughts. One aspect that struck me was their disciplined approach to work; it was like clockwork. There were no interruptions, no idle chatter, and no distractions from mobile phones. In fact, I think I was the only one whose phone rang in the office, which was quite embarrassing.

For the first few days, I settled into a routine, something I rarely follow. My days revolved around going to the institute, returning in the evening, cooking, eating, and sleeping. I stayed alone in an isolated building surrounded by a forest-like area. The nearest houses were about 200 meters away, but I never heard a sound from them. On most nights, it was just me and the trees, accompanied by a symphony of mysterious sounds that left me terrified at first. Over time, I started to identify the sources of these sounds, and the experience became unforgettable. It taught me resilience and reminded me every night how much I miss my country, India. But after this, I feel confident and I can live anywhere!

Gradually, I began to explore Heidelberg, a city overflowing with charm, history, and natural beauty. As someone naturally talkative, it was initially challenging for me to wander the city alone and find joy in solitude. However, with time, I learned to embrace peace and quiet, discovering that solitude can be a powerful teacher. My curiosity often led me to examine the plants and trees near my rented house, comparing them to the flora I was familiar with in India. To my delight, I identified several familiar species, which brought a comforting sense of connection to homewander, even though I was far away.

Visiting Heidelberg from February to June allowed me to experience its seasonal transformations in full. I witnessed the beauty of snow-dusted landscapes and leafless oak trees during the colder months, gradually transitioning into the vibrant colors of spring, with trees adorned with flowers and budding nuts. These changes were mesmerizing and gave me a newfound appreciation for nature's cycles. One of the most striking aspects of my stay was the variation in daylight hours - dusk arriving as early as 5 p.m. in February and as late as 11 p.m. in June. It was both surprising and fascinating to experience.

Heidelberg itself is a place of immense beauty and historical significance. Its scenic Neckar River, rolling hills, and iconic Heidelberg Castle create an almost fairy-tale setting. The castle houses the famous "Heidelberg Tun," an enormous wine barrel with a capacity of ~200,000 liters, which serves as a testament to the region's history and culture. The "Philosophenweg" (Philosophers' Walk), a historic path that offers stunning views of the city, was one of my favorite spots for reflection. Another standout attraction was the "Heidelberg Thingstätte," an open-air amphitheatre built in the 1930s, that can accommodate more than 10,000 people and carries a unique architectural and historical significance.

On the mountaintops surrounding the city, I explored the medieval "Michaelskloster Ruins" and "Stephanskloster Ruins," which transported me back to the ancient history I had read about during my school days. These sites, with their timeless beauty, reminded me of the enduring human connection to the past. Evenings by the Neckar River, with its icy waters and an abundance of bird life, including elegant swans, became a cherished part of my routine. They provided a sense of calm and balance, a perfect counterpoint to the excitement of exploring the city.

My travels also extended to nearby Mannheim (City in Germany), where the striking 19th-century water tower was a sight to behold. The city's architectural grandeur and cultural vibrancy left a lasting impression on me.

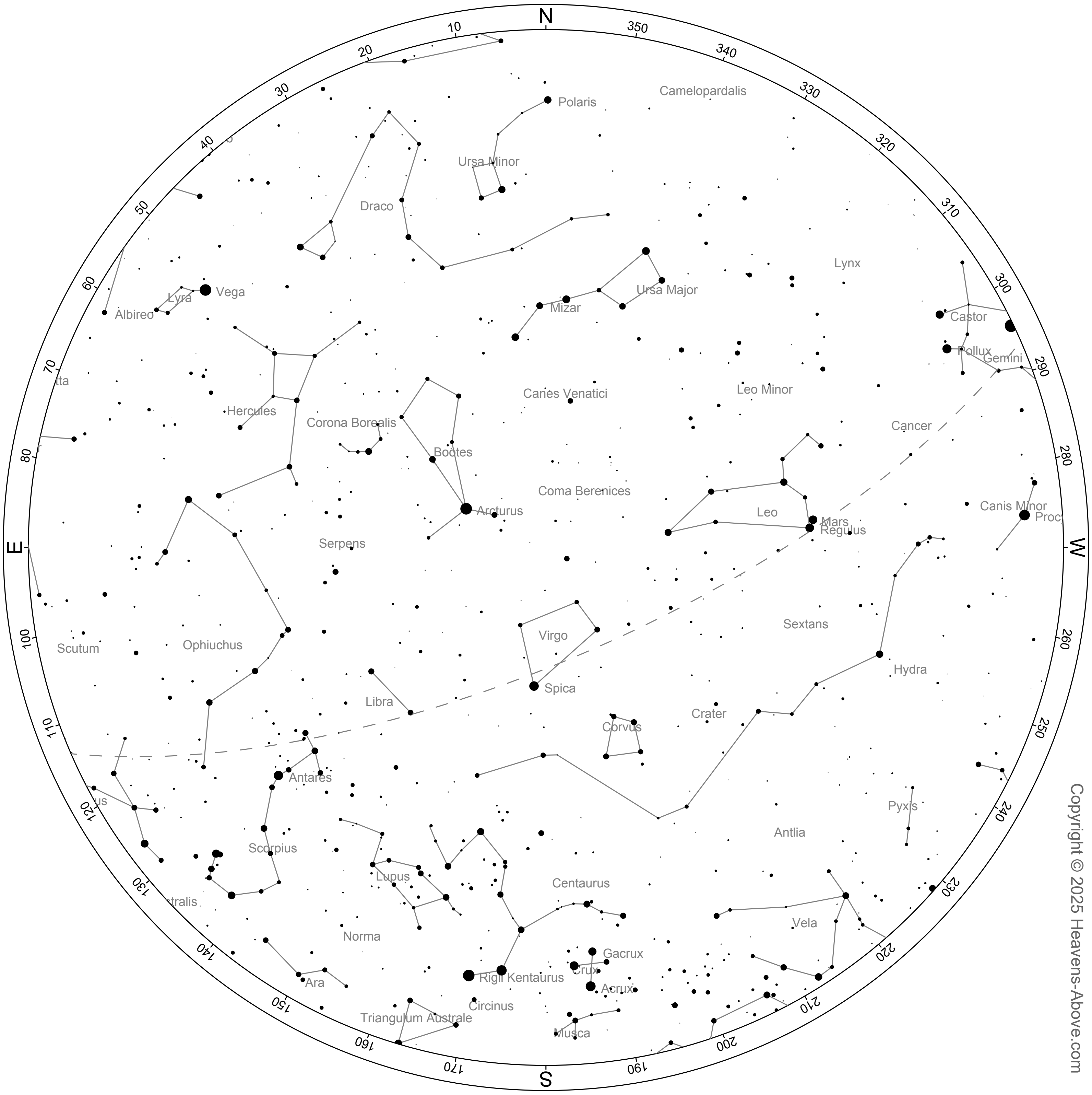
During these adventures, I kept my eyes open for fellow Indians, eager to strike up conversations and share a sense of community. Sometimes, I mistakenly approached Asians or Mexicans, which often led to amusing cultural exchanges. These interactions enriched my experience and helped me forge friendships, primarily with Master's students from southern India. Their warmth and camaraderie added a special layer of connection to my otherwise solitary days and reminded me of the universal bond that transcends borders.

Two places stood out during my stay: the university canteen and the library. The canteen was a haven of culinary diversity, offering everything from spicy Asian dishes to mild Western fare, with meals priced by weight - a fascinating concept. The library, on the other hand, was a treasure trove of knowledge. It housed an impressive collection of old books, and one of my most memorable moments was finding the annual report of an Indian institute during my initial days. It filled me with pride and reminded me of home.

This journey was more than just an academic experience; it was a whirlwind of emotions, challenges, and growth. It broadened my horizons, both personally and professionally, leaving me with memories to cherish for a lifetime. Heidelberg not only enriched my academic pursuits but also shaped me as an individual, teaching me resilience, adaptability, and the joy of discovery.

Payel Nandi is a Post Doctoral Researcher at IIA working with Prof. C. S. Stalin. Her research interests are exploring AGN and investigating the impact of AGN outflows on star formation.

International conference on Sun, Space Weather, and Solar-Stellar Connection held at Bangalore, India from 20-24 January 2025.



Skychart June 2025: (As on June 15, 2025. 20.00hrs Bangalore)

June 21 - June Solstice . The June solstice will take place at 08:10 AM IST on June 21. During this moment, the North Pole will be angled toward the Sun, which will be at its highest point in the sky above the Tropic of Cancer, located at 23.44 degrees north latitude. This event signifies the beginning of summer (summer solstice) in the Northern Hemisphere and the start of winter (winter solstice) in the Southern Hemisphere.

Violence in the Pinwheel galaxy (M101):

An autopsical insight into a cosmic demise leading to supernova '2023ixf'

Rishabh Singh Teja

In reality, the static-looking 'visible' night sky is full of dynamic phenomena, with several of those even being impermanent in shorter time scales. These events may last for a fraction of a second, to days, or even up to a few years in contrast to the million-billion astronomical time scales. We often refer to these time-critical classes of events as *'Transients'*. This word encompasses an umbrella of events such as novae, supernovae (SNe), gamma-ray bursts (GRBs), tidal disruption events (TDEs), etc. SNe are the terminal stages in the lives of stars, or simply, the stellar end-points. SNe are vividly categorized based on their observed spectral/photometric features and explosion mechanisms (Filippenko 1997).

Broadly, there are two supernova (SN) classes, Type I and Type II, based on the absence and presence of hydrogen Balmer lines (Figure 1). However, in physical terms, a star truly dies/explodes with only two main processes: a) An evolved white dwarf accreting mass from a companion star could become unstable by exceeding its Chandrasekhar mass limit (~1.44 solar mass), leading to a thermonuclear runaway and, at last, it explodes. b) A class of massive stars, mostly above 8-10 times the solar mass, evolve in an onion-like structure, forming heavier elements towards the core due to fusion (Figure 2). Eventually, as the iron group elements are formed in the core, further fusion is infeasible, resulting in an inert switched-off core with no energy generation to support a massive gravitation structure. This results in the material infalling onto the core, apparently an imminent collapse, eventually leading to a core-collapse SN, leaving the core as a neutron star or a black hole, depending on the star's initial mass.

Although, these violent explosions can easily be explained in terms of their physical mechanism. However, the stellar evolution history, environment, companionship, and various other factors make these events very exciting to study, posing

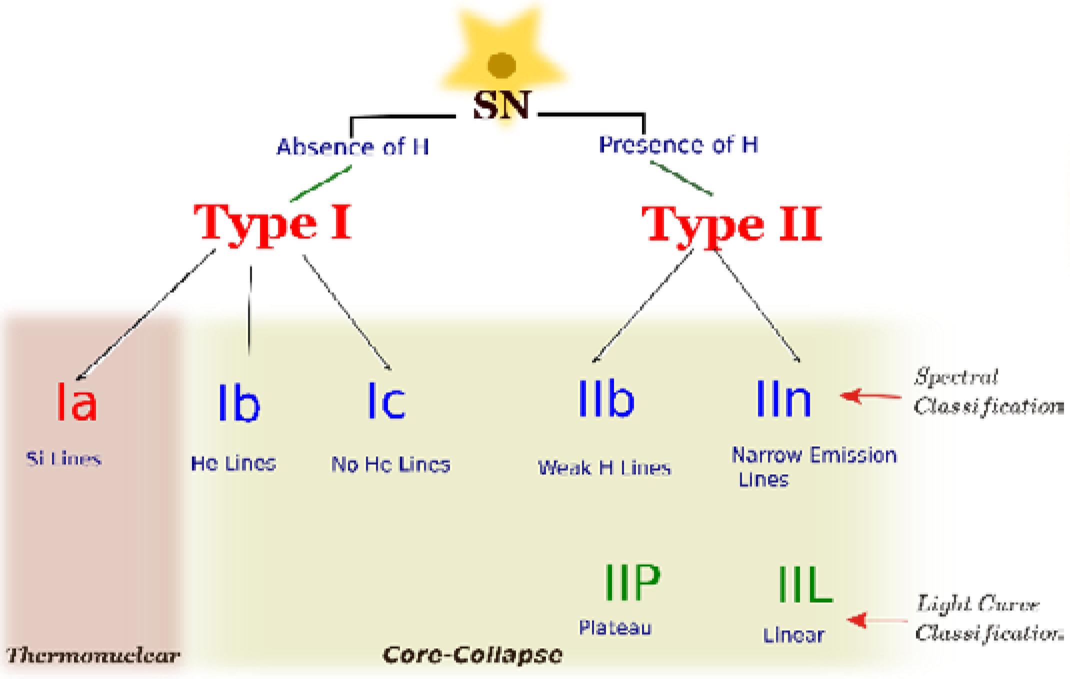


Figure 1: A broad classification scheme showing supernovae classes based on spectral lines presence/absence (Credits: Rishabh Singh Teja).

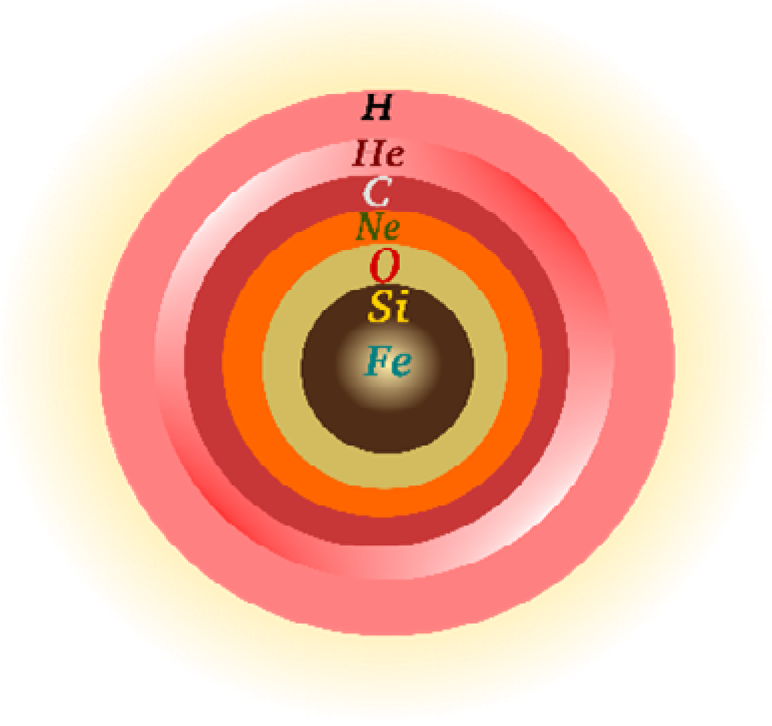


Figure 2: Depiction (unrealistic) of a pre-SN structure of a massive star resembling onion-like layers of various elements (Credits: Rishabh Singh Teja).

new challenges to our understanding with remarkable differences in what is being observed and why it is like that. Statistically, there should be 1-2 SNe per century per galaxy (the total number of SNe comes out to be enormous considering the number of galaxies in the observable universe!). Yet, the nearby events have been sporadic (even the Milky Way is due a century!), whether due to a lack of observations or the statistics not in our favor; that debate is for another day.

Fortunately, mid-way in the last year(2023-05-19), a renowned amateur astronomer reported a probable SN candidate (named SN 2023ixf) in the outskirts of Pinwheel galaxy (Messier 101), as shown in Figure 3, which was 14.9 magnitude bright in the clear filter (https://www.wis-tns.org/object/2023ixf). Around 6 Mpc (Riess et al. 2022) away, a nearby event after a decade created a flurry of observations across all observatories, and astronomers around the globe rushed to observe this in every wavelength domain possible (Berger et al. (2023), Grefenstette et al. (2023), Guetta et al. (2023), Ravensberg et al. (2024), The LIGO Scientific Collaboration et al. (2024)). We also actively started following it up with multiple observatories available in India. In the next few days, it was classified as a Type II SN with rarely observed ***'flash'*** signatures. These are very narrow (a few tens to hundreds of Km/s wide) and highly ionized features that appear in the very early spectra of SN (Yaron et al. 2017). We started a rapid follow-up program from the 2.0-m ***Himalayan Chandra Telescope (HCT)*** and 0.7-m ***GROWTH-India Telescope (GIT),*** and we put up a few Target of Opportunity (ToO) proposals in UVIT onboard ***AstroSat***. We also began near-infrared (NIR) observations in collaboration with researchers from Japan. We obtained near-ultraviolet (NUV) public archive data from the Ultraviolet and Optical Telescope (UVOT) onboard *Swift*.

Now, allow me to dissect this event and understand what transpired before and after the disaster in the light of multiwavelength observational evidence. In the initial few days, the light curves in different broadband filters showed a rise to a maximum, slightly shorter rise times than the other SNe of a similar class (Figure 4). Around the same phase, we

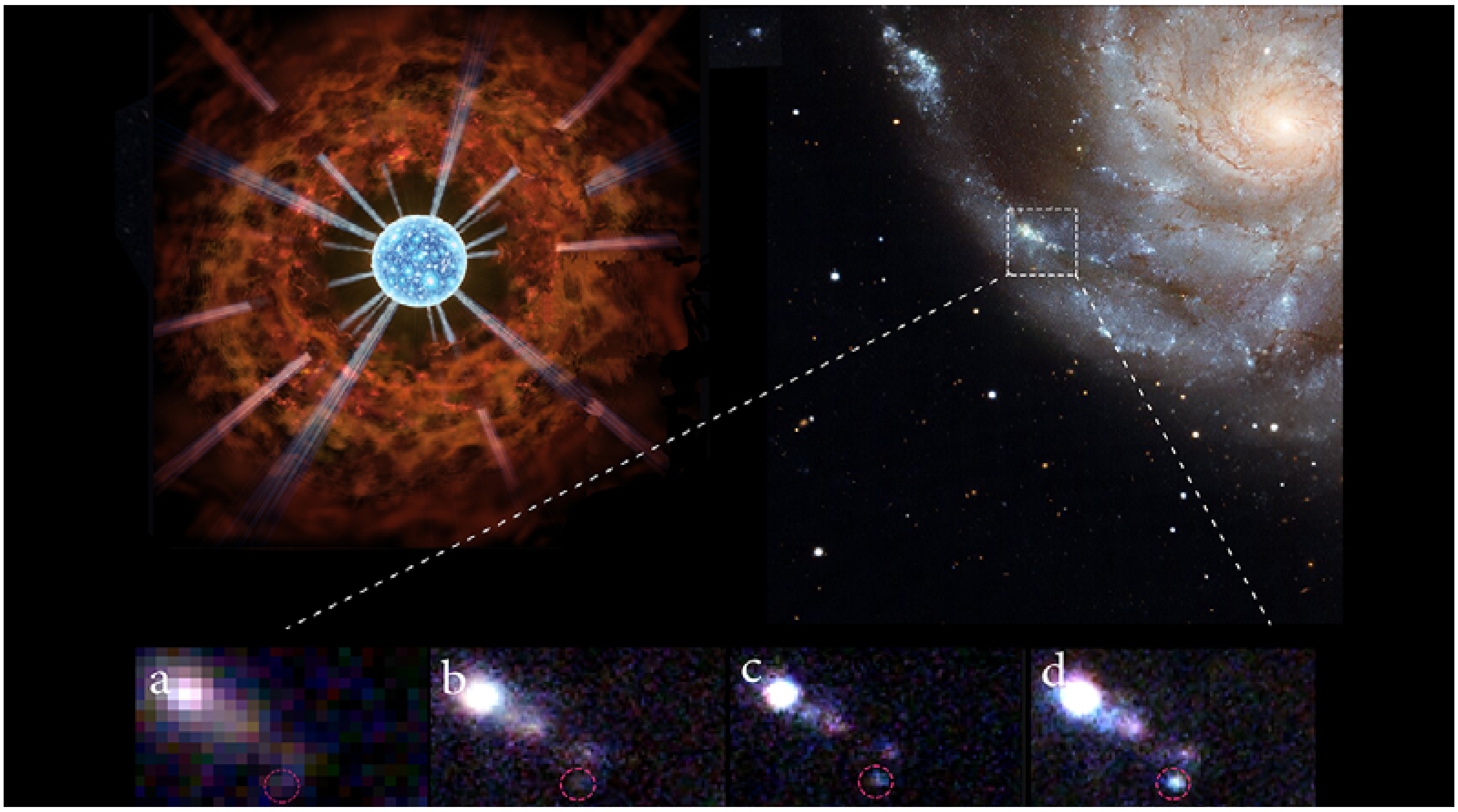


Figure 3: Sequential images of the SN 2023ixf explosion marking the transition from red to blue within a day [18 May 2023 (a-c); Early 19 May 2023 (d)] (Credits: Li et al. 2024)

see highly ionized species of He II, C IV, N IV, etc. in its optical spectral evolution, which subsided around 8 days after the explosion, and some residual interaction signatures were seen with broad and multi-peaked profiles (Figure 5). The reason for such a behavior is high-velocity SN ejecta smashing into some pre-existing matter around the star, also called circumstellar material (CSM). Additionally, it is possible that the SN shock breaks out inside the CSM, which in turn ionizes it. Using light curve modeling and spectral analysis (Teja et al. 2023), it was estimated that the material required to give such signatures has a mass loss rate of around 0.001 solar mass per year, which is very high in the case of red supergiant (RSG) stars shredding mass due to typical winds. We further deduced that the pre-existing material was ejected 2-3 decades prior to the SN explosion. But at this point, it is difficult to say what caused it. It could be induced due to factors like enhanced RSG winds, pulsations, and super winds. However, the mass loss rate estimated through various methods in multiple works clearly rules out steady winds, which are 2-3 orders less than the observed mass loss rates. For certainty, the CSM is due to enhanced mass loss in the end-phase evolution of the star prior to a few years or decades from its demise (Teja et al. (2023), Singh et al. (2024)).

We continued our quest and extensively followed it until it was too faint to register. Here, we summarise some interesting aspects revealed from the prolonged observations. The light curves showed a rare short plateau (< 80 days) evolution and sustained flux in the UV bands. Usually, we do not see any UV flux after a few weeks. Detailed light curve modeling suggested that there was persisting ejecta-CSM interaction, which provided this enhanced late-time flux. We proposed a secondary extended CSM component that was less dense than the inner compact CSM, which gave rise to the flash features (Singh et al. 2024).

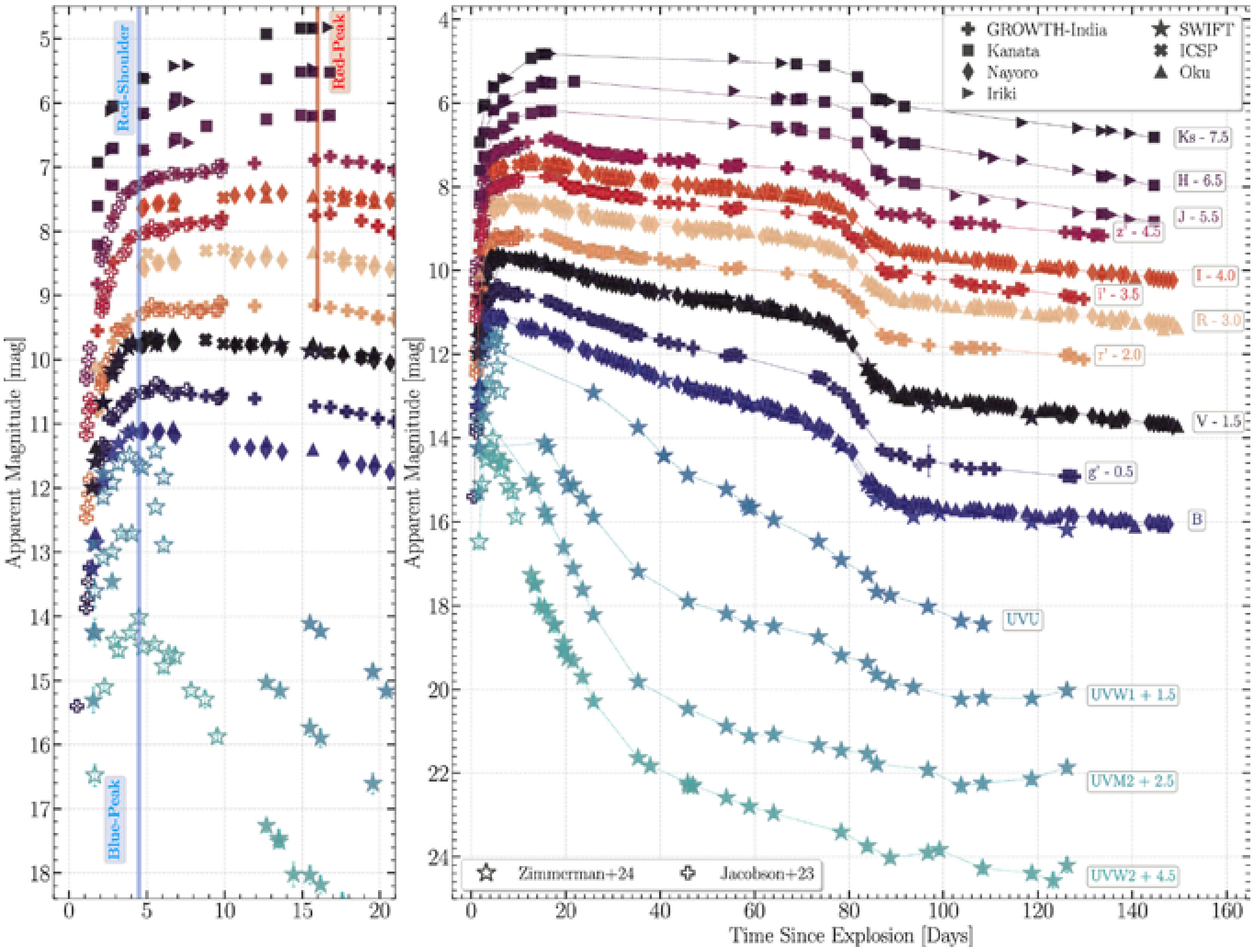


Figure 4: Multiwavelength photometry of SN 2023ixf, covering UV, optical, and NIR bands (Credits: Singh et al. 2024).

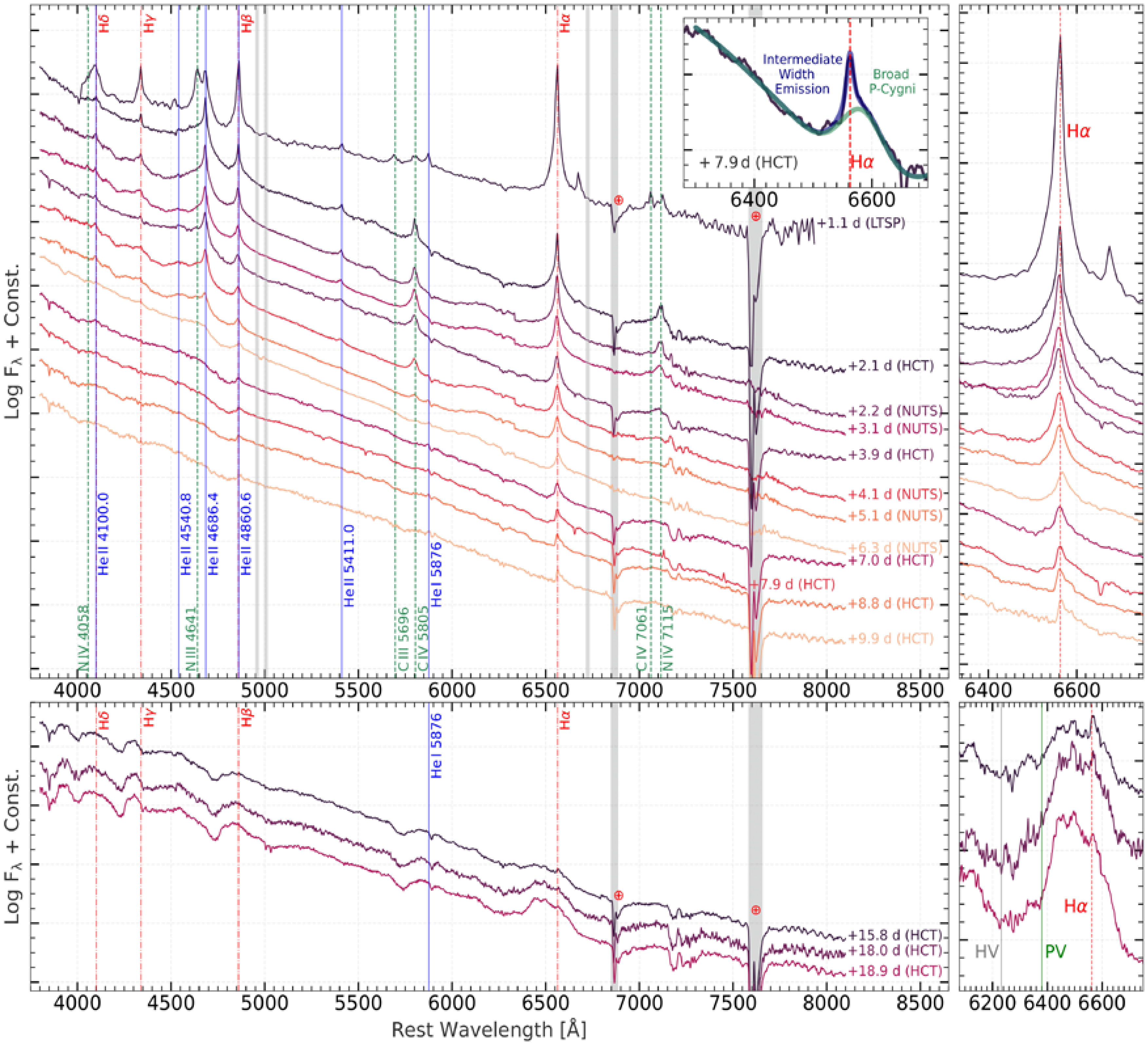


Figure 5: The optical spectral evolution of SN 2023ixf, corrected for the redshift of host galaxy M101, with epochs relative to the explosion date. Inset: Hα emission line decomposed into an intermediate width Lorentzian with an underlying broader P-Cygni Component. Top left: Early-time spectra show flash features, high-ionization lines, and Balmer lines; Top right: Hα line profile evolution during the flash phase. Bottom left: Spectral sequence during the photospheric phase. Bottom right: Multipeaked Hα emission evolution during the photospheric phase (Credits: Teja et al. 2023).

In summary, we provide a final picture of the event using optical observations combined with spectropolarimetric data. ***SN 2023ixf resulted from an RSG star, surrounded by a torus-shaped dense CSM across the equatorial plane and a clumpy low-density extended CSM.*** The left-hand side of Figure 6 highlights the flash-ionized phase resulting from interaction with the dense CSM. On the right-hand side of Figure 6, we see an aspherical shock front arising after shock breaking out from the confined dense CSM and the continued interaction with the low-density extended CSM. For brevity, other estimated parameters from hydrodynamical modeling are: it was an RSG with 10 times the mass of the sun, which exploded with 2 x 10^{51} erg energy, and, in turn, synthesized radioactive Nickel (Ni), which was 0.06 times the solar mass.

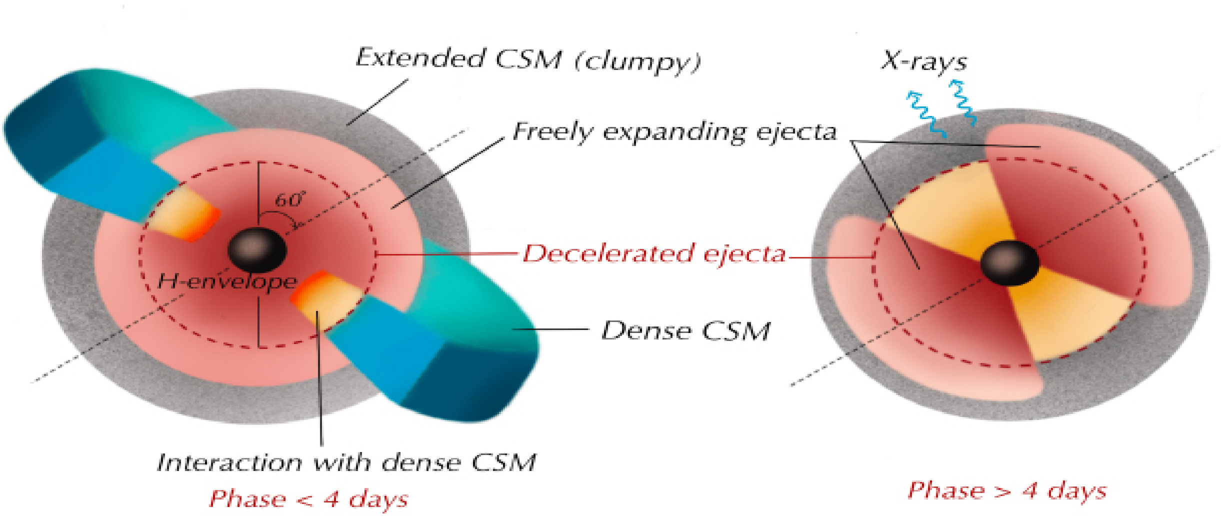


Figure 6: Schematic illustration of the geometry (as viewed face-on by the observer) proposed for the CSM around the progenitor of SN 2023ixf depicted by its equatorial dense CSM and a clumpy, low-density extended CSM at the two different phases (Credits: Singh et al. 2024).

Apart from creating unprecedented enthusiasm in the supernova community, SN 2023ixf challenged us to tweak our former understanding of how observational properties are affected by various environmental factors around the progenitor. SN 2023ixf has been an interesting case in putting constraints on gravitational waves (GW) and neutrino emissions in the nearby universe. Ongoing studies in the late phase are crucial to determine the true nature of the progenitor and dust around it. With coordinating efforts worldwide, we are fully ready to capture future events in all possible wavelengths. Upcoming UV facilities such as Ultraviolet Transient Astronomy Satellite (ULTRASAT) and Ultraviolet Explorer (UVEX) will also be crucial in catching these events much earlier.

This brief summary is based on the following two publications: Teja et al. (2023) and Singh et al. (2024).

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2. *Li et al. A shock flash breaking out of a dusty red supergiant.* Nature 627, 754–758 (2024)

3. *Riess et al. Cluster Cepheids with High Precision Gaia Parallaxes, Low Zero-point Uncertainties, and Hubble Space Telescope Photometry* ApJ 938 36 (2022)

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5. *Grefenstette et al. Early Hard X-Rays from the Nearby Core-collapse Supernova*

SN 2023ixf. [ApJL 952 L3 (2023)]

6. *Guetta et al. Low- and High-energy Neutrinos from SN 2023ixf in M101.* [ApJL 955 L9 (2023)]

7. *Ravensberg et al. Constraining MeV-scale axionlike particles with Fermi-LAT observations of SN 2023ixf.* [Physical Review D, Volume 109, Issue 2 (2024)]

8. *LIGO-Virgo-KAGRA Collab. Search for gravitational waves emitted from SN 2023ixf.* [eprint arXiv:2410.16565 (2024)]

9. *Yaron et al. Confined dense circumstellar material surrounding a regular type II supernova.* [Nature Physics, Volume 13, Issue 5, pp. 510-517 (2017)]

10. *Teja et al. Far-ultraviolet to Near-infrared Observations of SN 2023ixf: A High-energy Explosion Engulfed in Complex Circumstellar Material.* [ApJL 954 L12 (2023)]

11. *Singh et al. Unravelling the Asphericities in the Explosion and Multifaceted Circumstellar Matter of SN 2023ixf.* [ApJ 975 132 (2024)]

Rishabh Singh Teja is a Post Doctoral Researcher at the Indian Institute of Astrophysics, Bengaluru. He studies transients in Time Domain Astronomy, focusing on multiwavelength observations and modeling of core-collapse supernovae.

This abstract painting, created with fluid strokes and vibrant colors, reflects the deep emotions of a peacock dancing freely, spreading its wings without boundaries.

Art by: Shivani Gupta, Senior Research Fellow (SRF), IIA.

My Student Days at Kodaikanal and Nights at Kavalur

Prof. Tushar Prabhu

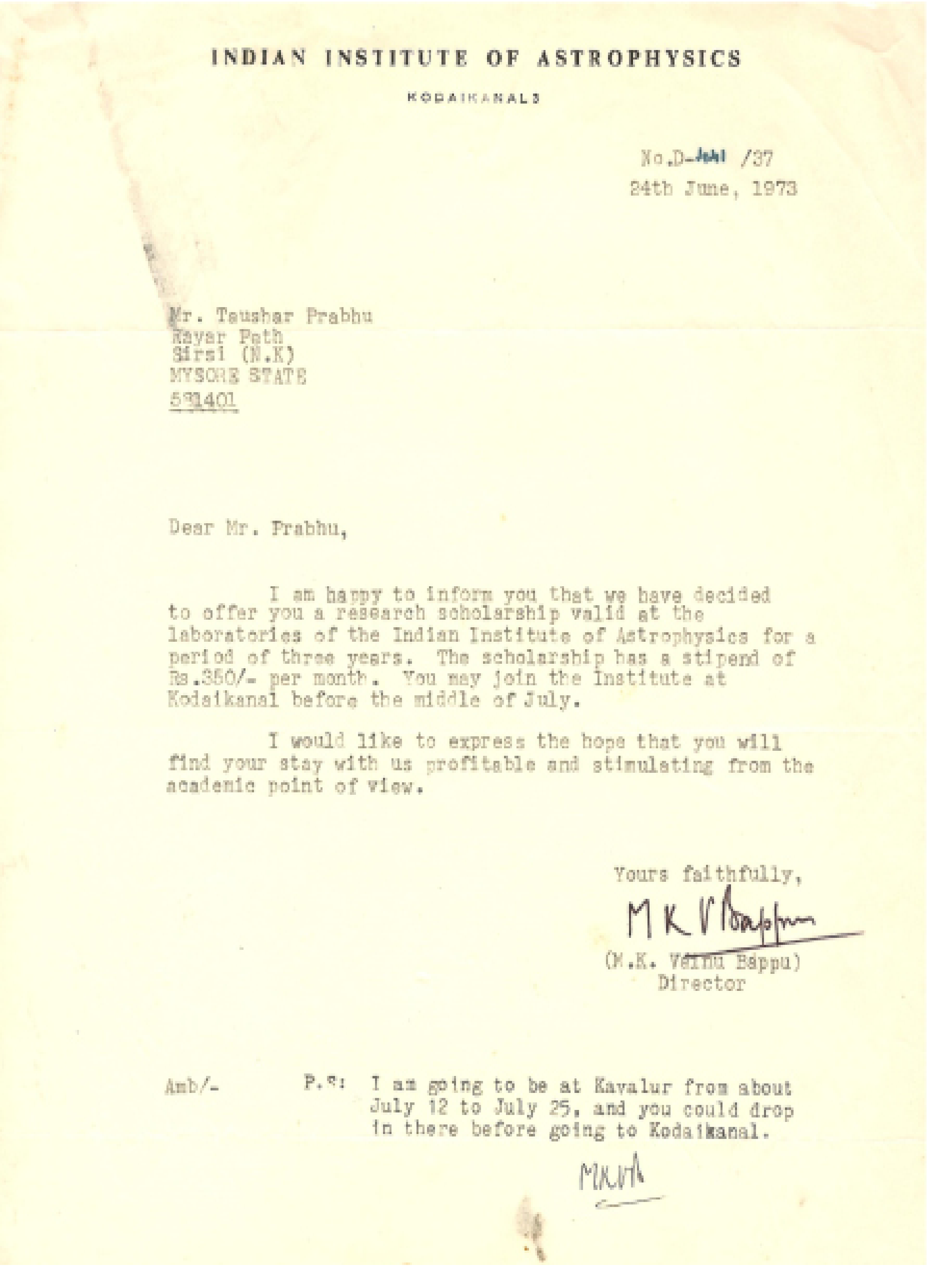
I met Dr. Bappu during the 1972 winter school in Kodaikanal and Kavalur, and he encouraged me to apply for the position of Research Scholar at the Indian Institute of Astrophysics (IIA), Kodaikanal (now known as Kodaikanal Solar Observatory). I was more comfortable with Dr. J. C. Bhattacharyya and requested him to guide me through the procedure. He responded that there are no standard forms and I should apply to the Director, IIA, "as soon as your results are out." By then, I had already written to Bappu reminding him of our meeting and confirming my continued interest. I wrote again, enclosing mark sheets from SSLC (equivalent to 10th standard now) to M.Sc. third semester and providing an estimate of final M.Sc. marks. A week later, I sent a third letter with my provisional M.Sc. certificate. My performance was one percent better than my estimate!

I received a Research Scholarship offer in early July. Bappu had asked me to "drop in" at Kavalur and meet him before proceeding to Kodaikanal. I sent my acceptance letter, packed my bags, and started. On my way, I met Bhattacharyya in his office at Raman Research Institute (RRI), Bangalore. There was no Bangalore campus yet, but some senior staff were splitting time between Kodaikanal and the lab space provided by RRI.

On July 20, 1973, I was shown a dormitory ("Kepler") in Kavalur, met a Research Assistant, and asked if Dr. Bappu was around. He stared at me and replied, "Yes, Director is here." It wasn't common to refer to Bappu by his name. Bhattacharyya was called "A.D." since he was Assistant Director, Kodaikanal Observatory, India Meteorology Department, before joining the newly formed IIA in 1971 as an Associate Professor.

I met Bappu over lunch, and my training began immediately after, learning to operate the 40-inch telescope. I was to work on galaxies for my thesis, so I had to undertake a reading project on their intensity distribution and two hands-on projects on stellar spectroscopy. Bappu supervised one on the Be/shell star Pleione. I was to approach M. Parthasarathy (then a Research Associate) for another project. Bappu taught me to record photographic spectrograms with the "Bhavanagar" (officially β) Spectrograph, measure the comparison lines with an Abbe Comparator, calibrate wavelength, and identify stellar lines.

Bappu left Kavalur, and I was too fascinated by the telescope



INDIAN INSTITUTE OF ASTROPHYSICS
KODAIKANAL 3

No.D-[illegible] /37
24th June, 1973

Mr. Taushar Prabhu
Rayar Path
Sirsi (N.K)
MYSORE STATE
581401

Dear Mr. Prabhu,

I am happy to inform you that we have decided to offer you a research scholarship valid at the laboratories of the Indian Institute of Astrophysics for a period of three years. The scholarship has a stipend of Rs.350/- per month. You may join the Institute at Kodaikanal before the middle of July.

I would like to express the hope that you will find your stay with us profitable and stimulating from the academic point of view.

Yours faithfully,
M K V Bappu
(M.K. Vainu Bappu)
Director

Amb/-

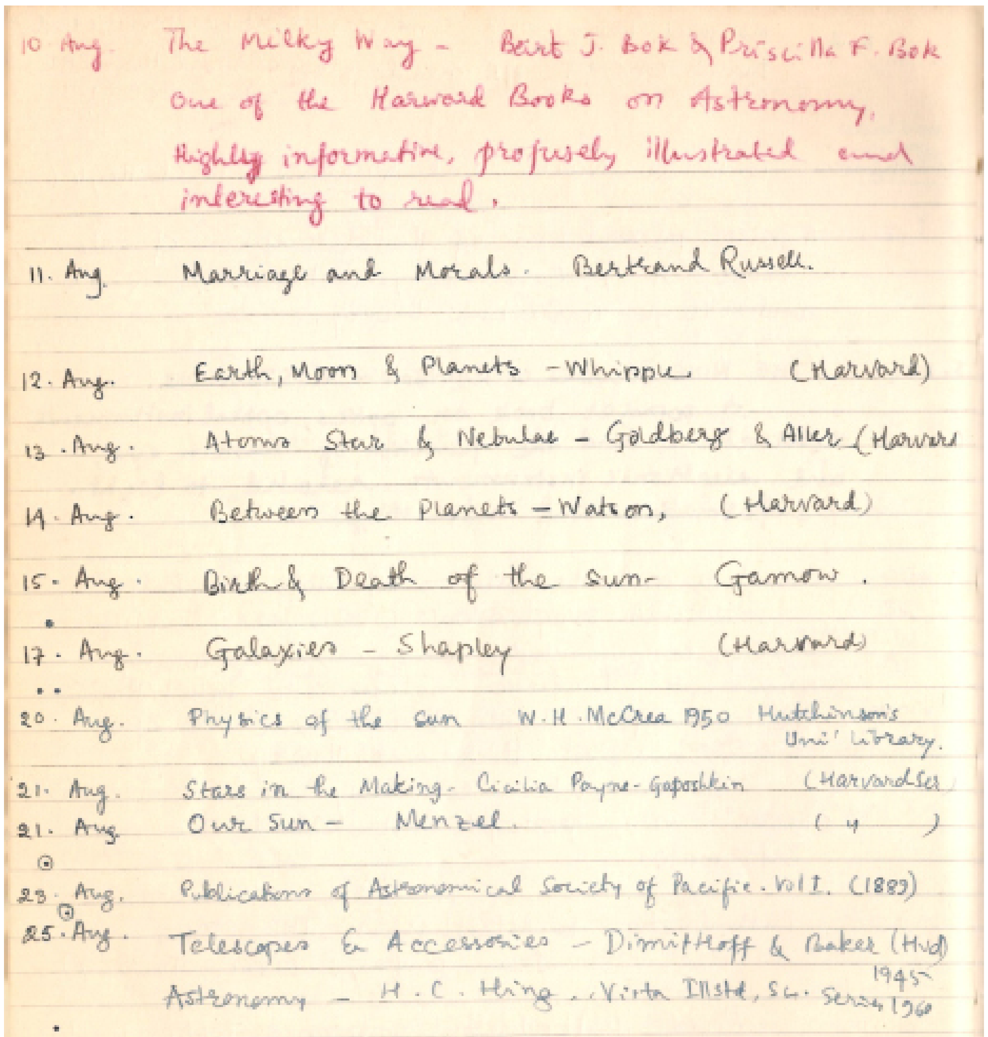
P.S: I am going to be at Kavalur from about July 12 to July 25, and you could drop in there before going to Kodaikanal.

MKVB

Figure 1: Offer Letter of IIA Research Scholarship

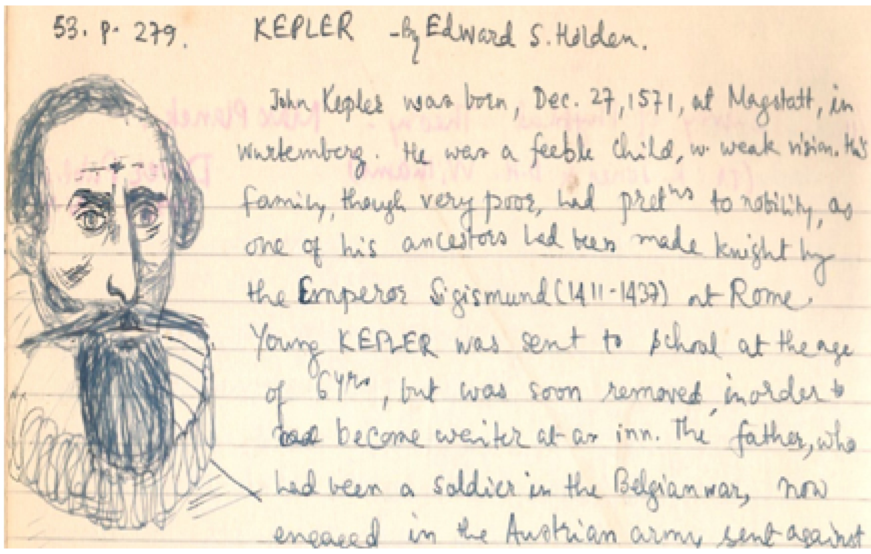
to ask him when I should go to Kodaikanal. Parthasarathy was returning there on August 6, 1973. I went with him and formally joined IIA as a Research Scholar. I was the only student. There was no canteen or mess. I had lunch at Velu's Cafe outside the IIA campus, which was closed for dinner, so I slept without. The following morning, I was admitted to a private mess operated by some bachelor staff.

Bappu was traveling when I joined IIA formally and found me in the library when he returned to Kodaikanal. My textbook would be Harvard Monographs on Astronomy. Additional reading included all the major journals in astronomy and astrophysics, beginning with Volume 1 (the library had them!). Bappu traveled frequently and would check my progress whenever he was around. "Astronomy is bedtime reading. You should finish one book during the day and one journal volume at night," he said. I tried hard until it got more and more difficult. My getaway was hills and forests whenever my brain needed rest!



10 Aug. The Milky Way - Bart J. Bok & Priscilla F. Bok
One of the Harvard Books on Astronomy.
Highly informative, profusely illustrated and
interesting to read.
11. Aug. Marriage and Morals. Bertrand Russell.
12. Aug. Earth, Moon & Planets - Whipple (Harvard)
13. Aug. Atoms Star & Nebulae - Goldberg & Aller (Harvar
14. Aug. Between the Planets - Watson, (Harvard)
15. Aug. Birth & Death of the sun - Gamow.
17. Aug. Galaxies - Shapley (Harvard)
20. Aug. Physics of the sun W. H. McCrea 1950 Hutchinson's Uni' Library.
21. Aug. Stars in the Making - Cecilia Payne-Gaposchkin (Harvard Ser
21. Aug. Our Sun - Menzel. (〃)
23. Aug. Publications of Astronomical Society of Pacific. Vol I. (1889)
25. Aug. Telescopes & Accessories - Dimitroff & Baker (Hvd) 1945
Astronomy - H. C. King. Vista Illstd, Sc. Series 1960

Figure 2: My early reading schedule on astronomy with occasional diversions, like on 11 August 1973



53. p. 279. KEPLER - By Edward S. Holden.
John Kepler was born, Dec. 27, 1571, at Magstatt, in
Wurtemberg. He was a feeble child, w. weak vision. His
family, though very poor, had pretns to nobility, as
one of his ancestors had been made knight by
the Emperor Sigismund (1411-1437) at Rome.
Young KEPLER was sent to school at the age
of 6 yrs, but was soon removed in order to
~~had~~ become waiter at an inn. The father, who
had been a soldier in the Belgian war, now
engaged in the Austrian army sent against

Figure 3: A snippet from my notebook on Johannes Kepler—great astronomers have always been a source of inspiration to me (Ref. PASP, Vol 8, No. 53, 1896)

Tests of my progress included explaining a figure from a book Bappu would pick and masking the caption with his hand. I appeared to have done well, except when he showed me a galaxy and asked me to name it.

Me: "NGC 5194 and its satellite NGC 5195."

Bappu: "What is its common name?"

Me: "M 51."

Bappu: "In words, I say, the popular name."

I admitted I didn't know.

"Whirlpool galaxy," he uttered and exited. I felt like a failure, but later learned he was impressed that I knew galaxies by their NGC numbers.

The Astronomical Society of India (ASI) had its first scientific meeting in Hyderabad early in 1974. Bappu made me present my results on Pleione. Subsequent admission to ASI as a regular member gave me a sense of belonging to the Indian scientific community.

I traveled to Kavalur frequently to obtain data and stayed on for months. The travel and food expenses were drawn from

Figure 4: First General Body Meeting of the Astronomical Society of India (ASI) on 28 February 1974. M. K. V. Bappu, then President of ASI, is prominently in the center, with Secretary K. D. Abhyankar to the right and Vice President U. R. Rao between them in the second row. ASI Council member V. Radhakrishnan, Director, RRI, on the right of U. R. Rao. M. Parthasarathy and Tushar Prabhu are in the second row, first and second from the right. R. Rajamohan is second from right in the front row. Credits: Astron-soc.in/gallery

my scholarship. Before one such travel, I gave a blank cheque to someone who would go to town for lunch, asking him to withdraw whatever I had in the bank. Bappu overheard and instructed the Administrative Officer (AO) to fix the Travelling Allowance and arrange free food for research scholars visiting Kavalur. The circular was issued very late, so I went on paying for travel and mess charges. AO was kind enough to reimburse my travel expenses during the interim period. I paid off the accumulated balance of the mess bill when I had a job.

The Pleione project didn't lead to a paper other than an abstract at the ASI meeting. Parthasarathy gave me a project to determine a spectroscopic orbit of the binary star δ Librae. R. Rajamohan, another Research Associate, helped me plan observations to cover all binary phases efficiently. I measured spectra and computed the radial velocity curve. Computing orbital elements using tables of logarithms was a challenging task. I asked Bappu if he would buy a manual mechanical calculator (I had used one during my B.Sc. in Pune). He said, "Equipment costing more than Rs 100 needs permission from Delhi", with a long wait.

The situation began to improve, and Kavalur got a Zeiss microdensitometer and a microcomputer to control a photoelectric spectrum scanner being developed in-house. The microcomputer ECIL TDC-12 with 4 KB internal memory was also available for offline work. I learned Fortran II, though running a program was tedious with limited memory. Programs had to be punched on tapes and loaded through multiple steps, and debugging meant repeating the entire cycle. When the teletype faltered, I improvised—punching holes manually and patching errors with scotch tape. I eventually began writing a program for binary orbit computation.

During the winter of 1974, while at Kavalur, I received a telegram from Bappu directing me to return to Kodaikanal immediately and attend the courses on Stellar Physics and Interstellar Matter conducted by Dr. D. C. V. Mallik, who had recently joined IIA. Sushma Mallik (*née* Gupta) had also joined IIA as a Research Scholar in 1974. Apart from the two research scholars, several scientific staff members also attended the courses. After completing the course, I took leave for my sister's wedding in Mumbai. On the way back, I gave my Fortran IV program and data to a friend in IISc to derive orbital elements of δ Librae. The output reached me by snail mail on the morning of my oral presentation at the second ASI meeting in Kodaikanal (March 1975).

I had registered for my Ph.D. at Madurai University in April 1974. A year later, Bappu conducted an oral test on Research Methodology based on the two projects I had completed. I passed the test and was ready to start my thesis on the surface photometry of galaxies, but Bappu pushed me to record galaxies' spectra. I couldn't see galaxies on the brass slit of the spectrograph, so Bappu made an acquisition and guiding unit where I could align crosswires with the slit, blindly center the nucleus of the galaxy on the slit, and use a field star to guide through the exposure.

Figure 5: ASI meeting, March 1975, at the Indian Institute of Astrophysics (IIA), Kodaikanal. Sitting on the chair in the center is K. R. Ramanathan, ex-DG, India Meteorological Department, Prof. Emeritus, Physical Research Laboratory (PRL), and member of the 1966 Committee for Scientific Reorganization, which recommended the formation of IIA. M. K. V. Bappu and incoming Vice President of ASI S. D. Sinvhal, Director Uttar Pradesh State Observatory (UPSO), on the left, and incoming President of ASI Govind Swarup, Secretary K. D. Abhyankar, and Councillor V. Radhakrishnan on the right. Parthasarathy, Ch. V. Sastry and Rajamohan are sitting on the ground at the extreme left in the picture. D. C. V. Mallik is standing at the extreme left in the front row. In the last row, standing: S. M. Alladin is 4th from left, and Tushar Prabhu is 8th from left. Credits: IIA archives

Figure 6: A studio photograph. From left to right: T. P. Prabhu, A. K. Saxena and Jagdev Singh

Figure 7: Kodaikanal Lake View photographed in 1982 when I could afford photography.

My first attempt yielded just one speck. Bappu was happy I registered the Hα emission line. I observed some bright nuclei of galaxies with no reported radial velocities, but that would not lead to a Ph.D project.

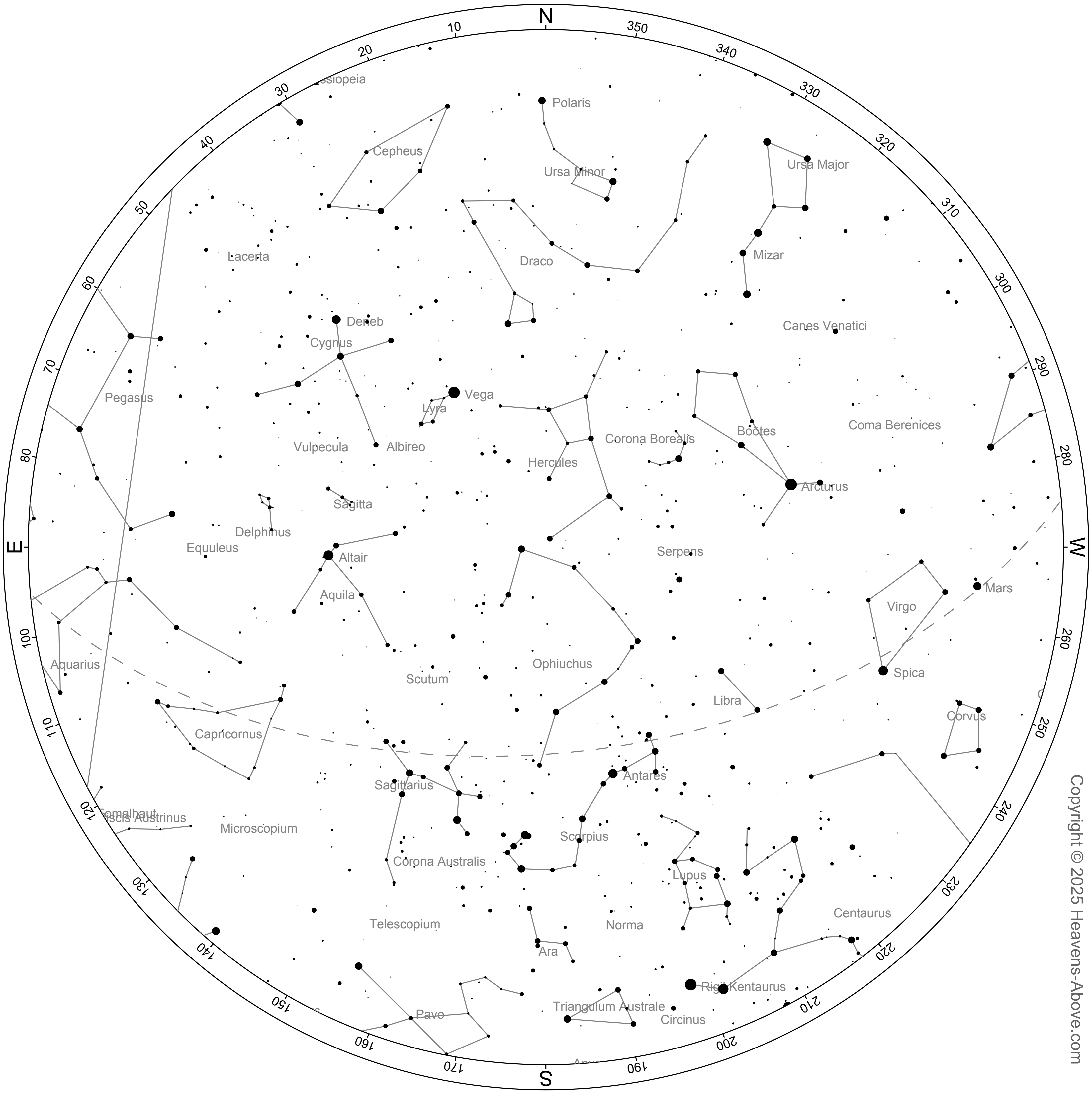
I studied the literature on the mass determination of galaxies from their velocity field. Margaret Burbidge et al.'s method was laborious for computation without a computer. Alar Toomre (Massachusetts Institute of Technology) had attempted an analytical solution for galactic discs, and I couldn't understand the theoretical derivation. I wrote a letter to him, and he explained elegantly. Encouraged by his response, I began to discuss some ideas for my thesis with him and G. de Vaucoulers (University of Texas at Austin). My ideas did not hold water. I stopped thinking of a thesis project for a while.

I had noticed an advertisement for a Research Associate position at IIA in late 1974. Candidates with an M.Sc. degree and research experience could apply. A. K. Saxena and Jagdev Singh had joined in a similar position. I applied and, after an interview, joined in August 1975 as a regular employee. Bappu began to give me additional assignments in research and development, which I thoroughly enjoyed.

By the end of the year, I received an office order transferring me to Bangalore. I had to leave Kodaikanal, taking with me pleasant memories of treks around Kodaikanal, Berijam Lake, Perumal Malai, and even Palani (we walked to Palani from Kodaikanal but returned by bus), New Year celebrations with the austerities of Jesuit Training Center, and inoculating myself against rumored ghosts by sitting with a matchbox in a lonely roadside place at midnight, where the story said a truck driver's ghost would ask for a match.

To be continued…..

Prof. Tushar Prabhu joined IIA, Kodaikanal, as a Research Scholar in 1973. Following a job advertisement in 1975, he joined IIA as a Research Associate and moved to the Koramangala campus in 1976. His research interests are novae, supernovae, and galaxies in the local universe. During data collection and analysis at VBO, he contributed to improvements in data quality, digital data analysis, and facility development. Beginning with the 2.01-m (Himalayan Chandra) Telescope Project at Hanle, he devoted most of his time to facility development and operation of the Indian Astronomical Observatory, Hanle. He was also associated with the ARIES 3.6 m telescope project through its fabrication, installation, and time allocation since its early days. He retired from IIA as a Senior Professor in 2014 and lives in Bengaluru.



Skychart August 2025: (As on Aug 15, 2025. 20.00hrs Bangalore)

August 2 - Saturn at Opposition. Saturn will be at its closest distance to Earth, with its surface completely illuminated by the Sun. It will shine brighter than at any other time this year and will be visible throughout the night. This is the prime opportunity to observe and photograph Saturn and its moons. Using a medium to large telescope will enable you to view Saturn's rings and some of its brightest moons.

August 12, 13 - Perseids Meteor Shower. The Perseids is among the finest meteor showers to witness, with the potential to produce up to 60 meteors per hour during its peak. Originating from comet Swift-Tuttle, discovered in 1862, this shower is known for its many bright meteors. The event occurs annually from July 17 to August 24, peaking this year on the night of August 12 and the morning of August 13. The waxing crescent moon will dip below the horizon early in the evening, ensuring dark skies for optimal viewing. The best time to watch will be after midnight from a location away from city lights. Although the meteors will appear to radiate from the constellation Perseus, they can be seen across the entire sky.

August 19 - Jupiter at Opposition. Jupiter will also reach its closest point to Earth, with its surface fully illuminated by sunlight. It will be at its brightest this year and visible all night long, making it the ideal time to observe and photograph Jupiter along with its moons. A medium-sized telescope will help you see some details in Jupiter's cloud bands, while a good pair of binoculars can reveal its four largest moons as bright dots flanking the planet.

This is one of my favorite paintings as it expresses the beauty of light within the dark beyond.

Art by: Tulip Ray, Junior Research Fellow (JRF), IIA.

Solar Frontiers: A Conversation on Space Weather and Scientific Growth

With Prof. Dibyendu Nandi

Prof. Dibyendu Nandi earned his PhD in 2003 from the Indian Institute of Science (IISc), Bangalore, where he focused on modeling the solar magnetic cycle. In 2008, he joined as an Assistant Professor in the physics department at the Indian Institute of Science Education and Research (IISER) Kolkata. He chaired the Aditya-L1 Space Weather Monitoring and Prediction Committee and is co-investigator of the Solar Ultraviolet Imaging Telescope (SUIT) onboard the Aditya-L1 spacecraft. Currently, he is a Professor of Physics and Head of the Center of Excellence in Space Sciences India (CESSI) at IISER Kolkata. He is also the President of Commission E4 of the International Astronomical Union and Chair of the Public Outreach and Education Committee of the Astronomical Society of India. He received several awards, including the Karen Harvey Prize of the American Astronomical Society-Solar Physics Division in 2012, the Modali Award of the Astronomical Society of India in 2018, and the Asia-Pacific Young Career Award in Solar Physics in 2019. In 2024, he received the prestigious Prof. Peraiah Foundation Award from the Indian Institute of Astrophysics (IIA) for his contributions to the field of theoretical astrophysics.

Raveena: First of all, congratulations on receiving the Prof. Peraiah Foundation Award. Would you like to share some of the major research highlights that led you to receive this award?

Dibyendu: Well, frankly, I don't know which research highlights were exactly picked up. I have worked in a couple of different domains. But I think my most valued contributions are in understanding the physics of predictability of the Sun's magnetic cycle and also, more recently, the development of computational modeling capabilities in India for space weather forecasting. So, if we talk a little bit about the first aspect, i.e., solar cycle predictions, as an analogy, you can think of terrestrial weather or climate prediction; it is very challenging. You can't predict weather beyond a couple of weeks because it is inherently a non-linear and turbulent system, but you can predict climate within some limits of uncertainty because you are dealing with large spatio-temporal averages whose predictability emerges out of a complex system. You have a better handle on physics-based prediction of climate over timescales of years and perhaps even decades within certain uncertainties than predicting the exact temperature or rainfall at a specific location, say, a month from now!

The challenge of such predictions, essentially, is two-fold. One is that we are dealing with a fluid dynamic system, which is highly stochastic and has turbulence like there is turbulence in the ocean and the atmosphere. This has been understood well in the context of weather predictions on Earth for a long time. Surprisingly, the Sun is not very dissimilar in terms of the basic mathematical equations underlying the fluid dynamic system, except that the Sun is a plasma system and we have to invoke magnetohydrodynamics. So, overall, beyond the usual set of equations that we use, like the Navier - Stokes equation and the energy equation, to describe a fluid dynamical system on Earth, you also have to deal with the magnetic field evolution equation, which is the induction equation.

In case of the Sun, the bigger problem is observations. For example, if you allow a theorist to simulate an elephant, they will fit it with 'N' number of parameters, but that model may completely fail to predict how an elephant wriggles its tail unless the model has imbibed that understanding.

Picture 1: Dibyendu Nandi with DOOT Team

For forecasting a dynamical system, you need to have well-constrained models, which implies that you have to assimilate data continuously. For Earth, forecasting is enabled by multiple observables, such as thermodynamic variables, humidity, wind speed, and direction. For the Sun, it's more challenging because the magnetic fields of the Sun are being produced in its interior through interactions with plasma flows, and those processes are not visible to us. Helioseismology allows you to map some large-scale flows but not all the flow components. We have to deal with these challenges and construct data-assimilated predictive models of solar magnetism through intelligent assumptions that are useful as predictive tools on the one hand, and advance our knowledge of physical processes in the Sun's interior on the other. This is a challenge very close to my heart.

I got into this field when this was a very controversial topic with diverging predictions from diverse physics based models. In fact, my first paper on predictions was not about predicting the sunspot cycle; rather, it was about understanding the underlying physics of predictability of the solar cycle and explaining how different assumptions can lead to different results. Our research has answered various important questions in this context. First of all, can you predict the Sunspot cycle? If yes, how long into the future can you predict it? And then, what are the important properties that you need to measure observationally and provide as inputs to solar dynamo models for making accurate forecasts? So, I started with that, and my first paper in this field was in 2007. I made the first forecast in 2018, 11 years after trying to understand the predictability of the Sunspot cycle! Our forecast for Sunspot cycle 25, the currently ongoing cycle, is that it would peak in 2024 and that it would be a moderate to weak cycle, stronger than the previous cycle 24. When we made this forecast in 2018, the community was expecting a much weaker cycle compared to the previous one. This perception was based on sequential cycles of decreasing amplitudes over the past several decades. People often look at a curve and think that I can just extrapolate it. That's the worst thing you can do in complex, dynamical systems, particularly ones that are highly non-linear and stochastic. I'm not so worried about how exactly right or wrong our forecast would eventually turn out to be, but I'm more in this to understand the physics that allows for forecasting stellar activity. That is something that drives me. I think being able to make the right forecast is a bonus, and failure always teaches you more.

Raveena: In predicting the Sunspot cycle, what are the major instruments or observations you look for that validate these predictions?

Dibyendu: If you look at the equations that determine how the Sunspot cycle originates and evolves, it has certain parameters related to the plasma flows inside the Sun. Of course, you need to be able to constrain the plasma flow. We have some handle on that from the field of helioseismology, which looks at oscillations on the Sun's surface to figure out the large-scale plasma flows in its interior. Since we're trying to predict magnetic fields, you also need to have good observations of the magnetic field itself. You should correct your models as you run them forward in time with magnetic field observations. In terms of magnetic field observation, the primary input required in forecasting models is the large-scale dipolar field of the Sun, near the minimum of the previous Sunspot cycle, for which the polar radial fields are a good proxy. Using these, you can forecast the next Sunspot cycle amplitude. All the satellites that we have around the Earth and the ground-based observatories are looking at the ecliptic plane, which means the projection effect does not allow you to observe the Sun's polar field very accurately. So, sending a mission out of the ecliptic to observe the Sun's poles is the next great frontier for solar physics.

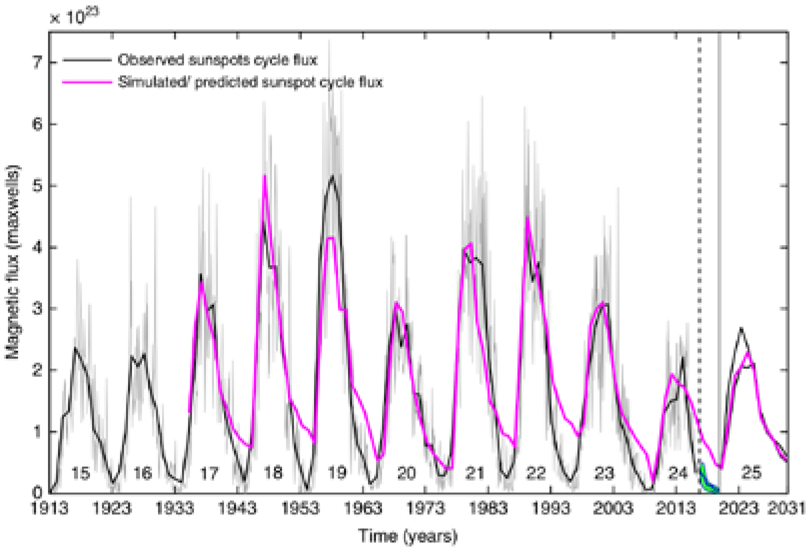
Chandan: What inspired your decision to pursue a career in astronomy, particularly in solar physics?

Dibyendu: This is a very popular question; unfortunately, I have a very bad answer to this question. Until class 12, I didn't know whether I was doing physics or chemistry. I entered Presidency College in Calcutta to pursue a BSc in Chemistry. I survived there for one month, and then organic chemistry and other such things hit me, and I quickly escaped. People told me that if you don't understand organic chemistry, you should not be doing chemistry; you're bad at it. Then, I moved to St. Xavier's College for a BSc in physics and IISc to

Picture 2: Dibyendu Nandi delivering an outreach talk at the Victoria Memorial Hall Kolkata in an astronomy night-out at the city organized by BITM, Kolkata and Indian Council of Science Museums and CESSI

do my integrated PhD. I didn't have a clear idea of what I'd be doing. I wasn't one of those kids who looked at the stars and got excited, thinking, "I'm going to be an astronomer." I was born night blind. So I didn't know what I was going to do. In fact, it was more of a matter of eliminating certain fields. In the set of circumstances I was in, things like nanoscience and material science were considered to be very hot topics at that time, and now they are as well. I was told that astrophysics is useless. But I chose to do astrophysics. I was told by my astrophysics friends, "Why do solar physics?" that it's the oldest astronomy that people have been doing since Galileo's time. Galileo started observing Sunspots around 1611. Everything has been figured out, and it's a dead field. However, I liked the fluid and magnetohydrodynamics course taught by my to-be PhD supervisor Arnab Rai Choudhuri. I liked the enigma of magnetic fields. I figured as long as I am enjoying what I am doing, I might end up making some useful contributions.

Now, that is luck, also accidental. I would say that whatever you're doing, just do it well. Try to be the best in that field. And you'll be fine. I mean, don't worry about my field being so hot. What is hot or what is the hottest evolves with time. Right now, suddenly, solar physics is booming. The reason it's booming is because this whole space weather angle has come up right now after we started sending satellites. We have realized that solar activity has a big influence on satellites. Geomagnetic storms can impair radio communications, satellite networks, defence and GPS navigation networks, civil aviation, and a lotof sectors. In my thesis, the topic of space weather never appears, even once! But now, I have played a significant role in pioneering the field of space weather assessment and forecasting in India and defining the direction of space weather research globally through my capacity-building roles in various international organizations. I am also now nucleating, with several others, the new field of star-planet interactions – which seeks to understand the impact of stellar variability on exoplanetary environments and habitability. So what happens to your field, to some extent, can be influenced by you if you're good enough. And if you're happy doing what you're doing and you're doing it well, I think that's the best reward you will ever have.



Picture 3: Prediction of Sunspot Cycle 25: The simulated Sunspot cycle from a solar dynamo model (magenta curve) is compared with the observed sunspot activity represented by unsigned magnetic flux (black curve). (For details, see Bhowmik & Nandi 2018, Nature Comunications

Chandan: As the Kodaikanal Solar Observatory celebrates 125 years, would you like to share any stories or memories associated with that observatory?

Dibyendu: Historically, when you look at the Kodaikanal Solar Observatory (KoSO), in any branch of astronomy, it is one of the first observatories on Indian soil. So it has a rich history and tradition. The long-term observational data has produced important constraints on the secular behavior of the Sun.

The KoSO is very significant in my life. When I was a PhD student, a big international conference took place at the KoSO, and there were a lot of international scientists from all over the world. Of course, we had a wonderful time. More importantly, for my career, I met my future postdoctoral supervisor there, Richard C. Canfield, from Montana State University. He was from the United States. He was a well-known person in solar magnetic field observations. I was doing only theory and modeling. However, I had a lot of conversations about solar activity and magnetism in general with him while he was in

Kodaikanal. After one year, he emailed me and basically said something to the effect, “Hey, Dibyendu, I have a postdoctoral position open in observational areas of solar magnetic fields. Would you be interested? I know you’re doing theory, but your knowledge of MHD (Magnetohydrodynamics) theory would be helpful. So would you like to apply for this position?”. I told Arnab, look, this has happened, and I have to finish my thesis quickly. I applied and got the position. So the Kodaikanal visit led to this association, which landed me my first postdoc without really looking for it. So, yeah, that was Kodaikanal Observatory. I would love to go back again.

Raveena: As you started your research as a solar astrophysicist, could you briefly describe how and why you transitioned from solar physics to space weather science?

Dibyendu: First, a caveat! It’s important that you have enough expertise in one area and make primary contributions in that area so that people recognize them. Working in three or four different fields but not being recognized as an expert in any of them is not necessarily good for your career. Your recognition and primary association of people will come from a few domains in which you are considered an expert. So in that sense, I am considered an expert in understanding the origin and evolution of solar magnetic fields. When I arrived back in India, no one was working on space weather forecasting models. I wanted to start something new, and it took me a decade of investment to develop globally competitive space weather expertise and models. I did this because no one was doing it, and it was to become – as you all know now – the most socially relevant astronomical research in the world.

One good thing about doing a postdoc in a completely different field, that is observational solar physics, having done my PhD in theory, was that it opened my eyes to the power of observations. And space weather is all about observations of the near-Earth space environment and being able to forecast it. When I came back to India, this field was almost non-existent. Now I have to deal with working between monitoring and forecasting. Monitoring is when you observe something happening in real-time and issue an alert saying that today’s temperature is going to be extreme or, right now, heavy rainfall is going on in Bangalore. As opposed to that, you may figure out that next week there will be heavy rainfall. This is forecasting, which requires modeling. Why? Because you have to advance certain equations into the future in time to be able to forecast. So, while you can make empirical and statistical forecasts based purely on observations, you must also create theoretical and data-driven models to make dynamic forecasts of a dynamic system. The idea and the possibility is that you can translate your knowledge into a domain that is useful for space-based technologies, government agencies, and satellite operators, which are bringing in the money and are the driving force behind even the basic and fundamental research going on in the field. So, when I came back, I took up the challenge to develop space weather forecasting models at the Center of Excellence in Space Sciences India (CESSI), IISER Kolkata. And today, I’m happy to note that we can forecast the possibility of solar flares. We have the first models from India that can forecast geomagnetic storms induced by the impact of coronal mass ejections (CMEs) on the Earth. And we can, in fact, also forecast how a solar storm would affect satellites. For example, we have figured out what happened to the Starlink satellites last year when almost 40 of them catastrophically deorbited, literally falling out of the sky after being hit by geomagnetic storms. So I have advanced my own knowledge, essentially building upon my expertise in MHD theory, modeling and observations to develop new space weather models from India, which can help protect global space assets. So, I’m pretty happy that I took that leap. Of course, I could not have done this alone, and many wonderful PhD and undergraduate students, and some collaborators, shared in my adventures.

Raveena: As you mentioned about the 40 Starlink satellite

Picture 4: A picture after a recent PhD viva voce at CESSI

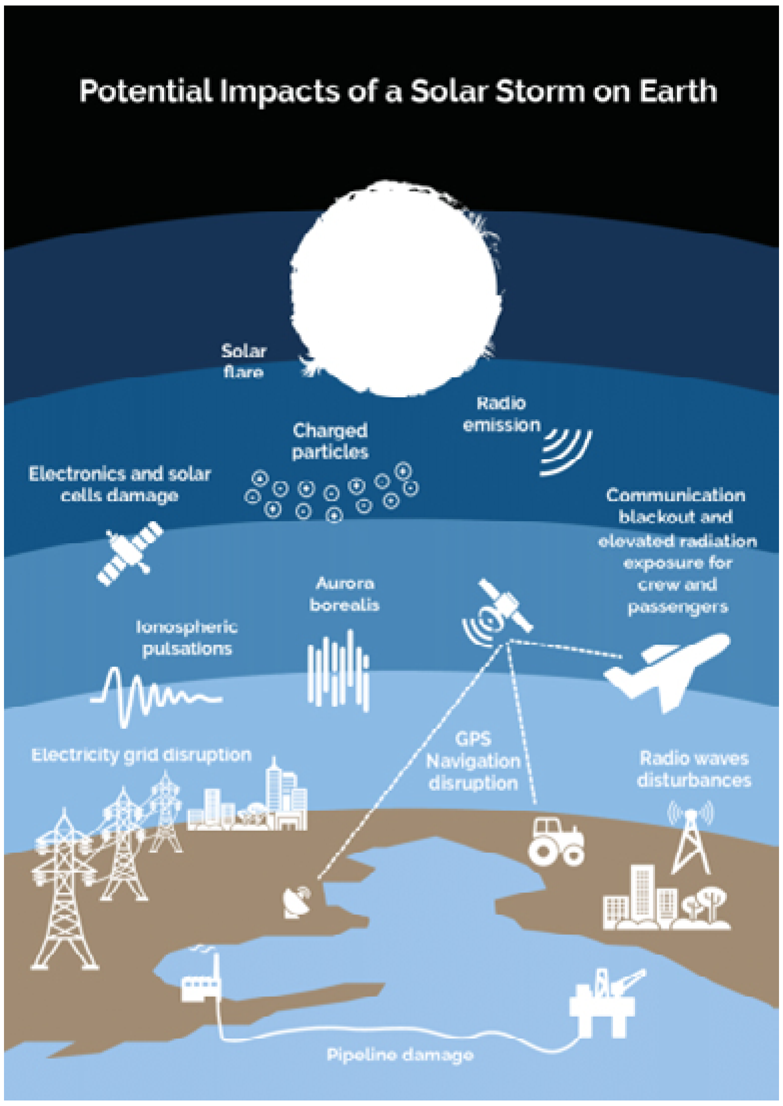
failure in Feb 2021, there was no high-class solar flare. So what was its reason?

Dibyendu: Right, it was not a solar flare that downed the satellites. In fact, there were three back-to-back CMEs, but they were quite moderate. What we found was that multiple storms hitting the Earth's magnetosphere sustained a perturbed state over four to five days, leading to atmospheric heating and enhanced drag on the Starlink satellites that had just been injected into very Low Earth Orbit. This unforeseen drag led to orbital decay and loss of the satellites. Curiously, SpaceX follows a certain regiment. It injects the Starlink satellites at very low earth orbit, between 200 and 300 kilometers. And then they do some housekeeping to check the health of the satellites. The healthy ones are boosted up to higher orbits. However, the disturbed space environment and enhanced drag essentially doomed most of the satellites before they could be boosted up.

We basically figured out the physics. The lower you are, the larger the density, so you have more friction. When you have a geomagnetic storm, the outer atmosphere gets heated and expands. So, the satellites encounter higher and higher densities. In this case, we have three geomagnetic storms because of three CMEs. So you're sort of going through this relatively denser medium for a sustained period that SpaceX did not plan for, which essentially takes away energy from the spacecraft. It is kind of a catastrophic scenario because the lower you come down in altitude, the higher and higher densities you encounter. So, there is no recovery. The more friction, the more energy loss, hence more orbital decay, and then essentially, the satellites fall through the atmosphere and burn up. This is what happened to the SpaceX Starlink satellites.

Raveena: What is the status/standing of the space weather forecast program in India? Briefly tell us about your vision for the improvement in this regard.

Dibyendu: I would say, the field of space weather in India is still nascent in the sense that we have isolated expertise in certain areas. We do not have that many people in this country working in solar physics and space weather modeling and prediction. We certainly need more computational modelers

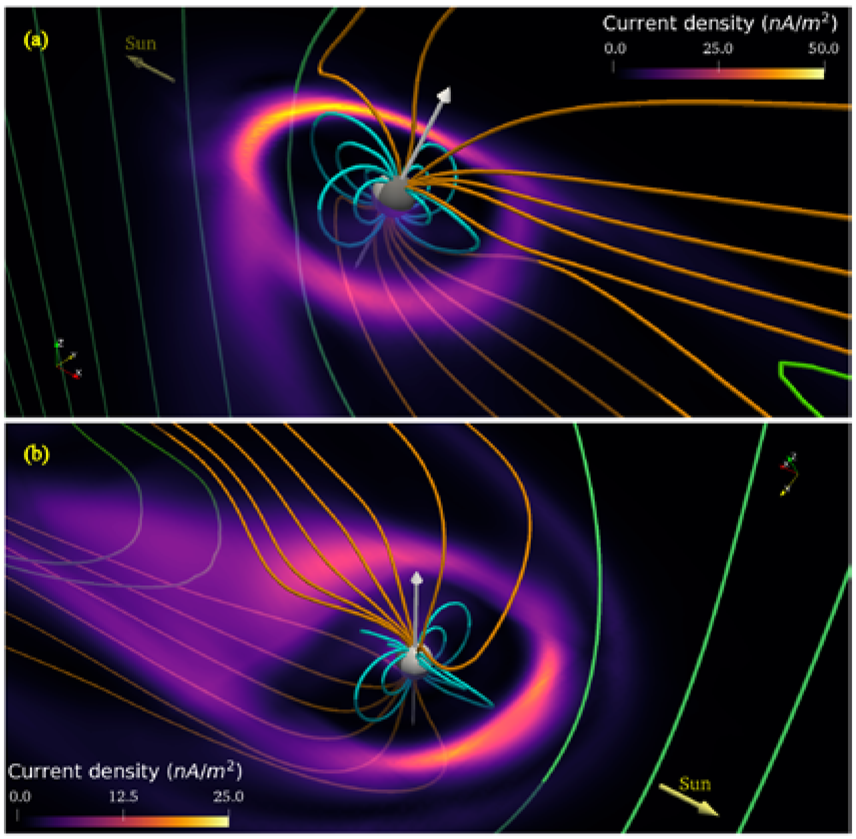


Picture 5: Illustration of extreme space weather events and their potential impacts on modern technology and infrastructure.
(Source: www.swsc-journal.org/articles/swsc/full_html/2021/01/swsc200032/F1.html)

and space weather researchers who can forecast the state of the near-Earth space environment. Furthermore, we need dedicated facilities to monitor space weather to know the current conditions, the origins of space weather and quantify its impacts on our space environment. That's something that we need to invest on, in terms of capacity, facilities and human resources. Otherwise, we shall always remain followers of more developed space nations and become dependent on models created by others. The thing that happens in India is, we don't crosstalk across disciplines very well. I don't find many common avenues for the interaction of solar physicists with, for example, ionospheric scientists, people working on geomagnetic fields, or upper atmospheric scientists. There are not many cross-disciplinary interactions as much as what happens in, for example, Europe or the United States. I think this also has to happen because you're not looking at a star or a planet in isolation. You're looking at the birth of solar activity, you're looking at its manifestations near planets, and eventually, its impacts on human technologies. I think you need people with multiple areas of expertise to come together, which is not happening very well yet.

Although it's recognized that space weather is very important, there is no dedicated center in India like the National Oceanic and Atmospheric Administration (NOAA) Space Weather Prediction Center, the UK Met Office, and the European Space Weather Unit (ESWW). We are still quite slow to move into this domain regarding creating or hiring expertise in space weather. I think Indian Space Research Organization (ISRO) needs to build up teams of scientists to scale this kind of research which is of rich societal relevance. National Aeronautics and Space Administration (NASA) or the European Space Agency (ESA) does this with dedicated funding and groups. There will be more employment for all the PhDs that have been produced in all the institutions, specifically space science institutes in India, if our space agency and national agencies realize that it is important to assimilate the human resources we are training instead of losing them. I mean, if you look at recruitments, every year, roughly one or two recruitments happen on average in every Department of an Institute, whereas look at the number of PhD students these Departments are producing. How many? Maybe 10-15, right? Where does the rest go? That problem exists in India. The national agencies, government agencies, and industries should hire scientists with a PhD. That ecosystem has not been catalyzed in India. We are digressing, but eventually, it's all connected. I think that also has to happen, and I see myself playing a role in catalyzing this, at least in my limited domain.

Another aspect is that computational modeling is not very well developed in India, particularly in space sciences. In weather and climate, particularly after the Ministry of Earth Sciences was established, rapid advances in computational



Picture 6: Simulated 3D visualization of Earth's magnetosphere from a vantage point just above the ecliptic plane. Magnetic field lines are color-coded: Earth's polar open field lines (orange), closed inner magnetospheric lines (cyan), and the interplanetary magnetic field (IMF, green). For more details, Roy & Nandi 2023, ApJL, https://doi.org/10.3847/2041-8213/acd77c

modeling for terrestrial climate, weather, cyclone forecasts, and monsoon predictions have happened. However, modeling for space sciences has not taken off in India because it is not easy, because it takes long and sustained training and because we have targeted the easy kind of science. I find an equivalent to this in the domain of instrumentation, which is also challenging, with limited expertise within India. We need vigorous, sustained hiring of expertise in computational space sciences, and space science instrumentation and create facilities to sustain these expertise. Otherwise, we shall always remain a nation of scientists that is using data from missions and observations and computational models created by others.

Chandan: Recently, India successfully launched the Aditya-L1 spacecraft. Could you tell us how it can help with space weather forecasting?

Dibyendu: Aditya-L1 will primarily observe solar activity and the near-Earth space environment for the creation of scientific knowledge. There are question marks regarding how quickly you can get the data for space weather monitoring and forecasting purposes. I mean, let's say a spacecraft is recording solar activity that is ongoing, but I do not get the data near-real time as I get from NASA SDO, GOES, WIND, ACE or DSCOVR spacecrafts; then there is no immediate assessment possible, and there is no predictive value. So, what is the Aditya-L1 for? Aditya-L1 has many eyes. It has multiple instruments, both remote-sensing and in-situ capabilities. It will be very good at uncovering the physics of the phenomenon underlying solar activity. If all the instruments function as envisaged, you can create an end-to-end understanding of how the solar transients that eventually generate space weather originate in the Sun and how they manifest near the Earth, that is, establish causality. This is an important aspect of scientific research. For this to be achieved, instrument data needs to be made easily and meaningfully accessible to the wider scientific community, just as NASA and ESA missions have done.

Raveena: Having a very successful research career spanning over two solar cycles, what advice would you like to give to the PhD students which will help them manage both work-life balance and excel in their fields and also maintain the sanity required during PhD?

Dibyendu: The last bit is the most important. Have fun.

Do not spend your whole time in the lab. While you are a PhD student, you must ensure that you have other avenues of happiness. Ensure that your happiness doesn't come only from your work. There will be frustration at work. There will be some years when you don't publish. There will be some years when you are sitting somewhere trying to figure out a bug in your code or cleaning up some data, which is so problematic that it makes you go nuts. At that point in time, it is important that you can fall back upon friends, other hobbies, or stuff that excites you and gives you happiness. It is important to have a balanced life and not to put all your eggs in a single basket.

Also, if possible, rise and challenge yourself over and beyond what your supervisor is pushing you to be. In fact, your supervisor should not be pushing you. You should be pushing yourself. Maybe you should be pushing your supervisor to a bigger challenge! But to achieve that, you should do a lot of reading—the one thing I did as a PhD student that helped me. I used to subscribe to all the journal table of contents emails and the arXiv postings in my field. I would go through them every day to check for any new advances in my domains of interest. In fact, I still read a lot and pain my students with random papers and ideas at random hours! As a student, every week, I would read something like 5-10 papers. It helped me in two ways. One, it improved my writing skills. I could figure out how to write papers very well. And I think you should also be reading papers not just in astrophysics but also in general journals such as Science, Nature, PNAS. It's important that we know what kind of work is getting in there and why. Second, this reading helps you understand the field over and beyond what your supervisor tells you. All of us have prejudices and finite expertise. So, this self-learning eventually makes you independent of your supervisor's mind, which I think is a great thing. When you leave, ideally, you should be your supervisor's colleague, someone s(he) can lean on in equal measure as you have on them.

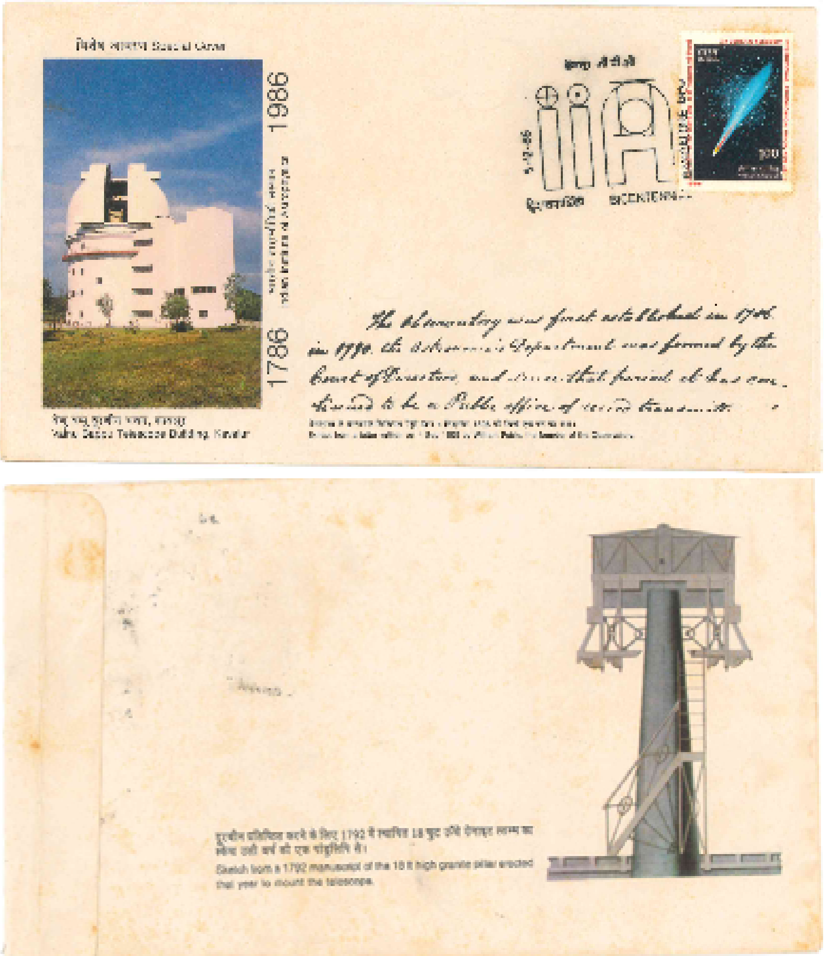
Raveena: That's a wonderful message. Thank you for your time!

Picture 7: Former Chief-editor Rishabh Singh Teja (left) handing Dibyendu Nandi the 8th Issue of DOOT magazine.

Philatelic Memorabilia

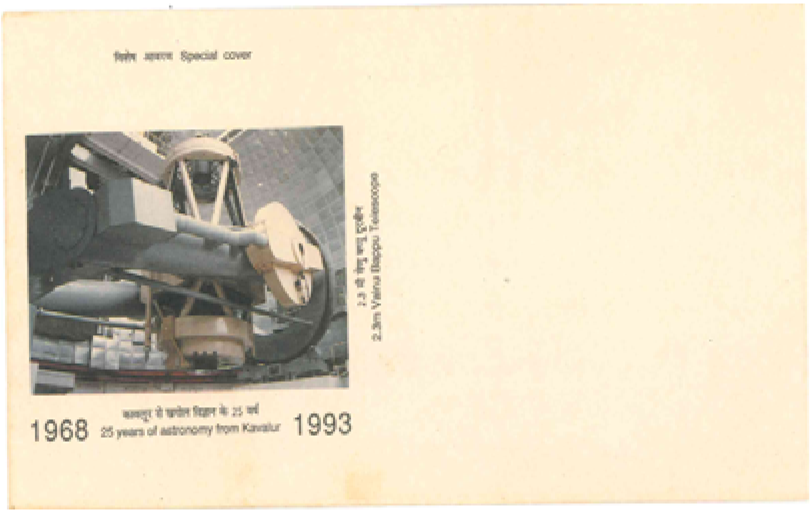
Prof. U. S. Kamath

The history of the Indian Institute of Astrophysics (IIA) can be traced back to the year 1786, when observations began at the Madras Observatory. So, the bicentennial year – 1986 – marked an important milestone in our journey. By a happy coincidence, the periodic comet Halley reached its perihelion that year. The old special cover shown below (Picture 1) marks this double celebration. Actually, the postage stamp was issued in 1985 to mark the 19th General Assembly of the International Astronomical Union (IAU) held in New Delhi. It was during this event that the IAU honoured Prof. Vainu Bappu by naming asteroid 2596 after him. A pictorial cancellation, unique to the depicted theme, is used on such special covers instead of the regular round postmark.



Picture 1. Special cover with pictorial cancellation (top) marking the bicentennial year 1986 at the Madras Observatory, and its back cover (bottom).

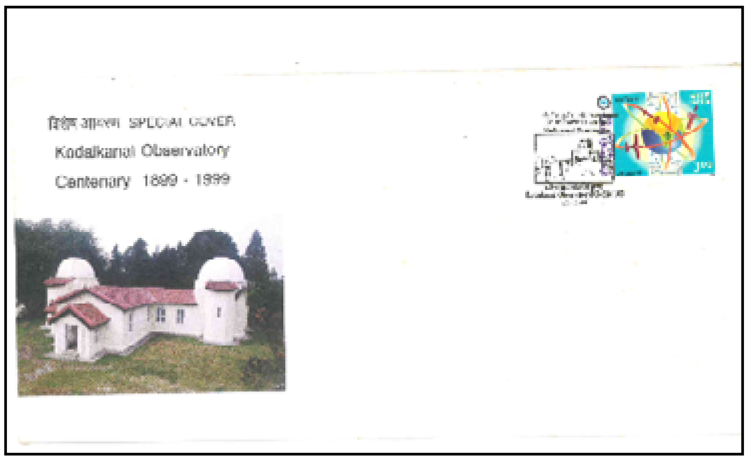
Here is another special cover, issued in 1993 to commemorate 25 years of astronomy from Kavalur. Prof. Vainu Bappu initiated a site search in South India in 1962 and identified a potential site near Kavalur village in the Javadi Hills of Tamil Nadu. Based on the topography of the area, it was expected to have good seeing conditions. This was confirmed by measurements using a locally made 15-inch telescope, which began in 1968. Depicted below is the blank (unstamped) variety of this cover that I have (Picture 2).



Picture 2. Special cover issued in 1993 to commemorate 25 years of astronomy from Kavalur.

Charles Michie Smith was the Government Astronomer for Madras. He replaced N. R. Pogson as the Director of Madras Observatory in 1891. Smith took up the initiative to shift the observatory to Kodaikanal in 1899 and continued as the director of the Kodaikanal Observatory. The following special cover (Picture 3) commemorates the centenary of the Kodaikanal Observatory. A nice pictorial cancellation is embossed on the appropriately chosen thematic stamp ('Jai Vigyan').

Commemorative postage stamps are issued to mark important events, to honour distinguished personalities or to propagate social messages. Practical considerations dictate the number of issues and the quantity printed per issue. It is often not possible to accommodate requests for new stamps to be



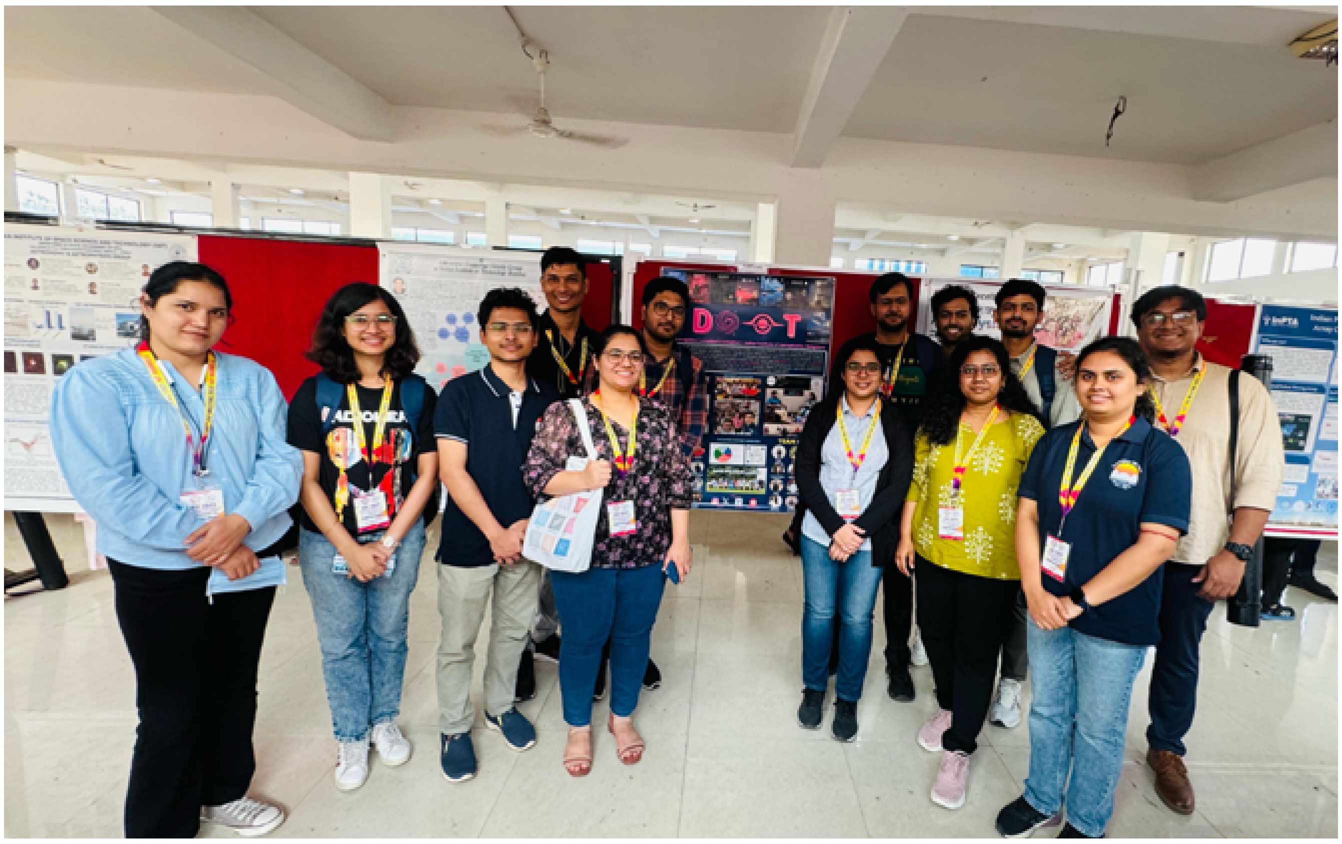
Picture 3. Special cover commemorating the centenary of the Kodaikanal Observatory.

issued. Then, the state or regional postal authorities issue special covers for that purpose. The cover and cancellation are artistically designed. In the above cases, the stamp chosen to be put on the cover conforms to the theme, thus adding to the overall beauty.

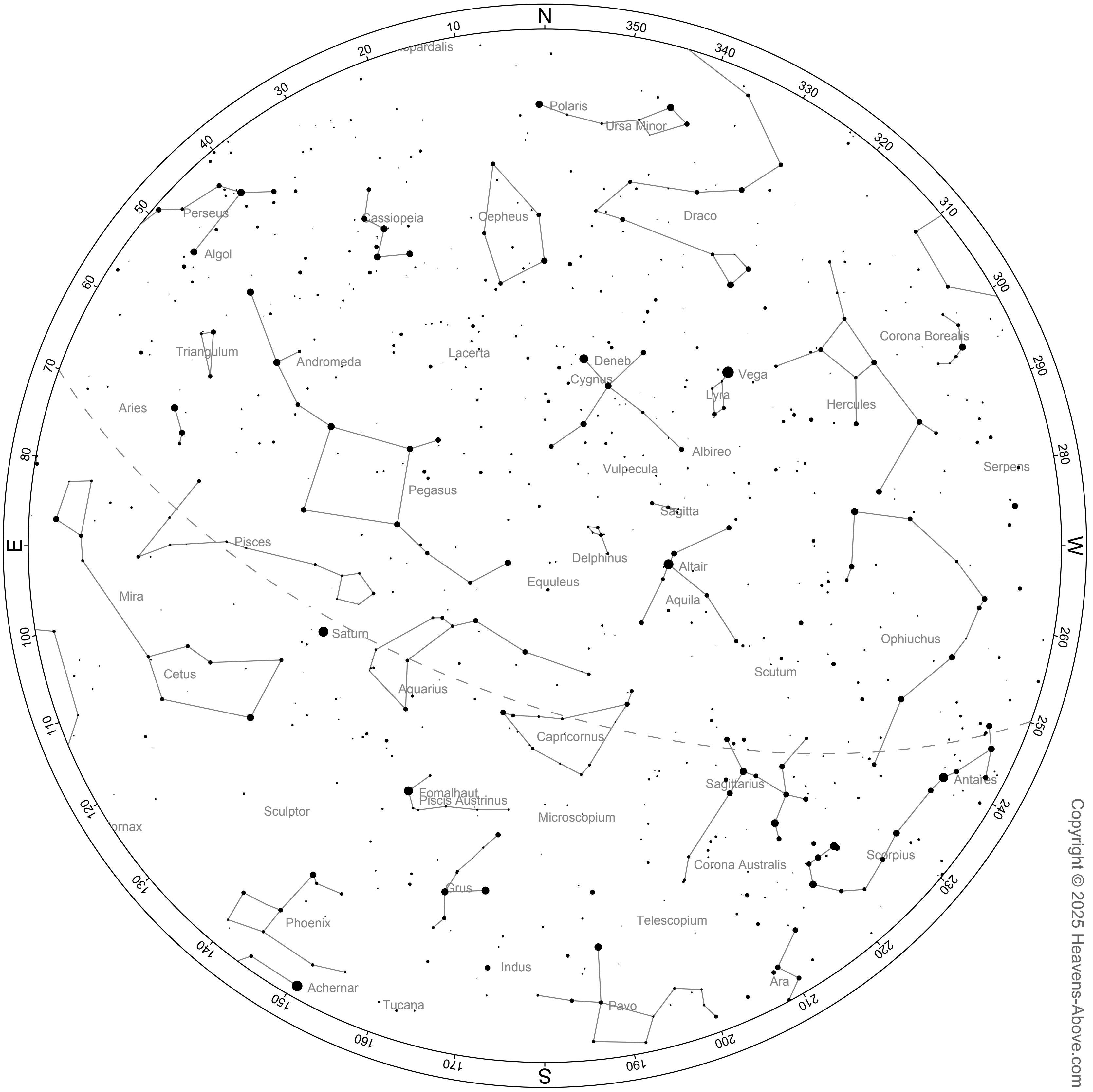
There are some other IIA-related philatelic items, like the cover on the Evershed effect, that I do not have in my collection. Below is the cover of a letter written to me by a friend at IIA (Picture 4). The postage paid is marked with a franking instead of a paper stamp. The rectangular slogan mark shows the Vainu Bappu Telescope (VBT) at Kavalur.

Picture 4. An old letter to Prof. Kamath marked with a franking on the right and a rectangular slogan mark on the left picturing the VBT.

Prof. Umanath S. Kamath is a Professor at the Indian Institute of Astrophysics. His research interests include coronal lines and dust formation in outbursting novae, inter-class relationships among cataclysmic variables, evolution of outbursts and orbital phase variations in symbiotic stars, imaging of star-forming regions, and infrared instrumentation.



Participation of DOOT members in the Astronomical Society of India (ASI) meeting 2025 held at NIT Rourkela, Odisha.



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Skychart October 2025: (As on Oct 15, 2025. 20.00hrs Bangalore)

October 21, 22 - Orionids Meteor Shower. The Orionids Meteor Shower will occur on October 21 and 22. This average meteor shower can produce up to 20 meteors per hour at its peak and originates from the dust particles left by comet Halley, which has been observed since ancient times. The shower takes place annually from October 2 to November 7, with its peak this year happening during the night of October 21 and the morning of October 22. However, the full moon may hinder visibility this year, as its brightness will obscure all but the most luminous meteors. With some patience, you may still spot a few impressive ones. The best viewing conditions will be in a dark area after midnight, and while meteors will appear to radiate from the constellation Orion, they can be seen throughout the sky.


Image Credit: ESO/L. Calçada

Knocking on the Door of Our Galactic Neighbors : The Magellanic Clouds

Sipra Hota

Just like our human neighborhoods shape our daily lives, complete with friendly chats over the chai (tea) and getting information from the human CCTV—our cosmic neighborhood is just as important, but on a much bigger scale. The Magellanic Clouds, those cheeky cosmic siblings—the Large and Small Magellanic Clouds (LMC & SMC, respectively)—are our closest massive galactic neighbors. They may not borrow sugar or return our favorite kitchen utensils, but they offer a fascinating glimpse into the cosmos, reminding us that even in the vastness of space, we're never really alone!

This article is structured to provide a historical perspective and a concise understanding and concludes by highlighting the significance of studying these Galactic satellites.

History

Historically, the Magellanic Clouds have been known by various names and have guided sailors for centuries. The native people of the Sea Islands (situated along the southeastern coast of America) called them the Upper and Lower Clouds of Mist. In AD 964, a Persian astronomer named Al Sufi (Abd al-Rahman al-Sufi) described their position in the sky, and southern Arab tribes called them Al-Bakr, the "White Ox of the Southern Arabs." For centuries, they were also known as the Cape Clouds because they were prominent in the sky as ships approached the Cape of Good Hope. These clouds were crucial for sailors, helping them to navigate in the southern hemisphere without a bright star like Polaris in the North. Between 1519 and 1522, the Portuguese explorer Ferdinand Magellan led the first expedition to circumnavigate the globe. When his crew reached the southern hemisphere, they saw two cloudy patches in the night sky, which were later named Magellanic Clouds in his honor by European astronomers. Today, we call them the LMC and SMC based on their visible size. They are popular among amateur astronomers because they are relatively easy to spot on clear, nights in the southern hemisphere. The LMC can be found in the Mensa and Dorado constellations, while the SMC is in the Tucana constellation. The Magellanic Clouds were first recognized as stellar systems (Nubeculae Major and Minor) by Herschel in 1847, who identified 244 objects in the SMC and 919 objects in the LMC—their nature as the two external galaxies were first summarised by Cleveland Abbe in 1867 (you can find more historical information about the Clouds on the website judy-volker.com/StarLore/Myths/MagellanicClouds.html).

Magellanic System

The Magellanic System comprises two galaxies, the LMC and SMC, a connecting structure called the Magellanic Bridge, a gaseous tail trailing behind the clouds known as the Magellanic Stream, and a Leading Arm, as shown in Figure 1. The LMC and SMC are two nearby irregular, gas-rich dwarf satellite galaxies of the Milky Way, located at distances of about 50 kpc and 60 kpc, respectively (de Grijs et al. 2014; de Grijs & Bono 2015). The Magellanic Bridge consists of gas and stars, formed from a recent collision between the two galaxies around 200 million years (Myr) ago (Hindman et al. 1963; Irwin et al. 1985; Muller & Bekki 2007; Zivick et al. 2019). The Magellanic Stream orbits the Milky Way following the LMC and SMC orbital path, while its counterpart, the Leading Arm, first detected by Putman et al. 1998, is moving toward the Galactic disk (Lucchini et al. 2020). Both the Stream and the Leading Arm are tidal features created by interactions between the Milky Way, LMC, and SMC (Lucchini et al. 2020). The Magellanic Bridge, the Magellanic Stream, and the Leading Arm are the signature of the LMC and SMC interactions with each other and the Milky Way.

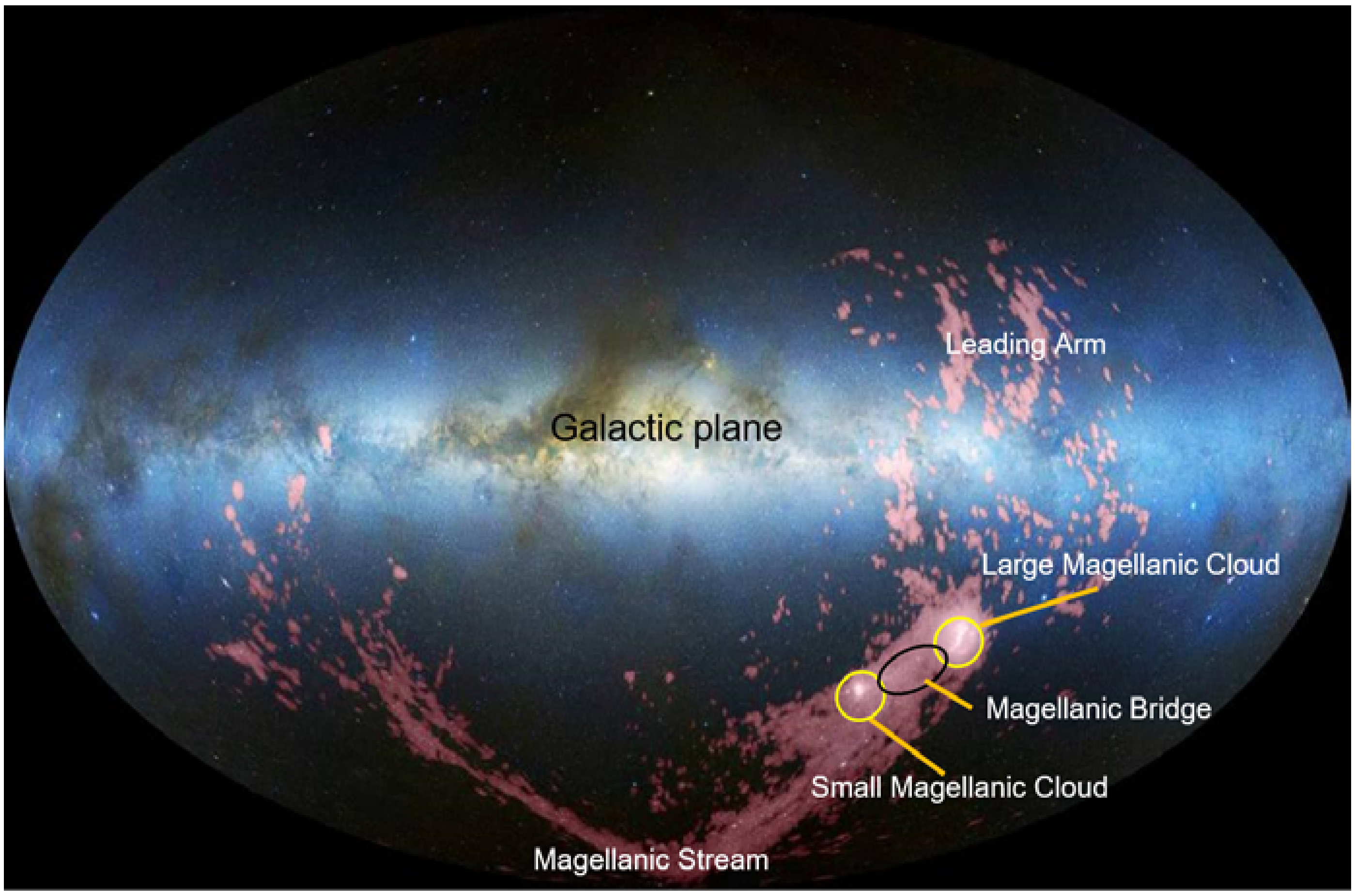

Figure 1: : A composite radio and optical image showing the Milky Way and the Magellanic System. The blue and white areas represent the Milky Way and the Magellanic Clouds. Red highlights hydrogen gas present in the Magellanic Stream, within the Magellanic Clouds' disks, in the Leading Arm and Magellanic Bridge. The plane of the Milky Way runs horizontally through the center of the image, while the Magellanic Clouds appear as bright spots toward the center-right, where the gas stream begins. Brown regions depict dust clouds within the Milky Way. (Image Credit: NASA/D. Nidever)

Figure 2: Infrared images of the LMC (left) and SMC (right) captured during the VISTA survey of the Magellanic Clouds (VMC). The LMC displays its bar and arm on the left, while the SMC on the right exhibits a triangular shape. The bright white spot at the far right of the SMC corresponds to the Galactic globular cluster 47 Tuc. (Credit: ESO/VISTA VMC)

LMC and SMC

The LMC is the third closest satellite galaxy to our Milky Way and the fourth largest galaxy in our Local Group (which is a collection of galaxies that includes our Galaxy). It has a prominent, off-centered, and warped stellar bar, along with a spiral arm (left panel of Figure 2). Supernova 1987A, the nearest supernova in recent years, was also located in the LMC. The mass and tidal radius (the tidal radius of a galaxy is the distance at which a star in a satellite galaxy gets pulled away from that galaxy and becomes bound to the galaxy it orbits) of the SMC are lower than those of the LMC. The SMC is considered the next closest dwarf galaxy after the LMC. The structure of the SMC looks ellipsoidal and is strongly stretched along the line of sight (Scowcroft et al. 2016). The SMC has a less noticeable bar (right panel of Figure 2) and an eastern extension known as the Shapley Wing (Shapley 1940).

Young and old stellar populations show different spatial distributions in the Magellanic Clouds. In the LMC, young stars have an irregular structure with spiral arms and tidal features, whereas old stars are more evenly and regularly spread out. In the SMC, young stars are concentrated in the central regions and the Wing, while older stars form a spheroidal or ellipsoidal shape. The LMC and SMC have experienced repeated interactions with each other. Observational evidence and simulations suggest that both are currently undergoing their first infall into our Galaxy halo.

Importance of the Magellanic Clouds:

According to the hierarchical model of galaxy formation (Figure 3), small galactic building blocks formed first and gradually merged to create larger galaxies over the lifetime of the universe. These early galaxies were metal-poor, similar to the Magellanic Clouds. As a result, the Magellanic Clouds are the best extragalactic targets for studying galaxy formation and evolution. The following properties of the Magellanic Clouds are significant attractions for astrophysicists to study them :

1. They are nearby dwarf galaxies, rich in gas.

2. One can obtain resolved stellar populations that range from young to intermediate to old stars, even using ground-based telescopes.

3. Their metallicity resembles that of the early universe.

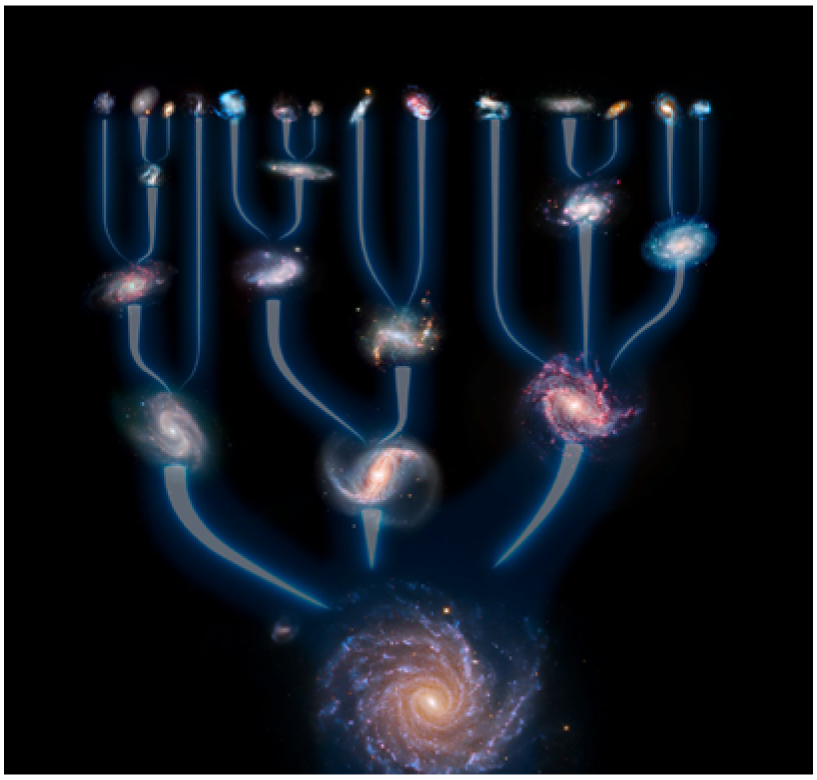

Figure 3: Hierarchical model of the formation of a large massive galaxy like the Milky Way. (Image Credit: ESO/L. Calçada)

4. They show active star formation.
5. The two clouds interact with each other repeatedly.
6. They are made in their first infall to the Mily Way.

These properties enable astrophysicists to understand how galaxy interactions can influence their formation and evolution, as well as the significance of interactions with the host galaxy. By studying the different stellar populations, researchers can gain insights into the effects of these interactions on the kinematics and dynamics of the galaxies.

Now that you have a better understanding of the Magellanic Clouds and their importance in extragalactic astronomy, you're ready to follow the ongoing research about them! These interesting dwarf galaxies are like the curious neighbors of our Milky Way, helping us learn how galaxies form and evolve over the time. Just as neighbors share stories and experiences, the Magellanic Clouds remind us how connected everything is in the universe. As researchers continue to study them, we can expect to uncover even more exciting details. So, stay tuned for the coming issues of DOOT, where we'll dive into the recent findings on the Magellanic Clouds—you won't want to miss it!

Sipra Hota is a Senior Research Fellow (SRF) at IIA working with Prof. Annapurni Subramaniam. Her research interests are extragalactic astronomy, Magellanic Clouds, star formation, and kinematics.

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COSPAR Workshop Chronicles: My First International Experience

Anjali Agarwal

On the evening of August 16, 2024, I was packing my bag for an unforgettable journey. While packing, one thought stood out: "I'll be picking up this bag outside the country!" Yes, you guessed it - I was about to start my first international trip and would love to share this experience with you.

During my second year of Ph.D. at the Indian Institute of Astrophysics (IIA), Bengaluru, I received the opportunity to attend the NASA-funded COSPAR (Committee on Space Research) Capacity Building Workshop (CBW) on Coronal and Interplanetary Shocks. The workshop was held from August 19–30, 2024, at Samarkand State University in Samarkand city, Uzbekistan. It all began about a few months earlier when I saw the announcement for this workshop in the INDUS (Indian Network for Dynamical and Unified Solar Physicists) newsletter. I was happy to see that the workshop was focused on one of the core topics of my Ph.D. research. But, I had several questions in my mind, so I approached my Ph.D. supervisor, Dr. Wageesh Mishra, for his advice. He resolved my confusion and encouraged me to apply for the workshop. He also told me he was invited to the workshop as a lecturer and could travel with his family. He advised me to start with my passport application immediately. Meanwhile, my father also talked to sir and discussed the usefulness of this workshop for me.

I applied for the passport and got it within a couple of days, and I was confident that it would be used soon. Meanwhile, I also applied for the COSPAR workshop by submitting various documents, including details of my ongoing research, a statement on the workshop's relevance to my future studies, and a recommendation letter from my supervisor. A few days after my application, I saw an email from Dr. Zavkiddin Mirtoshev, one of the organizing committee members, with the subject line, "Invitation for COSPAR CBW." I immediately shared the news of my selection with my supervisor. I also obtained permission from IIA to attend the workshop and applied for a Uzbekistan visa. Finally, we (my supervisor, his wife - Dr. Abha Pandey, their son - Atharv, and myself) started our journey from Bengaluru to Tashkent (City in Uzbekistan) via Delhi. In Delhi, we completed the immigration process, and I felt excited seeing the international travel stamp on my passport. Before boarding in Delhi, I spoke with my father, who reminded me, "In a new country, do all your work with sincerity and keep a pure heart." This stayed with me throughout the journey.

After a long journey, we reached Samarkand station; we were greeted by Mr. Abbos, a Ph.D. student from China who had come to pick us up on behalf of the organizing committee. He took us to the university where the COSPAR workshop would be held. There, Dr. Zavkiddin arrived to greet my supervisor, and I had the pleasure of meeting this thoughtful person. After settling in and refreshing ourselves, we ate some food that we brought from India and rested after that. In the evening, my supervisor introduced me to another lecturer from India, Dr. Nandita Srivastava, who is also his Ph.D. supervisor. I felt myself standing as a "third-generation" student with Sir and his supervisor.

The next morning, August 19, 2024, marked the start of the COSPAR workshop. I was filled with excitement, and soon, my supervisor introduced me to Dr. Natchimuthuk Gopalswamy from NASA - a highly respected figure in the solar astrophysics



Picture 1: (Left) A photo with Dr. Natchimuthuk Gopalswamy and Dr. Wageesh Mishra, along with his son Atharv during the special dinner. (Center) Group photo in the astronomical observatory, standing from left: Dr. Wageesh Mishra, Dr. Abha Pandey, Dr. C Kathiravan, Prof. Nandita Srivastava, and Myself. (Right) Ak-Saray Palace..

community. Despite his fame, Dr. Gopalswamy was calm, approachable, and genuinely committed to training the next generation of scientists. I also met other distinguished lecturers, Dr. Seiji Yashiro and Dr. Pertti Mäkelä (who later became my project guide during the workshop), both of them are NASA scientists.

The workshop began with a week of lectures, covering everything from the basics of the Sun to Coronal Mass Ejections (CMEs), radio bursts, and their connections with CMEs. We learned how radio data can be used to analyze shock speed. We had Python sessions to explore radio observations from the e-Callisto network of ground-based radio antennas worldwide. The week flew by quickly in this beautiful city, with its deep historical connections to India.

On Friday, August 23, after a coffee break, the organizing committee arranged a visit for participants and lecturers to the tomb of Amir Taimur, the 14th-century Turco-Mongol conqueror who once invaded India and established his empire in Delhi. The tomb is located near Samarkand State University, where he rests alongside his sons and mentor. The walls were adorned with gold, and I was reminded of India's history as the "golden bird". We also toured the Bibi-Khanym Mosque and then visited Siyob Bazaar, one of Samarkand's oldest and largest marketplaces.

The following day, on Saturday, Dr. Gopalswamy organized a special dinner with music for all of us, where local organizing committee members were honored with gifts. On Sunday morning, we toured the Kitob district. To reach there, we crossed a mountain, passing many fruit farms on the way, especially apricots and green apples, and entered a charming town with a very less population. There, we visited an ancient High Mountain Astronomical Observatories in Kitab Complex under the Uzbekistan Academy of Sciences built during the Soviet period for night sky observations. After lunch, we visited Amir Taimur's birthplace, the Ak-Saray Palace in Shahrisabz, where we saw a large monument of Taimur in the center of the palace grounds.

During the second week of the workshop, it was planned that six different groups would be formed, each working under one of six lecturers. I had the opportunity to work with Dr. Pertti Mäkelä, and it was a memorable experience. On the last day, I got the opportunity to present our group's analysis. This was my first experience presenting in front of an international audience. Though I was a little nervous, the presentation went well, as my supervisor told me later. After all the group presentations, the lecturers were honored with gifts from Samarkand State University. In the evening, we went to Registan Square to attend the international musical festival "Sharq Taronalari," an event held at this historic venue since 1997.

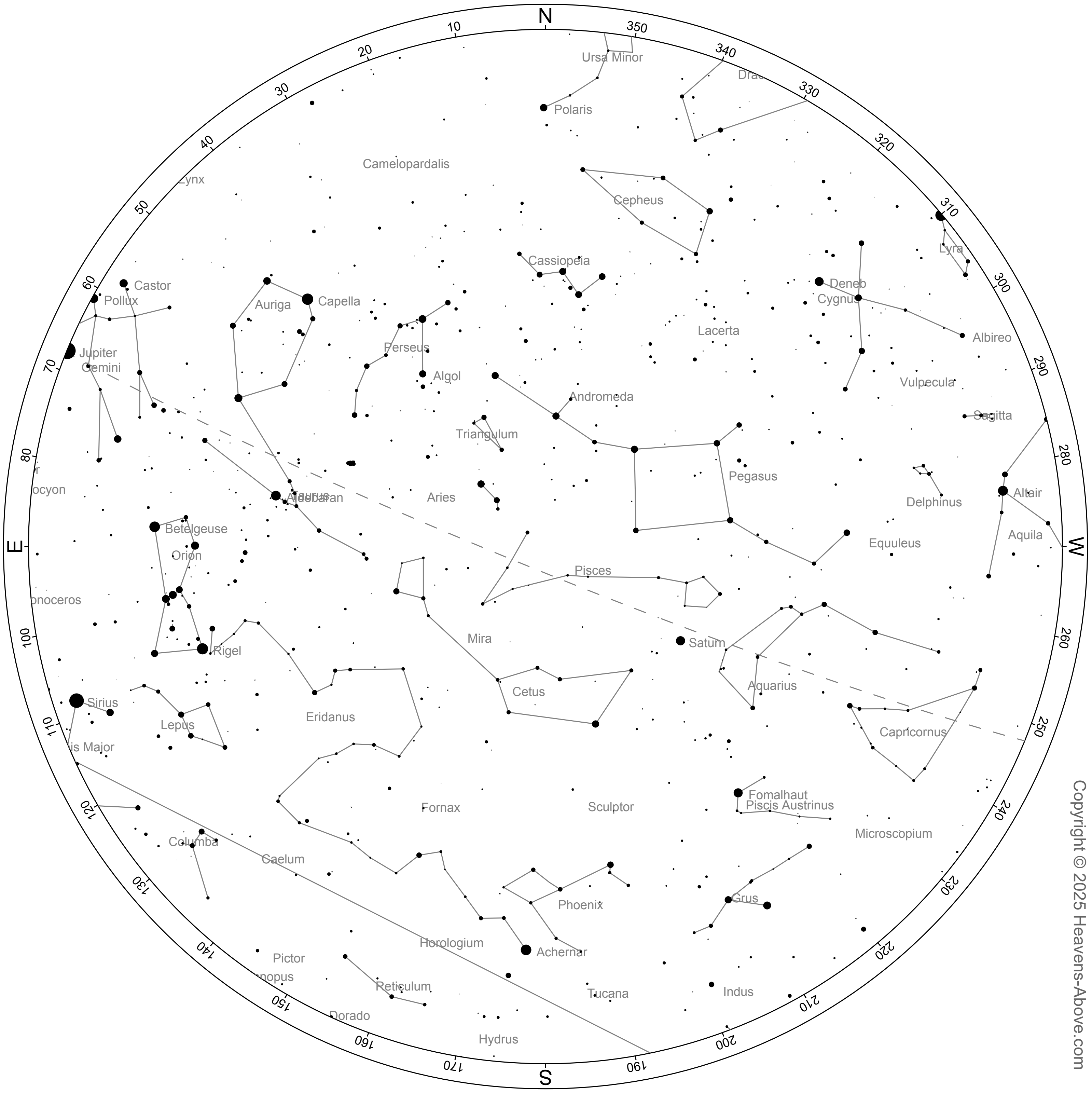
The next day began with a visit to the newly installed e-Callisto site in Samarkand and the nuclear lab at Samarkand State University. With the installation of e-Callisto, Uzbekistan is now on the world map for radio observations of the Sun from the ground. At the conclusion of the workshop, all participants received their attendance certificates. I was presented with mine by Dr. Seiji Yashiro. After lunch, we visited an ancient 1420s Ulugh Beg Observatory, named after the famous astronomer. The observatory had the versatile quadrant principle devices that were used to measure the altitude of stars and planets; some of the measurements of that time closely matched today's measurements. From there, we went to Shah-i-Zinda, a site adorned with beautiful ceramic tiles, which serves as a pilgrimage destination for the Uzbeks, housing the tombs of prominent figures, including nobles and religious leaders associated with Uzbekistan's history.

The next day, again the sun rose on 31 August, when we had to say bye to Samarkand. We met Dr. Nandita and said bye to her, who was traveling to Tashkent railway station with Mr. Arjun, an M.Sc. student from IISER Mohali. They will join us at Tashkent station on our journey back to India. We caught the train when there were only two minutes left before its departure, as at the end moment, the platform was changed. We reached Tashkent, where we reunited with Dr. Nandita and Arjun. We kept our bags in the cloakroom and then visited a significant place for all Indians - the Lal Bahadur Shastri monument, a place that is known for the Tashkent peace agreement between India and Pakistan. Afterward, we made our way to Tashkent airport to catch our flight back to India. On 1st September, we all arrived at Delhi airport and said bye to Dr. Nandita as she was heading to Udaipur while Arjun accompanied us all the way to Bengaluru.

Looking back on my trip, I am particularly struck by how highly accomplished individuals never show off, yet they maintain punctuality and energy every day. From them, I, too, have found a fire within me to do my best and contribute to the field of solar astrophysics. Attending this international workshop has instilled in me a sense of responsibility to do something meaningful in life, not only to make myself happy but also for the people who have expectations of me and to bring pride to my country.

Anjali Agarwal is a Senior Research Fellow (SRF) at the Indian Institute of Astrophysics (IIA), Bengaluru. She is working with Dr. Wageesh Mishra in solar astrophysics. Her primary focus is understanding the origin and evolution of solar transients such as Coronal Mass Ejections (CMEs) and their substructures.

Picture 2: (Left) Amir Taimur monument at AK-Saray Palace. (Center) Receiving attendance certificate for COSPAR workshop from Dr. Seiji Yashiro. (Right) A tribute to India's eternal second prime minister, "Lal Bahadur Shastri" at Tashkent.



Skychart Dec 2025: (As on Dec 15, 2025. 20.00hrs Bangalore)

December 21 - December Solstice. December 21 marks the December solstice, occurring at 15:50 UTC. During this time, the South Pole of the Earth is tilted towards the Sun, which will be at its southernmost point in the sky, directly above the Tropic of Capricorn at 23.44 degrees south latitude. This day represents the onset of winter (winter solstice) in the Northern Hemisphere and the beginning of summer (summer solstice) in the Southern Hemisphere.

Tidal Disruption Events: Unlocking the Extreme Environment near Black Holes

Neeraj Kumari

Tidal Disruption Events (TDEs) are among the most captivating phenomena in modern astronomy, offering a rare glimpse into the extreme environment near supermassive black holes (SMBHs). These events occur when a star ventures too close to a black hole, and the immense gravitational forces tear the star apart in a violent process known as tidal disruption (Rossi et al. 2021). The resulting burst of energy releases an immense amount of radiation, observable across multiple wavelengths, making TDEs key targets for astrophysical research.

In TDE, a giant star sufficiently close to the black hole is disrupted due to the immense tidal gravitational field, much like an extreme instance of Earth's tidal interaction with the moon. As we know, at the center of most galaxies, there is SMBH which is constantly growing by gulping the nearby objects. As per its name, black holes do not emit light on their own. When a star comes near SMBH, it is gravitationally pulled into the vicinity of the black hole. This tidal force stretches and compresses the star, eventually shredding it into streams of gas. Roughly half of this material is flung outward, escaping the black hole's grasp, while the other half spirals inward, forming an accretion disk around the black hole (Figure 1). As the stellar debris is consumed, it heats up and emits bright flares of electromagnetic radiation. These luminous flares can last from weeks to months, and their brightness often exceeds that of an entire galaxy during their peak (Rees 1988). It is a catastrophic and destructive end for the stars but a great opportunity for astronomers to study the center of galaxies, which is otherwise dormant.

Key Features of Tidal Disruption Events

1. Black Hole Mass and Star Interaction

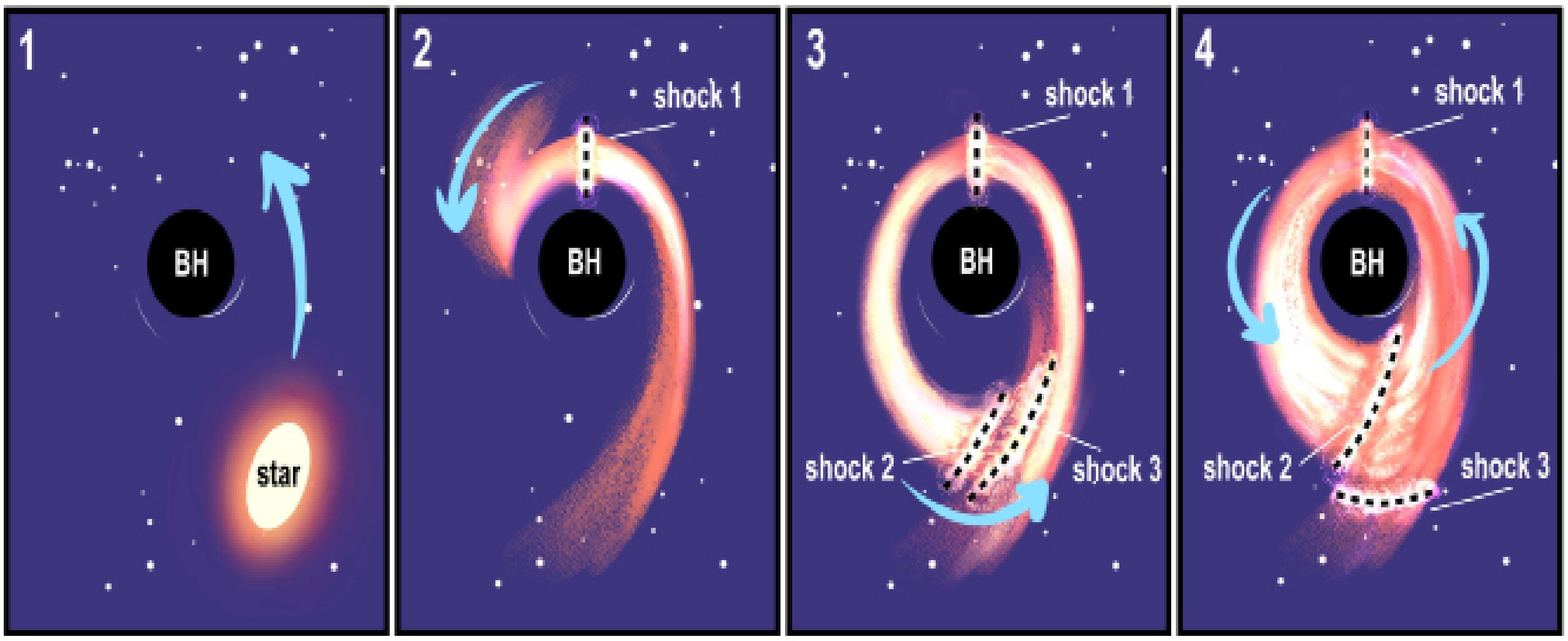


Figure 1: Artistic view of the TDE process: 1. The matter from the nearby star approaches the black hole due to the gravitational pull, 2. the stellar matter forms an elliptical stream around the black hole, 3. the tidal shocks are formed as the gas hits itself on its way back after circling the black hole, and 4. the shocks create bright outbursts of polarised light and the gas circling the black hole forms an accretion disk over the time period. (Credits: Jenni Jormanainen)

TDEs typically occur near SMBHs with masses ranging from 10^6 to 10^8 solar mass (Rees 1988). Larger black holes might swallow a star wholly without disruption, while smaller ones lack the gravitational reach to cause significant damage. Intermediate-mass black holes, however, provide an ideal environment for such events.

2. Observational Signatures

High-energy emissions in X-rays come from the innermost regions of the accretion disk, where temperatures can reach millions of degrees due to increased accreted material. In Active Galactic Nuclei (AGNs), the high energy X-rays originate in the electron plasma around the black hole as a result of inverse Comptonisation. Optical and UV emission is generated by the outer regions of the accretion disk due to thermal heating and the interaction of ejected debris with the surrounding material. Whereas radio signals arise when debris jets interact with interstellar matter, providing clues about the black hole's environment (Walter et al. 2011).

2. Relativistic Jets

In some TDEs, relativistic jets—streams of particles moving close to the speed of light—are ejected along the black hole's rotational axis (Figure 2). These jets produce radio and gamma-ray emissions, revealing information about the black hole's spin and magnetic field (Lei et al. 2016). AT2022cmc is one such event but the most distant one (Zhou et al. 2024). It was discovered in 2022 by the Zwicky Transient Facility (ZTF). The black holes in AT2022cmc and other similarly jetted TDEs are likely spinning rapidly so as to power the extremely luminous jets. This event has been observed across various wavelengths, including X-ray, optical, radio and sub-millimeter (Mummery & Balbus 2021).

Why are TDEs Important?

TDEs are not just spectacular cosmic events; they are valuable tools for probing the universe. Observing TDEs helps identify dormant black holes in distant galaxies. Most black holes are undetectable unless it is actively accreting material, and so TDEs provide a natural way to illuminate them. TDEs offer a real-time laboratory to study accretion physics, how matter behaves under extreme gravitational forces, and how black holes consume material. By mapping TDE occurrences across different types of galaxies, astronomers can gain insights into the population and growth of black holes over cosmic time.

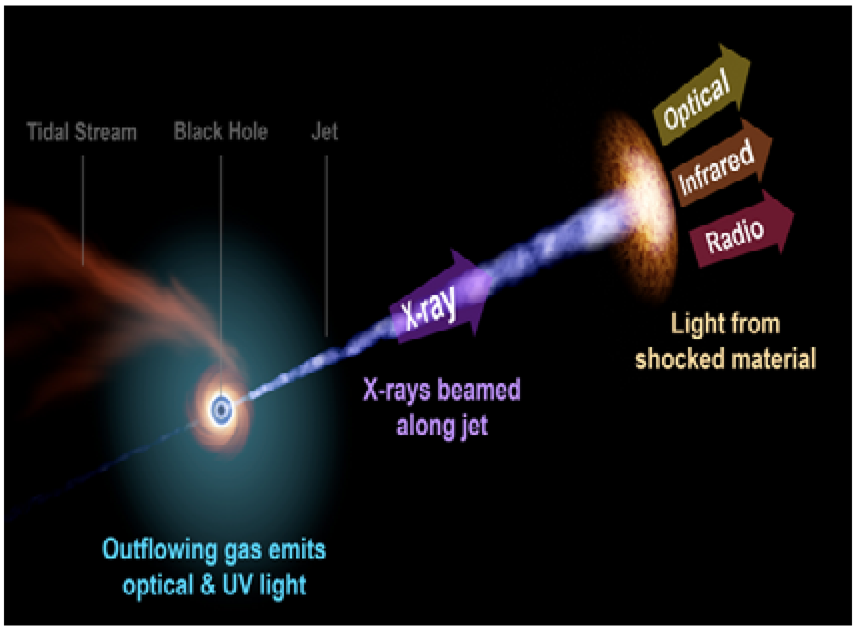


Figure 2: Artistic picturisation of how a black hole devours a nearby star. In rare circumstances, this can instigate the jet launching, which can be observed at many frequencies. (Credits: Zwicky Transient Facility /R. Hurt (Caltech/IPAC))

Recent Discoveries and Future Prospects

With advancements in observational technology, the detection rate of TDEs has surged. Surveys like the ZTF, Pan-STARRS, and the All-Sky Automated Survey for Supernovae (ASAS-SN) have identified numerous TDE candidates. Additionally, space-based observatories like NASA's Transiting Exoplanet Survey Satellite (TESS) and ESA's X-ray Multi-Mirror Mission-Newton (XMM) have provided high-resolution data (Holoien et al. 2019). The upcoming Vera C. Rubin Observatory is expected to revolutionize TDE studies by detecting thousands of these events annually. At the same time, instruments like the James Webb Space Telescope (JWST) will offer unprecedented detail on the environments surrounding black holes.

A Science Case Study of the Jetted TDE in X-ray Wavelengths: Swift J1644+57

TDEs and their short-term X-ray variability still leave us scratching our heads, especially since they share some similarities with AGNs. Jin (2021) studied the short-term X-ray variability in jetted TDEs and used Swift J1644+57 as a case study to explore how different properties evolve over time. These properties include the X-ray flux distribution, power spectral density (PSD), root mean square (rms) variability, time lag, and coherence spectra. They noticed that the flux distribution of Swift J1644+57 has a lognormal form when it's in the "normal" state, but things get weird in the "dipping" state as it strays far from the lognormal, hinting at different physical processes at play. During two of the early XMM-Newton observations in the dipping state, Swift J1644+57 showed steeper PSDs and higher rms than the normal state. Interestingly, a noticeable soft X-ray lag in these observations of about 50 seconds between the 0.3 - 1 keV and 2 - 10 keV ranges, with strong coherence, was found. Using the 2 - 10 keV rms values (ranging from 0.10 to 0.50), they estimate the black hole mass of Swift J1644+57 to be around (0.6 - 7.9) × 10^6 solar mass. That said, the rms changes as the TDE evolves, which adds quite a bit of uncertainty.

In another work by Chatterjee et al. (under review), the long-term spectral variabilities associated with the jetted TDE Swift J1644+57 have been studied by exploring the archival X-ray data obtained with Monitor of All-sky X-ray Image/Gas Slit Camera (MAXI/GSC), Swift's X-ray Telescope (XRT), and XMM-Newton X-ray observatory. As a jetted TDE, the source exhibited significant variability across both spectral and temporal domains, making it one of the most extensively studied TDEs to date. This analysis reveals that the spectral indices decrease non-monotonically as Swift J1644+57 evolves with time. This analysis also revealed several key similarities between TDEs and the declining phase of outbursting galactic black hole (GBH) transients. These similarities are particularly evident in their spectral energy distributions (SEDs) and the temporal decay of luminosity during the decline. In this TDE, the soft (0.3 - 1.5 keV) and hard (1.5 - 10 keV) X-ray photon counts are highly correlated and peak at zero lag. This indicates that the soft and hard X-ray photons are emitted from the same site, which is most likely a Compton cloud, i.e., the corona (Figure 3). The Lamppost model (Martocchia & Matt 1996 & Miniutti & Fabian 2004) provides a physical explanation for the X-ray spectra observed in AGNs, while the Optxagn model (Done et al. 2012) estimates the size of the corona, R_{cor}, by fitting the observed spectra.

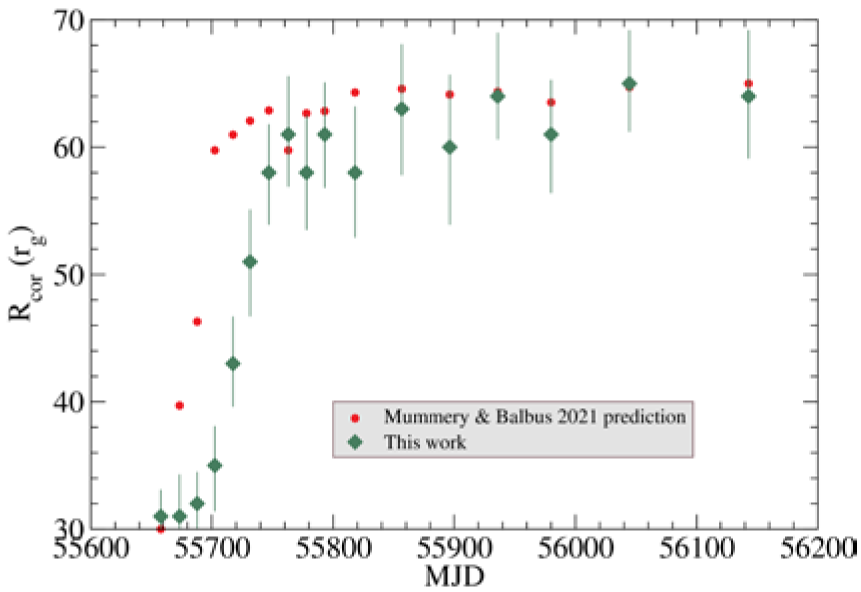


Figure 3: Coronal Variation with time is presented for Swift J1644+57. Swift/XRT fitted values are presented by green-diamond points (Chatterjee et al., under review). The red circles denote the theoretical values of $R_{cor}(r_g)$ as predicted by Mummery & Balbus (2021). This figure shows that the corona expands with time because hard X-ray photons increase, and soft photons are more scattered to be exhausted.

Additionally, it has been observed that the corona is a dynamic structure in both GBHs (Kara et al. 2019) and AGNs (Alston et al. 2020). This dynamic nature underscores the importance of investigating how the corona size evolves over time. Assuming the hard X-ray photons originate from the corona, it has been found that the corona undergoes rapid expansion during the early phases when accompanied by a relativistic jet launching and subsequently evolves toward a state of saturation with minor fluctuations in the latter stages. The temporal variation of the coronal size is consistent with a simple theoretical conjecture.

In summary, TDEs are celestial showcases of the raw power of gravity. By unravelling their complexities, astronomers can deepen their understanding of black holes, one of the universe's most enigmatic entities. As observational techniques improve, TDEs promise to shed light on fundamental astrophysical processes and the hidden black hole population, paving the way for groundbreaking discoveries in the years to come.

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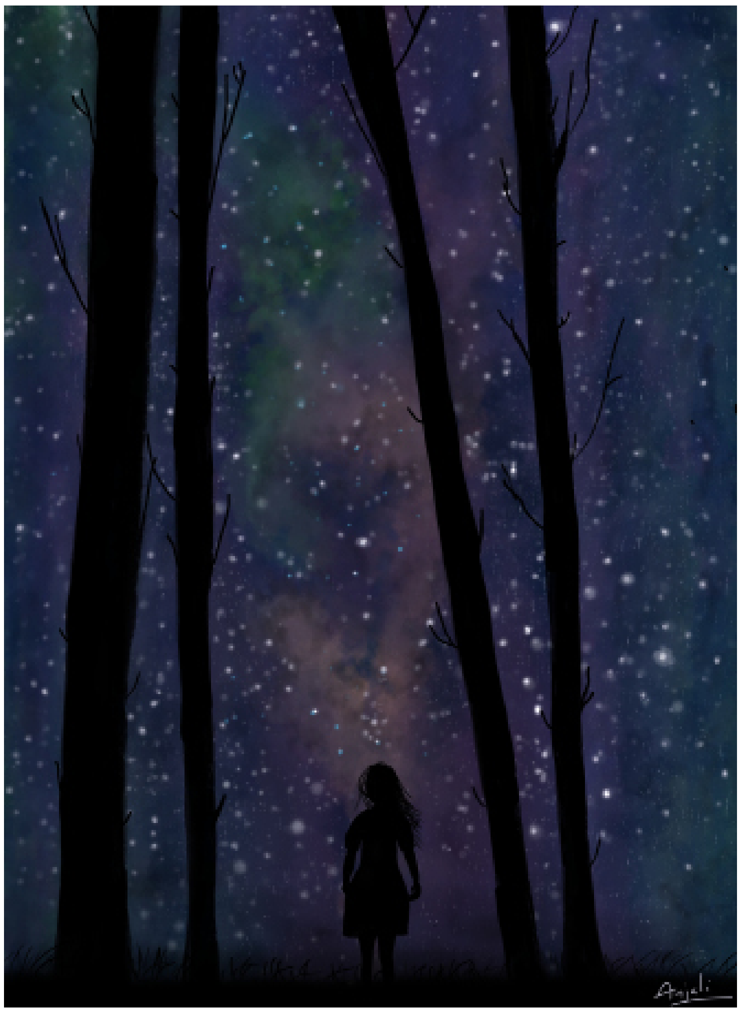
Neeraj Kumari is a Post Doctoral Fellow at the Indian Institute of Astrophysics, Bengaluru. Her main research area is the multi-wavelength studies of Active Galactic Nuclei (AGNs) to understand the ongoing physical mechanism in the immediate vicinity of the black holes.

Sketches by: Kanan Virkar, Junior Research Fellow (JRF), IIA.

This sketch is inspired by a majestic white tiger I saw in mysore zoo during my recent trip there.

The stare of a street cat as she suddenly notices you.



This painting reflects the deep passion within humans for the mysteries of the deep sky.

Art by: Anjali K A, Junior Research Fellow (JRF), IIA.

Team IIA at the Young Astronomer's Meet (YAM) 2025 at the Tata Institute of Fundamental Research, Mumbai.

The beginning of my long association with IIA

Prof. Sunetra Giridhar

I owe my entry into the Indian Institute of Astrophysics (IIA) to a Summer School in Astronomy and Astrophysics conducted in Bangalore in 1976, which introduced me to IIA and its observational facilities. However, my process of joining IIA as a student was quite interesting. I wrote a letter to Prof. J.C. Bhattacharyya (JCB), whom I had met during the summer school, expressing my interest in observational astronomy and my wish to join IIA for my Ph.D. work. He replied, stating that I could meet the Director of IIA, Prof. M.K.V. Bappu (MKVB), to discuss the matter. Hence, I came to Bangalore again in December 1976.

The Koramangala area, where IIA is located, was literally out of Bangalore. The landmark to reach the place was St. John's Medical College. JCB kindly gave me the directions, and I reached IIA around 11 AM. I met him at his office, and he told me that a meeting with MKVB would take place later in the day when MKVB would be free; meanwhile, I could sit in the library and wait.

IIA then had only a hutment building and an optics section; the rest of the campus was still under construction. There was no canteen or any eatery/hotel around IIA or, for that matter, in the entire Koramangala. There was a tea shack in front of the IIA gate where I could buy a biscuit packet. I sat patiently till 5 PM at the library in the hutment and later on a vacant chair of the receptionist near the entrance to the hutment. Around 7 PM, the Director's PA, Mr. Rajasekaran, informed me that the Director could now see me. MKVB interviewed me in the presence of JCB. I was asked about my exposure to astronomy. I had a "Spherical Trigonometry and Astronomy" paper in my B.Sc. (final). I had done an M.Sc. (Physics) that did not contain topics on astronomy. It was proposed that I study for one month and appear for a test to qualify as a Junior Research Fellow (JRF).

I was provided reading material, cleared the written test conducted by JCB, and formally joined IIA as a JRF in January 1977. IIA did not have any students' hostel or boarding facility in Bangalore. I learned of the Central College ladies' hostel on Palace Road, and a letter from IIA helped me secure accommodation there.

IIA had very few students (I think Sushma Mallik, Ashok Pati, and self in 1977). I registered at Pt. Ravishankar University, Raipur (my Alma Mater) for the Ph.D. degree. The university left the task of conducting the Pre-Ph.D. examination to the guide. Instead of lecture-based courses, we were given reading material and raw data for problem-solving.

In the first project, I was trained to measure the strengths of interstellar lines in a set of Wolf-Rayet stars by scanning the spectra using a microdensitometer. It gave an analog trace of the spectrum. By manually drawing lines on the tracing, the densities were read off every millimeter (mm) and converted to intensity using a response curve for the photographic emulsion. The line profile was then plotted on the graph sheet, and the area was measured by counting squares on the graph sheet. This laborious task was done for two profiles of interstellar lines for each spectrum. The results were published in the Kodaikanal Observatory Bulletin (KOB) in 1978.

In another project, I was given a set of medium-resolution spectrograms of the Wolf-Rayet spectroscopic binary HD 214419, and using an Abbe comparator, I calculated radial velocities over its orbital period. The spectra were prismatic; hence, the dispersion was non-linear. I used Hartman's formula on the arc lines to measure the dispersion. The Abbe comparator has remarkably high mechanical precision and stability. Using the main scale value and the circular vernier scale, one could measure the positions of spectral lines with an accuracy of a few microns. We published the radial velocity curve and orbital parameters in another paper in KOB.

These early projects under MKVB's guidance were valuable lessons in doing good science with very modest facilities.

During my participation in the summer school (Bangalore, 1976), I had an opportunity to visit the Kavalur Observatory and view a few astronomical objects through the 1m telescope. I was deeply impressed with its elegance and ease of operation. This experience, coupled with my subsequent long association with the telescope, made it my " new Alma Mater" for training in observational astronomy. Over the years, I used the 1m telescope for many projects taking full advantage of its spectroscopic accessories.

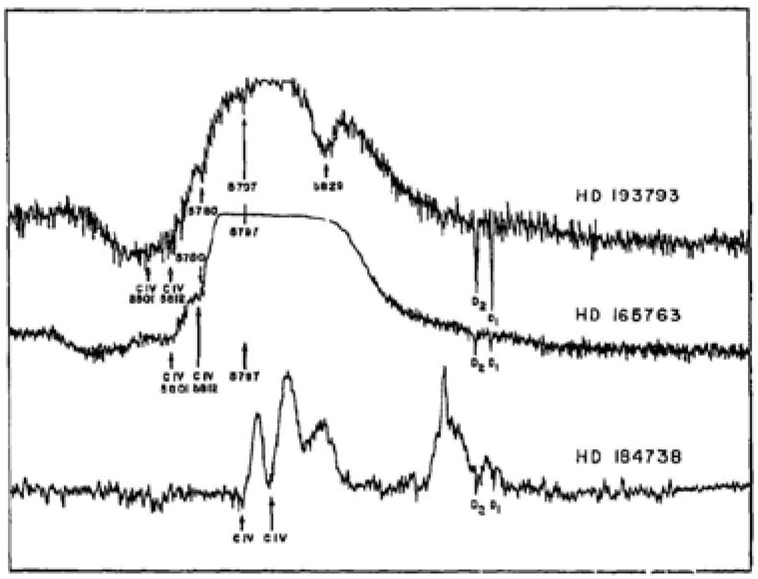


Figure 1: A plot of interstellar lines in Wolf-Rayet stars spectra

The 1m telescope building, with the telescope on the IV floor, did not have a lift. We had a vertical Coudé spectrograph (with cameras A and B giving dispersions of 16 Å/mm and 4.2 Å/mm, respectively) extending over two floors. The collimator was placed on the II floor, the grating and plate holder on the III floor, and the slit, calibration source, and guiding assembly on the IV floor. The cycle of loading the photographic plate in the plate holder (which was done in the photographic lab on the II floor), then climbing to the III floor to place it at the focal point, and going up to the IV floor to guide the star on the slit, was repeated several times throughout the night in darkness. It is no surprise that Coudé observers never had weight problems!

Figure 2: Abbe comparator

One of the target stars I observed and successfully got a well-exposed spectrum was Alpha UMi (Polaris). Achieving this result, however, was far from easy. I used the Coudé B camera of the vertical Coudé spectrograph, which gave a dispersion of 4.2 Å/mm in 2nd-order red. The spectrum recorded on the photographic plate can boast of being one of the very few spectra of the star at such high declination (+89°) from the latitude of Kavalur (12.6°). It was a challenging task as the telescope became nearly horizontal, and we had to use two different speeds to guide in Declination and Right Ascension. But the observing team at Kavalur those days, namely K. Kuppuswamy, J. Rosario, K. Jayakumar, Subramani, and Vadivelu, gave uncomplaining support through many unsuccessful attempts (due to poor sky conditions). When we did obtain a well-exposed spectrum, our happiness knew no bounds. We celebrated the event with butter dosa made by Devendran at early morning breakfast!

It was mandatory to meet MKVB following an observation run at Kavalur. He would eagerly await and examine the spectra recorded on photographic plates with an eyepiece, comment upon the quality of the spectra, and often reprimanded. But the well-exposed spectrum of Polaris earned me a (very rare) compliment! I just could not stop smiling the whole day!

We could measure the strength of the weak [OI] line at

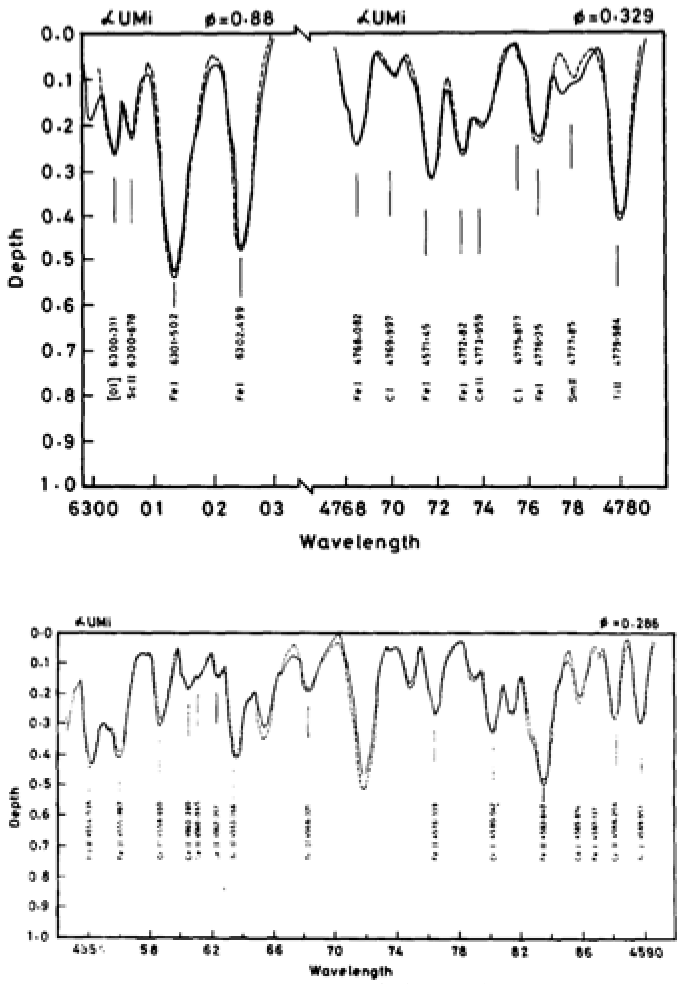


Figure 3: Spectrum of the Polaris covering [OI], CI lines

6300.6 Å in UMi quite accurately and those of CI lines in the 4771-75 Å region. Our results, published in 1985, were appreciatively cited by R.E. Luck and H.E. Bond in 1986 in an abundance analysis of this star using the 3m Shane Telescope at Lick Observatory.

The analog microdensitometer at IIA was upgraded by Mr. Viswanath by adding a digitizer using a microcomputer from the HCL 2200 series. It could digitize spectra in batches of 100 points at a time due to memory limitations. It was a big relief from drawing lines on analog plots and reading off density values. The digitized density values were then converted to intensities using the polynomial coefficients of the characteristic curve of the emulsion.

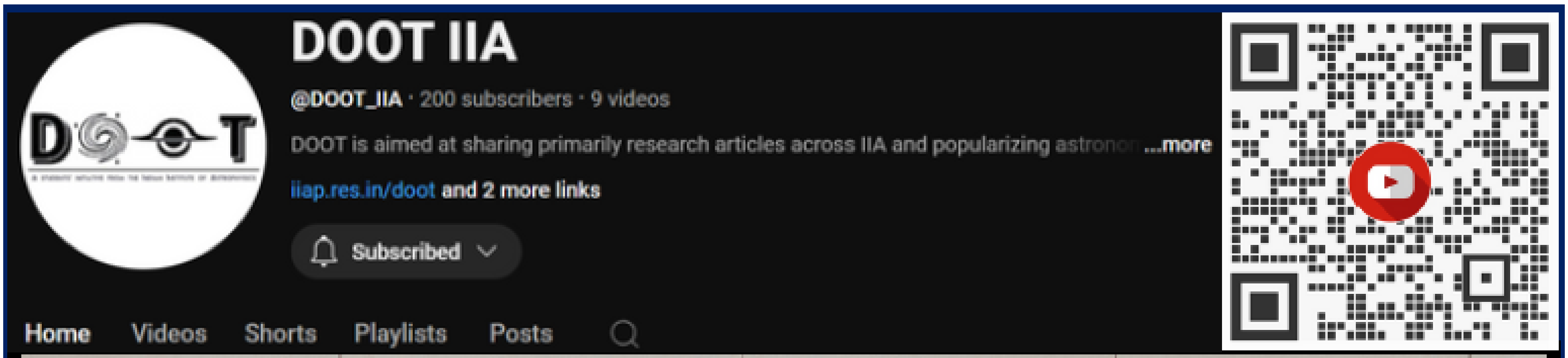
My Ph.D. work on deriving abundance gradient for our Galaxy using Cepheids as tools was submitted in October 1982, and I was awarded a Ph.D. in 1983. The work was presented at a meeting of the Astronomical Society of India (ASI) held in Gorakhpur (1982). It was preceded by the very tragic demise of MKVB in August 1982, plunging everyone at IIA into deep sorrow. However, JCB undertook the unfinished tasks of MKVB, and I submitted my thesis under his supervision. I am indebted to these two gentle scientists for all their help and kindness.

Figure 4: Photo taken during the ASI meeting held at Gorakhpur (1982) with many distinguished astronomers. Prof. Rajesh Kochhar, S.K. Jain, and S.M. Alladin are seated in the first row, along with Sunetra Giridhar. The second row has Prof. Alak Ray, Umesh Joshi, and M.H. Gokhale. Not all persons in the photo could be identified

I eventually joined the academic faculty at IIA, a transition marked by many milestones, perhaps a story for another time. Although officially I retired in June 2016, I still feel part of IIA.

Prof. Sunetra Giridhar joined IIA as a Research Scholar in 1977 and completed her Ph.D. in 1982. She joined Vainu Bappu Observatory (VBO), Kavalur, as a Research Associate in 1984 and retired as a Senior Professor in June 2016. She did spectroscopic investigations of classical Cepheids, RV Tauri stars, metal-poor stars, and post-AGB stars. She served on the International Astronomical Union (IAU) Commission 45 on Spectral Classification as an Organizing Committee (OC) member (2000-2003), Vice-President (2003-2006), and President (2006-2009). She played a leading role in the development of the high-resolution Hanle Echelle Spectrograph (HESP) for the 2m Himalayan Chandra Telescope (HCT) at the Indian Astronomical Observatory (IAO), Hanle.

DOOT NSD Stall at IIA - Some snapshot to show how kids enjoyed our company



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