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National Science Day 2025

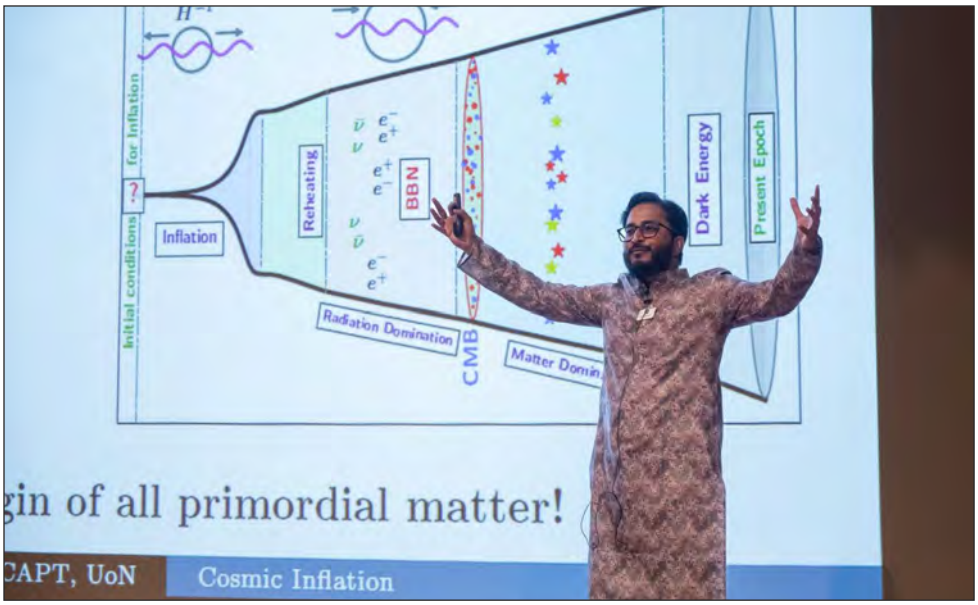
A vibrant science and public engagement celebration marked the National Science Day 2025. The institute organised a series of educational and interactive events throughout February, culminating in a grand Open Campus Day on February 28. The celebrations, themed *"Science & Innovation at IUCAA,"* attracted over 7,000 visitors of all ages from across Maharashtra. The highlight of the month-long festivities was the Open Campus Day, during which IUCAA opened its doors to the public, offering a glimpse into its scientific environment. Various locations across the campus hosted live demonstrations, hands-on exhibits, and public lectures, all designed to introduce visitors to the wonders of astronomy and astrophysics.

At the Aryabhata and Kund area, attendees explored the Foucault Pendulum, sculptures of legendary scientists, and solar telescopes providing real-time views of the Sun. A special aeromodelling show by Madhav Khare was a major attraction, especially for younger visitors. The Bhaskara area featured interactive exhibits on LIGO-India, gravitational waves, and the ADITYA-L1 solar mission, along with demonstrations of quantum science concepts and models of AstroSAT.

Public talks were conducted throughout the day at the Chandrasekhar Auditorium. The lecture series began with a session on solar studies by Janmejoy Sarkar and concluded with a talk on quantum entanglement by Anindita Banerjee from CDAC. Other speakers included Sourav Das,

Susmita Das, Parisee Shirke, Suraj Dhiwar, Swagat Mishra, Suvas Choudhary, and Atharva Pathak. Highlights of the day included an interactive "Ask a Scientist" session and a storytelling and puzzle activity led by Jayant Narlikar. Talks were delivered in English, Marathi, and Hindi to ensure broad accessibility. The Muktangan Vidnyan Shodhika area was dedicated to school-level astronomy exhibits, hands-on demonstrations, amateur radio astronomy, and displays of outreach projects. Model demonstrations by school students were prominently featured, offering a platform for young minds to showcase their creativity and understanding of science.

In the evening, IUCAA hosted a public skywatch event at the Savitribai Phule Pune University sports ground. From 7:00 to 10:00 pm, visitors enjoyed guided telescope observations of celestial objects, drawing large crowds.



Preceding the Open Campus Day, IUCAA conducted several student-focused outreach programs. On February 1, 2025, competitions in science quiz, essay writing, and drawing were organised for students from rural schools in Ambegaon Taluka. These events, held at Government Polytechnic, Awasari, were coordinated by Saurabh Magare, Sudhir Gholap, Snehil Pandey, and Soumil Sahu, with support from Nilesh Pokharkar and the SciPop team. Students from fifteen rural schools participated enthusiastically.

Another inter-school competition was held on February 22, 2025, for students from Pune City. Approximately 180 students from thirty-six schools participated in events which included drawing, essay writing, model-making, and a science quiz for classes VIII to X. The activities were coordinated by Rajeshwari Dutta, Anupreeta More, Sanjit Mitra, and Snehil Pandey. A special demonstration of the "Human Orrery" was conducted by Emmanuel Rollinde (CY Cergy Paris Universitй) and Surhud More for accompanying teachers. Winners from both rural and urban school competitions received prizes presented by the Director of IUCAA.

The month-long celebration successfully bridged the gap between the scientific community and the public, promoting curiosity, creativity, and a deeper understanding of science among diverse audiences.

Winners of National Science Day Competitions – 2025

Rural Schools

A) Quiz Competition

***First Prize*:**

Ayush Bhor, Tanmay Bhor, Niraj Khedkar (Shri Bhairavnath Vidyalaya, Awasari Khurd)

***Second Prize*:**

Tanishka Padwal, Tarun Patil, Yash Wakchaure (New English School, Landewadi)

***Third Prize*:**

Om Walunj, Rushi Nighut, Naitik Lande (Shivajirao D. Adhalrao Patil Vidyalaya, Landewadi)

B) Essay Competition

***First Prize*:**

Shrushti Waykar (Shri Bhairavnath Vidyalaya, Awasari Khurd)

***Second Prize*:**

Anushka Jadhav (New English School, Landewadi)

***Third Prize*:**

Kshama Lande (Shivajirao D. Adhalrao Patil Vidyalaya, Landewadi)

***Honourable Mention*:**

Vaibhavi Gengaje (Mahatma Gandhi Vidyalaya, Manchar)

C) Drawing Competition

***First Prize*:**

Sanchiti Pawale (Shivajirao D. Adhalrao Patil Vidyalaya, Landewadi)

***Second Prize*:**

Vedika Tawhare (Pandit Jawaharlal Nehru Vidyalaya, Nirgudsar)

***Third Prize*:**

Lavanya Anandrao (Mahatma Gandhi Vidyalaya, Chandoli Bk.)

***Honourable Mention*:**

Atharv Salve(Hirakani Vidyalaya, Gawadewadi)

D) Model-Making Competition

***First Prize*:**

Shlok Shete, Vedant Bhor(New English School, Landewadi)

***Second Prize*:**

Pruthveeraj Khose, Om Borhade (New English Medium School, Ghodegaon)

***Third Prize*:**

Siddarth Kale, Prajwal Bhosale (Yashwantrao Chavan Vidyalaya, Ambegaon Vasahat)

***Honourable Mention*:**

Vedha Bhor, Devanshish Chaskar (Sant Dnyaneshwar Vidyalaya, Chas)

Pune City Schools

A) Quiz Competition

***First Prize*:**

Divij Tikoo, Swarnima Garg, Manas Gupta (Delhi Public School)

***Second Prize*:**

Akshaj Khurana, Aryan Desai, Maithili Shirsat (City Pride School, Moshi)

***Third Prize*:**

Arvind Chindhe, Prabodh Shejwalkar, Sayujya Swami (Aksharnandan)

B) Essay Competition

***First Prize*:**

English Essay – Lakshanya Mishra *(Army Public School)*

Marathi Essay – Chinmayi Shete *(Mahilashram High School)*

***Second Prize*:**

English Essay – Ira Kulkarni *(New India School)*

Marathi Essay – Manas Joshi *(BVB Paranjpe High School)*

***Third Prize*:**

Marathi Essay – Shravani Bhalekar *(Jnana Prabodhini Navnagar Vidyalaya)*

C) Drawing Competition

***First Prize*:**

Bhavesh Choudhary (Vidyanand Bhavan High School, Nigdi)

***Second Prize*:**

Sanvi Kulkarni (Air Force School, Chandannagar)

***Third Prize*:**

Sarisha Darbastwar (D.E.S. Secondary School)

D) Model-Making Competition

***First Prize*:**

Satyaj Hedon (City Pride School, Nigdi)

***Second Prize*:**

Ansh Singh, Harsh Yadav (Air Force School, Chandannagar)

***Third Prize*:**

Ayush Wadekar, Gaurang Mane (BVB Paranjpe Vidyamandir, Kothrud)

Relativistic jet feedback on host galaxies

Feedback from supermassive blackholes (SMBH) in large early type galaxies has been strongly established as a major influencer of galaxy evolution. From a historical perspective, Bremsstrahlung driven cooling of gas in galactic (or cluster) environments has been posited to form cooling flows, which has been observed as early as late 1970s (Fabian et al. 1977). However, the fate of the gas cooled below X-ray emitting temperatures (≤ 1-2 keV) was left uncertain due to lack of distinct observational signatures (Peterson et al. 2001). This prompted considerations of re-heating of the gas by some mechanism, with feedback from the an Active Galactic Nuclei (AGN) being a viable source (Croton et al. 2006). The classical notion of AGN feedback considers a dual mode effect over the lifetime of a massive galaxy: a) Quasar/Establishment mode: AGN driven outflows regulate gas content and in turn SMBH and galaxy mass. The connection between feeding and feedback from the SMBH is predicted to set up the observed blackhole and bulge mass correlations. b) Radio/Maintenance mode: Large scale radio jets heat up the ambient environment, preventing cooling flows and limiting gas supply to the central regions, thus regulating mass build up. In this dual mode scenario, the role of relativistic jets have been largely confined to their impact on extra-galactic gas. However, in the recent decades, a large body of studies have demonstrated both from theory and observations that jets can have a significant impact on the ISM of the host galaxy. This makes the earlier dual mode distinction ambiguous in some cases, requiring re-thinking of the traditional definitions (see detailed reviews by Harrison and Ramos Almeida 2024 and Mukherjee 2025 for more technical comments).

In the mid and late 1970s, there were several seminal developments of theoretical models to explain the dynamics and emission from extra-galactic relativistic jets such as the `twin-exhaust' and beam models, the B-Z jet-launch mechanism, diffusive shock acceleration models, which defined the studies of jets and non-thermal emission in future (Blandford and Rees 1974, Scheur 1974, Blandford and Ostriker 1978). The first detailed 2D simulations of propagation of hypersonic jet beams and their structures were presented in 1982 (Norman et al. 1982). Since then simulations to study dynamics of relativistic jets have increased in sophistication. While the early simulations primarily focused on the magnetohydrodynamics (MHD) of these jets, later more holistic models explored realistic simulation setups that explored the impact of such jets drilling through the ambient interstellar medium (ISM) of their host.

The earliest suggestions of jets interacting with intervening gas clouds was proposed to explain the observed knots in the jet of Cen A, as early as 1979 (Blandford and Konigl 1979). Direct observational evidence of jets impacting ambient gas were found from joint observations of radio jets and ionised gas outflows in the early 80s (e.g. Butcher et al. 1980, Heckman et al. 1982, Heckman et al. 1984 and others). Further investigations of such notions were also prompted by discoveries of a class of radio sources characterised by a turnover in their radio spectrum, the so called GPS (Gigahertz-Peaked Spectrum) and CSS (Compact Steep Spectrum) radio galaxies. Such galaxies were often found to be gas rich with high rotation measures and low polarisation, all indicating jet-gas interaction as the potential cause of jet compactness. The early simulations of jets interacting with an inhomogeneous ISM were performed in the 1990s (De Young et al. 1990), who performed 2D simulations of jets moving through a random distribution of spherical clouds. Later, more realistic fractal descriptions of clouds were modelled in such simulations (Saxton et al.

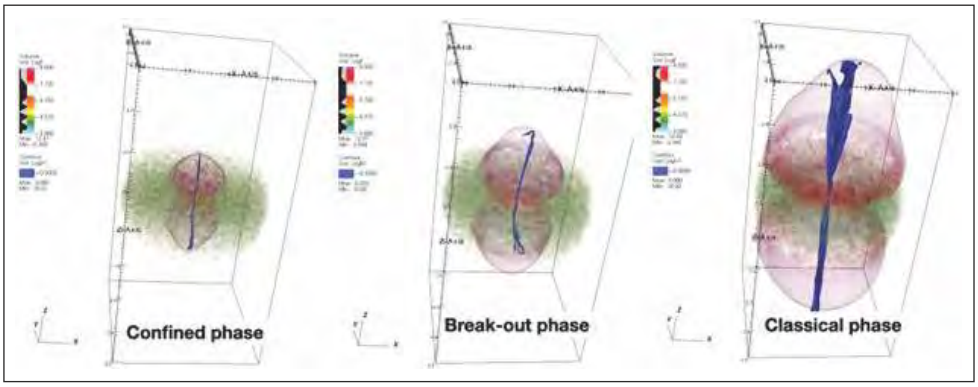


Figure 1. Evolution of a jet through a dense kiloparsec scale gas disk (from Simulation B of Mukherjee et al. 2018b), depicting the three phases of evolution. The 3D visualisation shows the temperature of the gas and the jet tracer in blue. The red-coloured contours trace the cocoon of hot gas expanding into the ISM. Post break-out, the hot pressurized cocoon spreads over the ISM and engulfs it from the upper and lower regions.

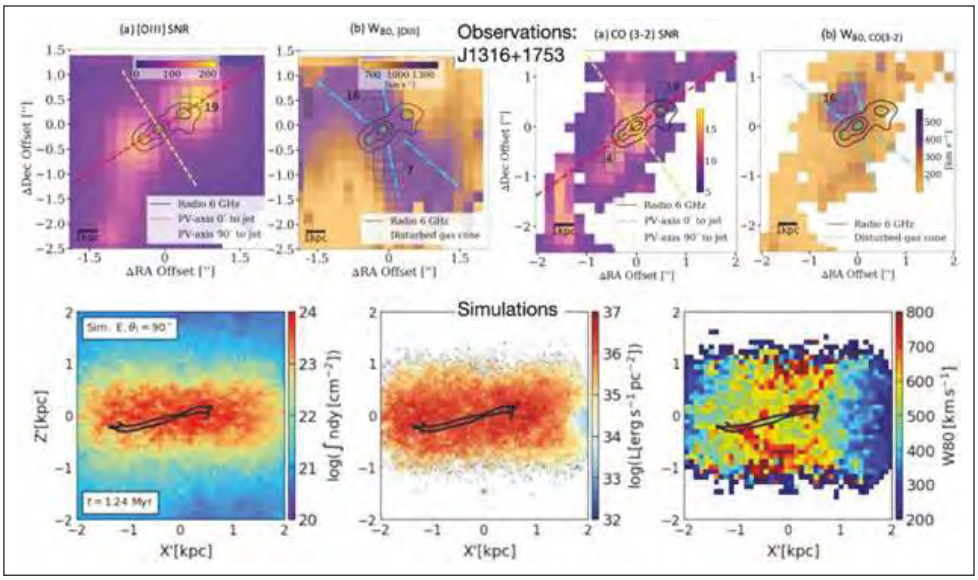
2005, Sutherland and Bicknell et al. 2007). These were later improved upon by more detailed 3D simulations including relativistic solvers and a wide variety of physics modules (Wagner et al. 2011, 2012, Mukherjee et al. 2016, 2017, 2018b).

Although specific individual results often vary between different simulations, due to different choices of parameters, all studies show a set of general outcomes. The evolution of a jet through the host's ISM follows a set of evolutionary sequences (as shown in Figure 1). First is the confined phase, where the jet remains trapped within the ISM as it interacts vigorously with the dense gas clouds. The jet-plasma is diverted to low density channels through the clouds, percolating into the ISM, resulting in the formation of the so-called "Flood-Channel" evolution. This is the most important phase in terms

of local impact of jet driven AGN feedback on the galaxy. The trapped jet shocks the ambient gas, driving multi-phase outflows and injecting turbulence. This results in strong disturbance to the gas kinematics, which has been confirmed from spatially resolved observations of jet-ISM interaction (see Figure 2). During the phase, although the jet's progress is slowed down, the forward shock keeps expanding as the jet's energy is redirected to other areas beyond the jet-beam. This results in the formation of a quasi-spherical energy bubble that sweeps through the ISM creating localised outflows and shocks.

Such outflows regulate the gas content available within the host galaxy's potential that can form stars. Multiple episodes of AGN/jet activity are predicted to create a galactic fountain like scenario, where a fraction of gas is kept off-limits from the starformation process, though not completely escaping the galaxy's potential. The induced turbulence is expected to further add to the decline of starformation rate or at least, in reduction of the efficiency of starformation (Mandal et al. 2021). Beyond the confined phase, the jet breaks out of the dense gas (the "break-out" phase) and extends into the ambient low density background. For a duration beyond the break-out, the jet still keeps influencing the gas as the high pressured cocoon engulfs the ISM driving shocks and compressing the gas on scales beyond the immediate confines of the jet. From here-on, the un-hindered jet proceeds fast, with a more conical shaped forward shock (the "classical" phase).

The simulations have been aptly supported by spatially observations of jet-ISM interactions. For some specific sources, detailed comparisons of qualitative predictions from the simulations have been made with the observed results, such as IC 5063 (Mukherjee et al. 2018a), 4C 31.04 (Zovaro et al. 2019), B2 0258+35 (Murthy et al. 2022), 2MASSX J23453269-044925 (Nesvadba et al. 2021), Tea Cup galaxy (Audibert et al. 2023) etc. The ready access to large scale international observational facilities (e.g. VLT, ALMA, JWST etc.) with sufficient resolution to provide spatially resolved variation of gas kinematics through has revolutionised



Top: Representation of the top two panels of Fig. 5 and 6 from Girdhar et al. 2022 showing enhanced kinematics in ionised and molecular gas of J1316+1753, a prototype of multi-phase observation of jet-ISM interaction. Bottom: Representation of the middle panel of Fig. 8 of Meenakshi et al. 2022 showing predicted [OIII] emission and line widths (W80) from simulations of jet-ISM interaction, with enhanced widths perpendicular to the jet, as also observed in multi-phase observations, such as top panel.

such studies. Although initially such studies had been confined to a few selected sources for observational convenience, large scale surveys have been initiated in recent years such as QSFeedS (Jarvis et al. 2021), QSOFEED (Ramos Almeida et al. 2022), GATOS (Garcia-Burillo et al. 2021), to identify the influence of the AGN in general and the radio jet in particular on their hosts. For a more detailed list of such observational efforts the reader is referred to the recent review by Mukherjee 2025.

Thus the combined efforts of simulations and observations have strongly established that jet driven local feedback can strongly influence the host galaxy, confirming the dual role of jets in the AGN feedback scenario. While jets are essential to drive the large scale radio/maintenance mode feedback to offset cooling flows, they also contribute to the quasar / establishment mode by affecting the local ISM, which has hitherto been neglected. This is in contrast to earlier general skepticism of the local impact of jets. However, such perceptions are starting to change. One of the major concerns of the role of jets on their host galaxy was whether they have enough gas in the first place to be affected by jets. The traditional view has been that in the nearby universe, powerful radio jets are usually found in early type galaxies (ETG), which were considered to be gas poor. However, in the last decade, systematic surveys of such systems have uncovered a significant fraction (~34% Tadhunter et al. 2024) to have dense gas to the order of 107-107 M⊙ . Radio-loud galaxy (RLG) fraction hosting dense gas has also been found to increase with red-shift (Audibert et al. 2022). Thus a significant fraction of RLG have dense gas and are expected to undergo the feedback processes outlined above. Another point disfavouring the role of jets was the low fraction of RLG in earlier galaxy surveys (~10-30%), indicating the radio loud phase comprises a small fraction of galactic lifetimes. However, again, recent deeper surveys by advanced instruments such as LOFAR has changed this, and find a higher fraction of such sources in general, with all galaxies showing some level of radio-AGN activity at lower luminosities (Sabater et al. 2019).

However, in spite of these advances, this field is still yet to fully mature. Most observational and even simulations provide a single snapshot of the galaxy during its evolutionary course. The long term impact of such activities both on the evolution of the gas and stars is not well studied both in observations and theory.

Some recent large-scale surveys have attempted to address this by identifying the global impact of the jet on molecular gas (e.g. Molyneux et al. 2023) or presence of large-scale disturbance in gas kinematics (Kukreti et al. 2023). The broad results are that although ionised outflows are found in a large fraction of RLGs, global scale impact on the kinematics of the dense gas is lacking. However, the central few kpc are certainly strongly affected in all systems. Thus it appears that jets do affect the properties of the nuclear region of galaxies and large scale region might show transient effects. More detailed studies on this topic with upcoming telescopes such as SKA, NgVLA, TMT etc can help provide a consensus.

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Dr. Dipanjan Mukherjee is an Associate Professor at IUCAA. Prof. Mukherjee's research interests are primarily on the topic of computational astrophysics with a broad region of application, from fluid flows near compact objects to galaxy evolution and physics of relativistic jets.

Dynamical transitions in stars- a data driven approach

Recent research at all levels is highly mediated by digital data, either experimental or observational, and the increase in the availability of a large number of data sets makes this all the more demanding. This is especially so in the area of astronomy and astrophysics, where large amounts of observational data are waiting to be analysed for an understanding of the astrophysical sources and events that generate the data. Hence, computationally efficient and reliable algorithms that can extract knowledge out of data is the need of the day.

Most often, the dynamical processes guiding the evolution of such sources like stars are not fully understood, and we have to depend on observational data to arrive at their dynamics, which necessitates a data driven approach in their study. In this context, the techniques developed in nonlinear time series analysis provide powerful methods to detect nontrivial structures in such data that will indicate the nature of the underlying dynamics. We will see how these techniques can be applied to observational data of the light curves from stars to reconstruct the dynamics, so that we can understand the variability and transitions in their dynamics.

Let us start with the familiar example of a pulsating irregular variable star for which stellar pulsations result in irregular light curves. The reconstruction techniques discussed below give strong evidence that the light curves of many variable stars like R UMi, RS Cyg, UX Dra, SX Her, W Vir, R Scuti, etc. are generated by a low-dimensional chaotic pulsational dynamics[1,2].

To reconstruct the dynamics of a star from its light curve or intensity data, the method of time delay embedding is used by defining delay vectors on its phase space of dimension M as,

$$\bar{X} = [x(i), x(i+\tau), x(i+2\tau), \ldots . x(i\,(M-1)\tau]$$

Here, τ is the delay time and M is the embedding dimension of the reconstructed phase space. One of the methods to estimate τ is to look for the time when the autocorrelation $C[\tau]$ falls to 1/e of C[0], and that for M is the method of False Nearest Neighbours [3]. The intricate dynamical structure of the reconstructed dynamics is then captured from the recurrence pattern of its trajectory points in the M-dimensional phase space. For this, the recurrences are defined as points which are closer than a chosen threshold ε and a 2-d Recurrence Plot (RP) is derived from them, displaying all the recurring points.

We mention two important measures defined on the RP, Determinism(DET), which comes from the distribution of diagonal line segments and Laminarity (LAM) from that of vertical line segments. These reflect the nature of the dynamics and hence can differentiate periodic, chaotic, and noisy dynamics.

Sudden changes in dynamics can occur with small changes in the parameters or can be induced by stochastic effects. Such changes in the dynamics, called critical transitions, will cause variations in the phase space structure even prior to the transition and therefore can be detected and quantified by recreating the dynamics over time in windows that are shifted over the data. The corresponding changes in the pattern of recurrences can be analysed using DET and LAM, calculated in each window over time. Then the transitions in dynamics will become evident as significant changes in these measures. They can even be tailored to predict upcoming transitions or major changes in dynamics. Our recent research on the data from Betelgeuse illustrates the efficiency of this procedure [4].

Betelgeuse [α Orionis, HD 39801, M1-

M2Ia-Ibe, V = 0.2 to 1.3] is an especially bright star, a red supergiant, whose intensity variability makes it a semiregular variable star, off the main sequence. The interest in this star suddenly increased at the end of 2019 because of a dimming and subsequent rapid brightening event that took place during 2019-2020. This historic event, called the Great Dimming, caught the attention of astronomers and the general public worldwide. Multiple hypotheses were suggested to explain this dimming, including the formation of a dust cloud, changes in the photosphere, the presence of spots on the stellar surface and cooling in convective cells, but these could not be validated by later studies.

We examined whether the dimming and brightening event of 2019–20 could be due to a critical transition in the pulsation dynamics of Betelgeuse by studying the characteristics of the light curve prior to the transition from the AAVSO International Database. For this, the light curve of Betelgeuse was binned into ten-day bins to examine the long trends in the data. The quantifiers, DET and LAM, were calculated over moving windows with a size of 300 points by one data point at a time. The corresponding RPs are constructed for each window and plotted against time to check for any significant variations over time. (Fig1)

We find DET and LAM both increase systematically as the dimming episode approaches, which is an indication of a dynamical transition (Fig 2). We extended the analysis to multiwavelength data from different bands in the photometry data collected from the Wing photometry (IR/near-IR) and Wasatonic observatory (V-band)[5]. We found the changes were simultaneous in all wavelengths, which means the dimming was not a surface phenomenon. It should be related to a dynamical process that affected the whole star, with a change in its pulsation dynamics. Some of the later studies found increased prominence of the ~180-day period post dimming, supporting our conclusions.

Thus, signatures of an approaching change in the underlying dynamics could be observed from the changes in the recurrence measures that capture changes in the dynamical structure of the light curve of the star. In addition to gaining insight into the nature of dynamics, the method of reconstruction of dynamics from data, followed by analysis of the measures from its recurrence patterns, can help to understand transitions in dynamics. We see several applications in astrophysical data analysis, in classifying sources based on the nature of their dynamics, understanding the nature of transitions and more importantly, identifying measures that can predict an approaching transition.

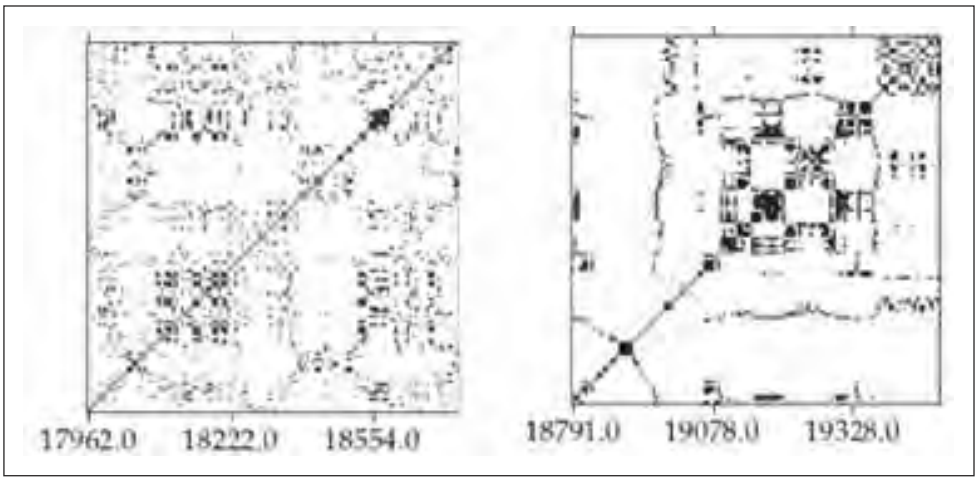

Fig 1. Recurrence plots calculated from the light curve of Betelgeuse before (left) and during (right) dimming.

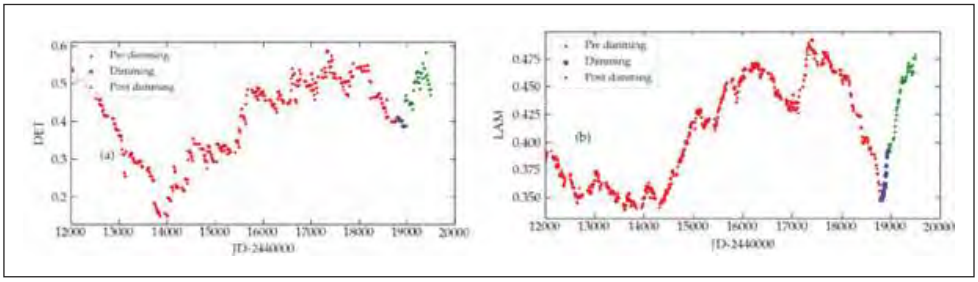

Fig 2. Recurrence measures (a) Determinism (DET) and (b) Laminarity (LAM) before dimming (red), during (blue), and post dimming (green).

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Prof G Ambika is a theoretical physicist specialising in the area of Nonlinear Dynamics, Complex systems and time series analysis. She is currently Professor(Hon) in the school of Physics, at the Indian Institute of Science Education and Research Thiruvananthapuram and a Visiting Associate of IUCAA, Pune. She is also an Editorial Board Member, Philosophical Transactions of the Royal Society A, London and The European Physical Journal Special Topics (EPJST), and Vice President, Society for Nonlinear and Complex Systems (SoNCoS), India.

Prof. G. Ambika has active participation and involvement in the women-centric schemes & programs under DST, as Chairperson, Subject Expert Committee (SEC), Physical & Mathematical Sciences, WISE PhD and WISE PDF and Member, Programme Advisory Committee (PAC) under CURIE and WIDUSHI. She has a passion for painting and art and does oil paintings inspired by scientific themes.

Events at IUCAA

2nd Daksha Workshop: Indian Eyes on Transients Skies

The Second Daksha Science Workshop was held at the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, on March 29-31, 2025, in a hybrid format. The workshop successfully brought together a wide audience, comprising about seventy participants attending in person and over a hundred joining virtually. The event received an enthusiastic response from the scientific community and served as a vibrant platform for the exchange of ideas and ongoing research related to the Daksha mission.

The workshop featured a series of talks and discussions focusing on key scientific themes central to the Daksha mission. Topics included gamma-ray bursts (GRBs), electromagnetic counterparts of gravitational wave (EMGW) sources, solar phenomena, terrestrial gamma-ray flashes, and multi-wavelength observational strategies. The sessions encouraged collaboration among researchers, students, and domain experts, fostering a deeper understanding of high-energy astrophysics and advancing the scientific goals of the Daksha initiative. The workshop was coordinated by Gulab Dewangan (IUCAA) and Varun Bhalerao (IIT, Mumbai).

IUCAA Workshop on AI/ML Applications to Astronomy & Astrophysics (AMAA)

The IUCAA workshop on AI/ML in Astronomy and Astrophysics (AMAA) was held from January 6-10, 2025. It was jointly organised by Ajit Kembhavi (IUCAA) and Arif Babul (University of Victoria, Canada). The primary objective of the workshop was to foster collaboration among researchers in India and abroad working on the rapidly evolving field of machine learning applications in astronomy, astrophysics, and related areas.

The academic program featured a combination of invited and contributed lectures, panel discussions, and hands-on demonstration sessions. The workshop covered a broad spectrum of AI/ML techniques, including traditional machine learning, deep learning, generative AI, natural language processing, and large language models. Applications in astronomy and astrophysics included cosmological galaxy formation simulations, gravitational waves, galaxy morphology, spectral classification of stellar, galaxy, and AGN spectra, solar astronomy, and time-domain astronomy.
The workshop was hosted by ten leading international experts and was attended by a hundred in-person participants, including faculty members and young researchers from India. Additionally, nearly a hundred participants joined the sessions online. The event provided a platform for researchers to exchange knowledge, discuss advancements, and explore potential collaborations in the application of AI/ML to astronomy and astrophysics. The workshop was coordinated by Arif Babul (Univ. of Victoria, Canada) and Ajit Kembhavi (IUCAA).

Events outside IUCAA

National Conference on Data Science Innovations in Astronomy (NCDSIA)

The National Conference on Data Science Innovations in Astronomy (NCDSIA) was successfully held on January 3-4, 2025, at Amity University Kolkata. This event brought together experts and researchers to explore the integration of data science and astronomy. Organised collaboratively by Amity University Kolkata and ICARD Kolkata, sponsored by IUCAA, Pune, the conference saw the participation of approximately seventy attendees. The event comprised a series of insightful sessions, keynote addresses, and poster presentations. The inaugural session featured addresses by eminent personalities, including Asis Kumar Chattopadhyay and Sanjeev Dhurandhar, who highlighted the vital role of data

science in expanding the understanding of the universe.

A special memorial session was dedicated to the late Tanuka Chattopadhyay, recognising her invaluable contributions to the field of astrostatistics. In this session, her lifelong collaborators, including Asis Kumar Chattopadhyay and Didier Fraix-Burnet, presented their final collaborative works with her. The first day concluded with technical presentations on solar astrophysics and an engaging poster session that provided a platform for students and early-career researchers to showcase their innovative studies.

The second day of the conference continued with a series of technical sessions chaired by distinguished experts. These sessions focused on advanced computational methods in astrophysics, the application of artificial intelligence in gravitational wave detection, and statistical modeling for cosmic microwave background analysis. A highlight of the day was the poster competition, where young researchers presented their work. Sraddha Biswas (Indian Centre for Space Physics) secured the first position, while Aswathy S. (Providence Women's College, University of Calicut) secured the second position. The conference concluded with a valedictory session led by Abisa Sinha Adhikary, convenor of the seminar, who expressed gratitude to the sponsors and participants. Contributions from the seminar were encouraged to be submitted for publication in a special bulletin of the IAPQR Transactions, ensuring that the groundbreaking discussions and innovations presented at the conference would be documented for future reference. The conference was coordinated by Abisa Sinha (Amity University) and Asis K. Chattopadhyay (University of Calcutta).

Focused Meeting on Cosmology and Gravitation

A focused Meeting on Cosmology and Gravitation was held from January 08-10, 2025, at the Department of Physics, Gauhati University (GU), Assam, in collaboration with IUCAA, Pune. The primary aim of the meeting was to commemorate the century of developments in cosmology since Friedmann's publication of the first relativistic expanding cosmological models between 1922 and 1924. The event brought together experts and researchers in the field of gravity and cosmology, focusing on current challenges and developments in these areas. The target audience for the meeting included Ph.D. students, Post-Doctoral Fellows, and faculty members working in cosmology and gravitation. The meeting was inaugurated by Utpal Sarma (Registrar, Gauhati University), who welcomed the participants and set the tone for the discussions. The inaugural talk was delivered by Naresh Dadhich (former Director and Emeritus Professor, IUCAA), who discussed the historical development of cosmology. He also presented lectures on the physical aspects of general relativity

and the nature of gravitationally collapsed objects. Naresh Dadhich also engaged the public with a special talk on the conceptual development of general relativity. Kanak Saha (IUCAA) contributed to the discussions by presenting talks on the high redshift universe and the astrophysics of JWST observations, with a focus on cosmic reionisation history. Pravabati Chingangbam (IIA) spoke about testing the Cosmological Principle through observations, while Shadab Alam (TIFR) discussed methods for testing general relativity, dark energy physics, and modified gravity theories by observing large-scale structures. Umananda Dev Goswami (Dibrugarh University) spoke about the possibility of testing modified

gravity theories using observations of Type Ia Supernovae.

The meeting provided a platform for in-depth discussions on the frontiers of gravity and cosmology, allowing participants to engage with the latest research. Sponsored by IUCAA and the Centre for South East Asian Studies, Gauhati University, the event was attended by thirty participants, including researchers and students, who actively participated in the sessions. The focused meeting successfully honoured the centenary of Friedmann's work while

fostering meaningful scientific discussions on the current state of cosmology and gravitation. The meeting was coordinated by Sanjeev Kalita (ICARD Coordinator, Gauhati University) and Kanak Saha (IUCAA).

Radio Astronomy School

The Radio Astronomy School 2025 was held at Fergusson College, Pune, from February 17-24, 2025, under the aegis of the IUCAA Centre for Astronomy Research and Development (ICARD). Coordinated by Manish S. Hiray and Gajanan D. Harale, with overall guidance from Raka Dabhade, the event brought together forty selected undergraduate and postgraduate students from seven institutions across Maharashtra, chosen from seventy-eight applicants.

The participants included twenty-three males and seventeen female students. The week-long program featured five expert lectures by scientists from IUCAA, NCRA, and RRI, along with three hands-on sessions. Ruta Kale introduced the basics of radio astronomy, followed by sessions from Avinash Deshpande on single dish radio telescopes, Dharam Vir Lal on radio interferometry, Divya Oberoi on solar radio emissions, and Rajeshwari Dutta on the 21-cm hydrogen line in galaxy studies. Hands-on training included 21-cm hydrogen line observations with a horn antenna, led by Jameer Manur, and a radio data analysis workshop using CASA software, conducted by Sameer Salunkhe with Ph.D. student support. Participants appreciated the blend of theory and practice and valued the opportunity to engage with leading scientists. The school successfully introduced students to modern techniques in radio astronomy and inspired further interest in the field.

Exhibition: On the Shoulders of Giants

As part of ICARD activities at Fergusson College, Pune, a two-day exhibition titled '*On the Shoulders of Giants*' was held on January 15–16, 2025. The exhibition was coordinated by Raka Dabhade and conceptualised and executed entirely by undergraduate students of the Department of Physics. The exhibition was inaugurated by alumna Hamsa Padmanabhan, and the exhibits were evaluated by PMRF scholars from IISER Pune - Supritha Bhowmick, Nipun Bhave, and Deep Muzumdar (the latter two being Fergusson alumni). Special certificates were awarded to the top three teams. Open

to the public, the event attracted over 800 registered visitors, including school groups, parents, and well-wishers. Structured around ten thematic groups, the exhibition traced the evolution of Physics from early natural philosophy to modern cosmology. Each group, led by a third-year B.Sc. student and supported by juniors, promoted peer learning and teamwork. The themes included the contributions of thinkers like Copernicus, Aryabhatta, Maxwell, Tesla, Curie, Bohr, Schrųdinger, Heisenberg, Raman, Hawking, Chandrasekhar, Hubble, and Rubin, highlighting breakthroughs in fields like electromagnetism, quantum theory, nuclear physics, cosmology, and dark matter. Around sixty undergraduate students participated, creating posters, models, and demonstrations—many

handmade—including a heliocentric model, Tesla coil, double slit experiment, atomic models, Raman spectrograph, and galactic rotation visuals.

The exhibition not only engaged a wide audience but also provided students with hands-on experience in science communication, teamwork, event management, and public engagement. It fostered a deeper understanding of physics and inspired curiosity in both participants and visitors.

Tenth Southern Regional Astronomy Meeting: Astronomy Research – Opportunities and Challenges

The Tenth Southern Regional Astronomy Meeting, titled *Astronomy Research: Opportunities and Challenges*, was held from January 31 to February 2, 2025, at the Department of Physics, Cochin University of Science and Technology (CUSAT), Kochi, Kerala. The event has become a significant platform for researchers in southern India to connect, share ideas, and present their work, fostering collaboration within the regional astronomy community. The meeting was inaugurated by Junaid Bushiri (Vice-Chancellor, Cochin University). The welcome address was delivered by Aldrin Antony (Head, Department of Physics), and the vote of thanks was proposed by Charles Jose, one of the meeting coordinators.

Over the course of three days, forty-three researchers and nine faculty members presented their work on diverse topics, including observational astronomy (planets, stars, the intergalactic medium, and galaxies), active galactic nuclei, the Sun and the solar system, exoplanets, dark matter, relativistic astrophysics, and cosmology. The program featured three plenary lectures delivered by Ajit Kembhavi (IUCAA), Ishwar Chandra (NCRA), and A. N. Ramaprakash (IUCAA). The sessions were

chaired by esteemed experts, including Titus K. Mathew (CUSAT), K. Indulekha (M G University), C.D. Ravikumar (University of Calicut), Ninan Sajeeth Philiph (AIRIIS4D), Naseer Iqbal (Kashmir University), Vinu Vikraman (Central University, Kasaragod), Blesson Mathew (Christ University), Minu Joy (Alphonsa College), Debhijoy Bhattacharya (Manipal University), and Kazuyuchi Faruuchi (Manipal University). A dedicated poster session was also part of the meeting, allowing participants to showcase their latest research.

A discussion on career opportunities in astrophysics, led by Naseer Iqbal (Kashmir University), took place on the first evening. On February 1, a special session was held in memory of V. C. Kuriakose, where Babu Joseph, Ajit Kembhavi, and others reflected on his significant contributions to the regional meeting and the broader astronomy community. The meeting upheld its tradition of knowledge-sharing and fostering research collaborations, bringing together young researchers and experts from diverse fields. It provided a valuable platform for networking and discussion, further strengthening astronomy research in the region. The event was coordinated by Ranjeev Misra (IUCAA), Charles Jose (CUSAT), and Joe Jacob (ICARD, Newman College, Thodupuzha).

Workshop on Optical Astronomy

A three-day workshop on Optical Astronomy was organised by the Department of Physics, St. Thomas College, Ranni, in collaboration with ICARD (Newman College, Thodupuzha) and the Centre for Excellence in Astronomy and Astrophysics, CHRIST (Deemed to be University), Bengaluru, from February 28 to March 02, 2025. The workshop brought together thirty-nine undergraduate students from fifteen colleges, including five participants from outside Kerala. The event was inaugurated by Ninan Sajeeth Philip (Senior IUCAA Associate and Dean & Director of AIRIS4D, Thelliyoor, Kerala). The welcome address was delivered by Anju Joseph (Head, Department of Physics), and the session was presided over by Sneha Elcy Jacob (Principal, St. Thomas College). Felicitations were offered by Sreeja S. Kartha and Joe Jacob, with a vote of thanks by Marykutty James.

Introductory lectures on astronomy were delivered by Joe Jacob and Sreeja S. Kartha, followed by hands-on training sessions. Akhil Krishna R. (Research Scholar, CHRIST University) led a session on FITS image fetching and processing, while Arun Roy (Post-Doctoral Fellow, IIA) conducted a session on Python programming for astronomical applications. On the second day, R. Srianand (Director, IUCAA) delivered a lecture on the challenges of galaxy formation in the early universe. This was followed by a session on stellar clusters by Sreeja S. Kartha, and hands-on activities on stellar cluster analysis using CLEA and TOPCAT by Nidhi S. Sabu (CHRIST University). The day concluded with an Astropy-based practical session on stellar spectra analysis, led jointly by Nidhi S. Sabu and Arun Roy, and an interactive discussion with participants.

The final day began with a second lecture by R. Srianand (Director, IUCAA), who focused on India's upcoming mega-science projects. Advanced sessions on astronomical data handling and galaxy redshift estimation using Python were then conducted by Akhil Krishna R. and Arun Roy. The workshop concluded with a valedictory session featuring participant feedback and reflections. Sreevalsa K. (St. Thomas College) delivered the concluding vote of thanks. The workshop successfully blended theoretical insights with practical training, sparking strong interest in optical astronomy among participants. It was coordinated by Sreeja S. Kartha (IUCAA Associate and Associate Professor, CHRIST University) and Joe Jacob (Coordinator, ICARD, Newman College, Thodupuzha) and Ranjeev Misra (IUCAA).

Tensions and Anomalies on the Sky: Quest for New Physics at Cosmological Scales

A three-day workshop titled 'Tensions and Anomalies on the Sky: Quest for New Physics at Cosmological Scales' was organised at the Centre for Theoretical Physics, Jamia Millia Islamia, from March 06-08, 2025. The event was supported by the IUCAA Centre for Astronomy Research and Development (ICARD) and the Anusandhan National Research Foundation (ANRF). The workshop brought together forty-seven participants from various institutes and universities across India. Among them were thirteen distinguished plenary speakers representing premier institutions such as Ashoka University, BITS Pilani, IISc Bengaluru, IISER Kolkata, IMSc Chennai, ISI Kolkata, IUCAA, Jamia Millia Islamia, NCRA-TIFR, Pune, SGT University, TIFR Mumbai, and Visva-Bharati. In addition to the plenary talks, the program included ten research presentations by Ph.D. students and postdoctoral researchers, as well as nine poster presentations by research scholars.

The event facilitated vibrant discussions and encouraged collaborative efforts within the scientific community on the topic of emerging tensions and anomalies in cosmological observations. The workshop proved to be highly successful in promoting scholarly interaction and advancing the discourse on the quest for new physics at cosmological scales. The workshop was coordinated by Anjan Ananda Sen (Jamia Millia Islamia) and Anupam Bhardwaj (IUCAA).

Workshop on Stellar Evolution and Pulsation Modelling

A two-day workshop on Stellar Evolution and Pulsation Modelling, organised by the Department of Physics, DDU Gorakhpur University, Uttar Pradesh, in collaboration with IUCAA, Pune, was held from March 24-25, 2025. The workshop provided a platform for students and researchers to explore the field of stellar astrophysics through lectures, discussions, and hands-on training. Approximately fifty participants attended the hands-on sessions, while twenty-five participants engaged in both lectures and practical training. The resource persons for the workshop included distinguished experts from IUCAA and BHU, who delivered insightful lectures on various topics. Anupam Bharadwaj (IUCAA) provided in-depth discussions on stellar evolution and pulsation modelling, covering theoretical aspects and computational techniques. Prasanta Bera (BHU) delivered a talk on late-type degenerate stars, focusing on their physical properties and evolutionary pathways. Raj Prince (BHU) presented an engaging lecture on Active Galactic Nuclei (AGN), discussing their role in galaxy evolution and high-energy astrophysics. A

key highlight of the workshop was the hands-on session, where students gained practical experience with MESA (Modules for Experiments in Stellar Astrophysics). They successfully traced the life cycles of stars across various mass ranges, enhancing their computational astrophysics skills.

On the first day, all speakers delivered introductory lectures, which progressively transitioned to more advanced concepts over the course of the workshop. The final session concluded with an open Q&A, discussions on basic astrophysics, and closing remarks. Participants received certificates upon completion of the workshop. Shantanu Rastogi (ICARD Coordinator, Gorakhpur) chaired the session. The event was a valuable and enriching experience, combining theoretical insights with practical applications, inspiring participants to further explore the field of stellar astrophysics. The workshop was coordinated by Apara Tripathi (DDUGU), Prabhunath Prasad (DDUGU) and Anupam Bhardwaj (IUCAA).

Farewell to...

Tathagata Ghosh, Bikram Keshari Pradhan and **Partha Pratim Deka**, Senior Research Fellows, who left IUCAA at the end of their tenure.

Colloquium

30.02.2025 Prof. Santosh Vadawale on ***The Alpha Particle X-ray Spectrometer (APXS) onboard Pragyan rover of the Chandrayaan-3 mission - an incredible journey.***

20.02.2025 Prof. Subhadeep De on ***Instrumentation for Sensing with Unprecedented Accuracy.***

27.02.2025 Prof. Debarati Chatterjee on ***Unravelling the interior of Neutron Stars with Gravitational Waves.***

13.03.2025 Prof. Jnanadeva Maharana on ***An Odd Story.***

20.03.2025 Prof. Vaidehi Paliya on ***High Energy Emission from Cosmic Beacons***.

Seminars

02.01.2025 Dr Divya Rawat on ***Evolution of the Comptonizing medium of the black-hole candidate Swift J1727.8–1613 along the accretion state transition using NICER.***

14.01.2025 Dr. Alberto Roper Pol on ***Gravitational waves from turbulence in the early Universe.***

16.01.2025 Dr. Swagat Saurav Mishra on ***Inflationary Gravitational Waves as a Probe of the Unknown Expansion History of the Early Universe.***

23.01.2025 Kaustav Kashyap Das on ***The Faint and the Furious: What are the Lowest Mass Stars that Explode as Core-Collapse Supernovae?***

28.01.2025 Dr. Tanmoy Chattopadhyay on ***Development of fast, low noise X-ray detectors for the next generation astronomical observatories.***

04.02.2025 Dr. Swetha Bhagwat on ***Learning About Nature Of Gravity and Black Holes Using Gravitational Wave Observations.***

13.02.2025 Dr. Yash Bhargava on ***Delving deeper into the enigmas of highly accreting Neutron star X-ray binary GX 340+0.***

18.02.2025 Dr. Aru Beri on ***Unraveling Accretion and Magnetic Field Configurations in X-ray Pulsars.***

25.02.2025 Dr. Arghajit Jana on ***Opportunities and Challenges in Decoding Changing-Look AGNs with Multiwavelength Observation.***

06.03.2025 Dr. Vaibhav Tiwari on ***A rapid advance in our understanding of binary black hole population.***

11.03.2025 Dr. Swagat Saurav Mishra on ***New Frontiers in Preheating: The Gateway from Inflation to the hot Big Bang in the early Universe.***

18.03.2025 Dr. Suman Bala on ***Cosmic Fireworks: Unlocking the Mysteries of Gamma Ray Bursts.***

25.03.2025 Dr. Dimple Panchal on ***Compact Binary Mergers: GRBs, GWs, and the Dawn of Multimessenger Astrophysics.***

Public Outreach Activities

Outreach Activities at IUCAA

A special session was conducted for IUCAA Post-Doctoral Fellows on January 02, 2025. The session included an interactive discussion on outreach opportunities, followed by a skywatch session, aimed at encouraging greater engagement in public science communication among early-career researchers.

Outreach by Associates and ICARD

As part of its outreach support to Associates and ICARDs, IUCAA facilitated several educational initiatives across the country:

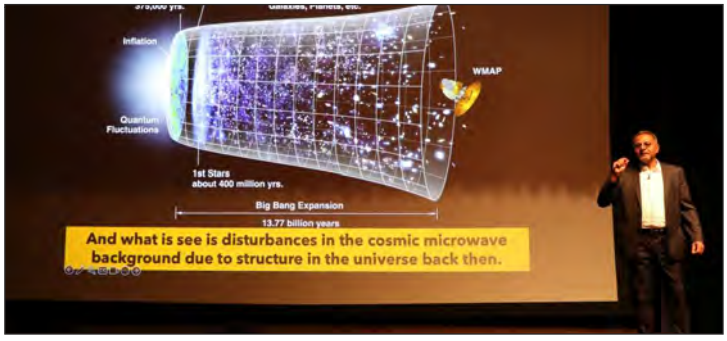
- A *Basic Astronomy and Telescope Making Workshop* was held on January 11–12, 2025, at St. Claret PU College, Bengaluru. The workshop, proposed by S. B. Gudennavar (ICARD, Christ University), was conducted by Samir Dhurde and Tushar Purohit. It engaged 70 students and 10 teachers and culminated in the successful making of 23 telescopes.

- During *AstroWeek* at IIT Gandhinagar, organised by Anand Sengupta, Samir Dhurde delivered a lecture and led amateur astronomy activities, including a public skywatch attended by approximately 200 participants.

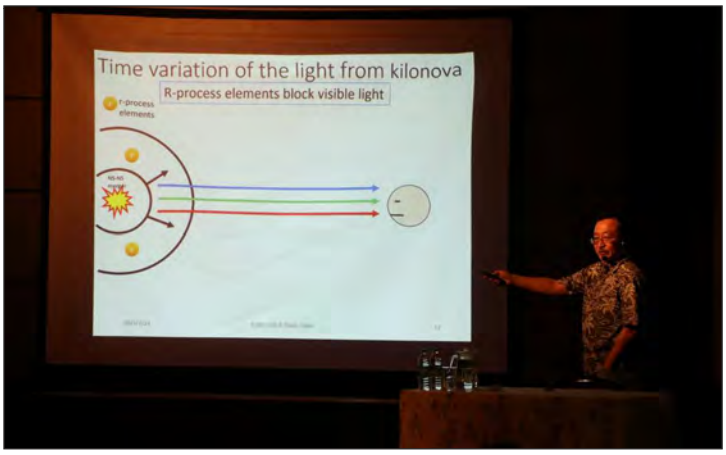
- Another telescope-making workshop was organised from March 19–21, 2025, by Prof. Hemwati Nandan (HNB Garhwal University). Maharudra Mate and Tushar Purohit conducted the sessions, guiding 63 students and 5 teachers in building and testing four telescopes.

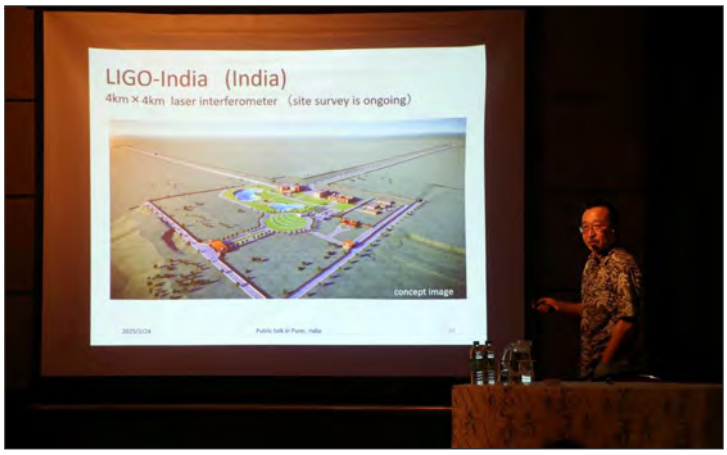
Chandra Public Lectures

As part of IUCAA's public engagement initiatives, two *Chandra Public Lectures* were delivered:



Arif Babul (University of Victoria, Canada) presented a lecture titled *"How Did the Universe Come to Look the Way It Does?"*

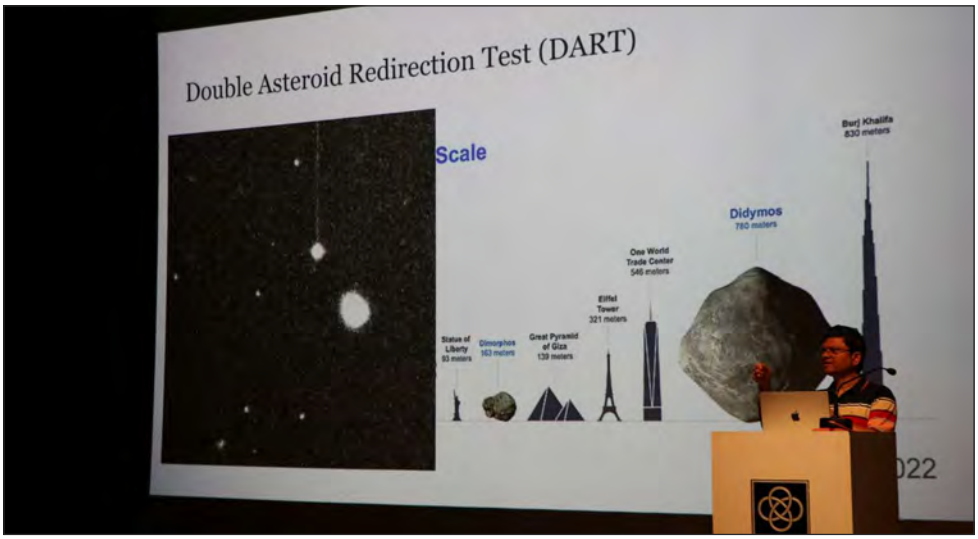




Michitoshi Yoshida [Vice-Director General, National Astronomical Observatory of Japan] delivered a talk titled '*Striking Gold with Gravitational Waves*'

Second Saturday Lectures and Demonstrations

IUCAA continued its monthly Second Saturday public engagement series with the following talks and demonstrations:



Ashish Mahabal [Caltech, USA] delivered a lecture on '*Astronomy, Artificial Intelligence, and the Future*'

Madhav Khare [Founder and Trustee, Shastravahini, Pune] presented a demonstration session on '*The Science of Flight*'

Regular Workshops, Visits, and Outreach Events

1. **Astronomy Workshop & Sky Observation**
   C.T. Bora College of Arts, Commerce & Science, Shirur (2 January)
   Attended by 500 students and teachers.

2. **Astronomy, Optics & Science Toys Session**

   S.P.S. College of Education, Sangli (9 January)
   Attended by 50 students

3. **Sky Observation Session**

   T.C. College, Baramati (10 January)
   Attended by 550 students and teachers.

4. **Sky Observation Session**

   Ratnai Mahila Mahavidyalaya, Rajgurunagar (11 January)
   Attended by 85 students and teachers.

5. **Astronomy and Telescope Session**

   Shibumi School, Bengaluru (13 January)
   Attended by 80 students and 4 teachers

6. **Rural Teachers' Training Workshop (Astronomy & STEM)**

Annasaheb Awate College, Manchar (17–18 January)
Attended by 40 teachers



7. **STEM & Astronomy Lab Training Workshop**

SVS High School, Khadki (22 January)
Attended by 25 teachers





8. **Sky Observation Session**

In collaboration with the Centre for Science Education and Communication (Savitribai Phule Pune University) (24 January)
Attended by 500 members of the public

9. **Sky Observation Session**

Avasara Academy, Pune (24 January)
Attended by 90 students and teachers


10. **Telescope Making Workshop & Sky Observation Session**

KTHM College of Science, Nashik (27–28 January)
Attended by 140 teachers

11. **Sky Observation Session for Schools**

Panchayat Samiti, Wai (3 February)
Attended by 600 students and teachers

12. **Sky Observation Session**

V.P.'s Vinodkumar Gujar Bal Vikas Mandir, Baramati (3 February)
Attended by 950 students and teachers.

13. **Presentation on IUCAA Education & Outreach at EduConclave 2.0**

Organised by Pune Knowledge Cluster (5 February)
Attended by 35 teachers.

14. **LIGO-India Starfest & Teachers' Workshop**

Hingoli (5 February)
Attended by 35 teachers.

15. **Sky Observation Session**

Podar International School, Kolhapur (8 February)
Attended by 2,500 students and teachers.

16. **Astronomy Workshop & Sunspot Observation**

For DIET Teachers from Palghar District (4 March)
Attended by 25 teachers.

17. **Talk on Research at IUCAA**

Annasaheb Awate College, Manchar (4 March)

18. **Science Toys Workshop & Sky Observation Session**

State Reserve Police Force (SRPF), Daund (8 March)
Attended by 500 people.

19. **Astronomy Workshop**

For DIET Teachers from Satara District (17 March)
Attended by 37 teachers.

20. **Astronomy Workshop**

For DIET Teachers from Chhatrapati Sambhajinagar District (19 March)
Attended by 25 teachers.

21. **Astronomy Workshop**

For DIET Teachers from Nanded District – Batch I (19 March)
Attended by 72 teachers.

22. **Astronomy & Optics Workshop**

For Zilla Parishad School Students, Dharshiv (24 March)
Attended by 67 students and 5 teachers.

23. **Astronomy Workshop**

For DIET Teachers from Nanded District – Batch II (25 March)
Attended by 72 teachers.

24. **Telescope Making Workshop & Sky Observation Session**

Rajiv Gandhi Academy of e-Learning (26–27 March)
Attended by 10 students and 2 teachers.

25. **Messier Marathon**

Parut Village, Mahabaleshwar (28 March)
Attended by 10 amateur astronomers.

IAU-Related Outreach

As part of the International Astronomical Union's (IAU) co-National Outreach Coordinator (co-NOC) team for India, Samir Dhurde contributed to the international *"Equal Day"* pilot events held on March 20, 2025. Supported by the IAU Office of Astronomy for Education, this global initiative witnessed the registration of 135 events worldwide and was considered a significant success in promoting astronomy education and public engagement.

In another IAU-aligned outreach effort, Samir Dhurde participated in *Nakshatra Sabha*, an astro-tourism event, where he delivered a talk titled *"Dark Sky Conservation: Current Worldwide Efforts and Challenges."* The session highlighted global initiatives and obstacles in preserving dark skies, bringing attention to light pollution and sustainable skywatching practices.

Astronomy Centre for Educators

Malaviya Mission Teacher Training Centre

Workshop on Astronomy, Science, and Society

A two-day workshop on *Astronomy, Science, and Society* was jointly organised by the Maharashtra State Faculty Development Academy (MSFDA), Pune, and the Astronomy Centre for Educators (ACE) of IUCAA at G.H. Raisoni International Skill Tech University, Pune, on February 20–21, 2025. This recurring program, conducted several times a year across different regions of Maharashtra, is designed for faculty members from all academic disciplines—sciences, arts, humanities, and professional courses—in institutions of higher education.

The February edition marked the first program of the year and was attended by approximately 40 faculty members from across Maharashtra. The workshop aimed to explore the scientific and societal dimensions of astronomy through expert presentations, interactive sessions, and night sky observations. The program commenced with an introductory session on the night sky and celestial objects by Jameer Manur. Participants were introduced to how the Universe reveals different characteristics when observed across various wavelengths of the electromagnetic spectrum. To illustrate this, Ruta Kale (NCRA) presented the radio view of the Universe, while Vaidehi S. Paliya (IUCAA) discussed the high-energy perspective. Prakash Arumugasamy conducted a timeline-based quiz on astronomical discoveries, emphasising the non-intuitive nature of many cosmic phenomena and introducing techniques to grasp the vast numerical scales associated with astronomical measurements. The first day concluded with an open-air rooftop session that included night sky observations and telescope viewing,

facilitated by Jameer Manur and Tushar Purohit.

On the second day, Sneha Pandit delivered a talk on the Sun, highlighting its significance in modern life and its connection to the potential for life in planetary systems. Rajeshwari Dutta followed with an in-depth presentation on the interstellar medium, detailing its composition, processes, and observation methods. In the afternoon, Dhruba Saikia presented a talk on the importance of inclusive scientific communities, sharing narratives of scientists from marginalised backgrounds and reflecting on the broader societal implications of their journeys. The workshop concluded with an interactive Q&A session led by D. J. Saikia.

A notable feature of the workshop was the inclusion of three short bird-watching sessions. During these, participants catalogued 14 bird species, including a sighting of the Asian Green Bee-eater

captured with the Moon in the background by a participant from Symbiosis International University. As a result of these sessions, G.H. Raisoni International Skill Tech University was registered as a restricted-access birding hotspot on eBird.org, with 15–20 participants actively contributing to the activity.

The workshop was coordinated by Surajkumar Babar, Bhargav Valanju, and Rutuja Tambe from MSFDA, in collaboration with Team ACE from IUCAA. The event effectively combined scientific exploration with interdisciplinary engagement, offering participants a broadened understanding of astronomy and its relevance to society.

LIGO-India Education and Public Outreach (LI-EPO)

LIGO-India is an upcoming gravitational wave detector in India, set to join the global network of gravitational wave observatories, which includes LIGO (USA), Virgo (Europe), and KAGRA (Japan). This mega-science initiative aims to construct a 4 km Ч 4 km "L"-shaped interferometer in the Aundha-Nagnath Taluka of Hingoli District, Maharashtra. The project is being developed under the aegis of the Department of Science and Technology (DST) and the Department of Atomic Energy (DAE), Government of India, through a Memorandum of Understanding with the National Science Foundation (NSF), USA. The four principal institutes involved in the LIGO-India project are the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune; the Directorate of Construction, Services and Estate Management (DCSEM), Mumbai; the Institute for Plasma Research (IPR), Gandhinagar; and the Raja Ramanna Centre for Advanced Technology (RRCAT), Indore. The LIGO-India Education and Public Outreach (LI-EPO) program is committed to nurturing a vibrant community of young individuals interested in the interdisciplinary field of gravitational wave science. One of its key goals is to inform students in STEM fields about career opportunities within this emerging domain. LI-EPO also bridges the gap between scientists and the general public through interactive talks, public events, and participation in national science festivals. Furthermore, the program actively engages with the residents of Hingoli, where the detector is being built, to raise awareness and ensure local involvement, while also advocating the project's significance to policymakers and stakeholders.

Categories of Outreach

LIGO-India's outreach activities are broadly classified into four categories:

- **National Outreach:** Promoting awareness of gravitational wave astronomy and LIGO-India across the country and encouraging students to pursue careers in this field.
- **Hingoli Outreach:** Building strong connections with the local Hingoli community and keeping them well-informed about the project's developments.
- **Social Media Outreach:** Using online platforms to disseminate information and highlight career opportunities to the youth.
- **International Outreach:** As part of a global network of gravitational wave observatories, LIGO-India collaborates with LVK-EPO groups to plan joint outreach initiatives.

Key Outreach Activities

LIGO-Livingston Virtual Tour

With contributions from Gaurav Waratkar (Ph.D. scholar, IIT Bombay), Shreejit Jadhav (Postdoctoral researcher, Swinburne Institute of Technology), and William Katzman (LIGO Science Education Center), a Marathi-language virtual guided tour of the LIGO-Livingston facility was developed. Specifically tailored for the Hingoli audience, this video helps visualise what the upcoming detector will resemble. Released in January 2025 via LIGO-India's YouTube and social media platforms, the video has been showcased at multiple outreach events in Hingoli and national science festivals.

Hingoli Rural School Outreach

Recognising the vital role of young minds in shaping the future of mega-science projects, LI-EPO organised two school outreach programs in Hingoli since January 2025. The team visited the APJ Abdul Kalam Lab at a Zilla Parishad school and another rural ZP school. In these interactive sessions, students learned about the LIGO-India project, gravitational wave science, and had the opportunity to ask questions. These efforts continue the tradition of engaging rural schools in the region.

Hingoli Star Fest

On February 5, LI-EPO organised a Star Fest in Hingoli, attended by over 150 teachers and astronomy enthusiasts. The event supported the creation of Khagol Manch (amateur astronomy groups) in each Taluka of Hingoli, which will regularly host astronomy events and make use of donated telescopes. With the presence of the District Collector and CEO of Hingoli, one Newtonian telescope (donated through Newton-Bhabha funds), two refractor telescopes, and a *Listening to the Universe* pop-up book in Marathi were distributed to each Khagol Manch. The fest featured a Q&A with GW scientists from IUCAA - Sudhir Gholap and Debarati Chatterjee - followed by an astronomy lecture, hands-on telescope handling sessions, and a stargazing event that brought the night sky to life for the attendees.

Fergusson College Outreach

Debarati Chatterjee (IUCAA) and Saurabh Salunkhe (IUCAA) were invited to present a special session on LIGO-India and its outreach activities at the *Frontiers in Physics* conference at Fergusson College, Pune, on February 12. Their interactive talks covered the fundamentals of gravitational wave science and discussed the diverse career opportunities offered through the LIGO-India project.

National Science Day at IUCAA

On February 28, IUCAA celebrated National Science Day, honouring Dr. C.V. Raman's contributions to science. The LI-EPO team set up an engaging booth focused on gravitational wave science. Several models and demonstrations were showcased, including:

- A perihelion shifts model of Mercury to illustrate the difference between Newtonian and Einsteinian gravity
- A scaled-down model of the LIGO-India detector
- A gravitational wave generator simulating mergers of compact objects
- A space-time fabric model explaining gravity and gravitational waves
- A gravitational wave activity kit for children
- A Michelson interferometer model to demonstrate how LIGO detects gravitational waves

These models helped demystify complex scientific concepts for a diverse audience and sparked curiosity among young visitors.

Collector and Debarati presenting Listening to the Universe ~Marathi Version to teachers

Telescope Distribution

Interferometer Model

Telescope Session

Visitors

[January – March 2025]

Hemani Acharya; Sanath Kumar S Adiga; Sushmita Agarwal; Sajad Ahmad Ahanger; Shahzada Akhter; Somi Aktar; Kewal Anand; G.C. Anupama; Kanishka Arora; Anuraag Arya; Arit Bala; Suman Bala; Arunima Banerjee; Dipankar Banerjee; Srimanta Banerjee; Sudhanshu Barway; Prasad Basu; Aru Beri; Manthan Bhagat; Swetha Bhagwat; Varun Bhalerao; Daneshwar Bhandari; Priya Bharali; Yash Bhargava; Naseer Iqbal Bhat; Pratyush Bhatnagar; Debadri Bhattacharjee; Dipankar Bhattacharya; Mahasweta Bhattacharya; Soumya Bhattacharya; Sree Bhattacherjee; Soumadip Rabindranath Bhowmick; Gautam Bhuyan; Federica Bianco; Smita Bidani; Promila Biswas; Ritabrata Biswas; Hritwik Bora; Mary Bosco; Mukhil C.; Siddharth Chaini; Soumya Chakrabarti; Chandrachur Chakraborty; Manoneeta Chakraborty; Nand Kumar Chakradhari; Hum Chand; Krishan Chand; Chandravanshi Chandra Kuma; Amom Lanchenbi Chanu; Pradip Kumar Chattopadhyay; Suchismito Chattopadhyay; Surajit Chattopadhyay; Tanmoy Chattopadhyay; Shivani Chaudhary; Suraj Kumar Chaurasia; Navin Chaurasiya; Anupama Choudhary; Bikramarka Choudhury; Madhurima Choudhury; Phanindra D.V.S.; Pravat Dangal; Kaustav Kashyap Das; Rimo Das; Rishita Das; Ujjal Debnath; Ashwin Devaraj; Laishram Saroda Devi; Ruchika Dhaka; Shashi Kumar Dhiman; Payaswinee Hoke; Mamoru Doi; Aman Dube; Broja Gopal Dutta; Sreeraj E.; Clara Froment; Jerin M. George; Tuhina Ghorui; Rohit Ghosh; Shubhrangshu Ghosh; Suprovo Ghosh; Sushant G. Ghosh; Yash Gondhalekar; Koushik Ballav Goswami; Goyal; Labanya Kumar Guha; Anshika Gupta; Soumya Gupta; Sandip Haldar; Soumyadeep Halder; Mubashir Hamid; Shravan Hansoge; Priya Hasan; Anikul Islam; Jeril George Jacob; Swaraj Rahul Jadhav; Drishty Bharat Jadia; Chetana Jain; Dhruv Jain; Arghajit Jana; Akhila K.; Avinash Kale; Vishal Kale; Naga Satyanarayana Kalidindi; Sammi Kamal; Debalina Kar; Rahul Kashyap; Ekjot Kaur; Jaskirat Kaur; Arun Kenath; Gopala Krishna; Harshit Krishna; Rajesh Kumar; Ravi Kumar; Ritish Kumar; Sahit Kumar; Sanjay Kumar; Sayan Kundu; Badam Singh Kushvah; Ofer Lahav; D. Lakshmanan; H. Lalthantluanga; Jeremie Lasue; Ashish Mahabal; Suddhasatta Mahapatra; Jnanadeva Maharana; Ritanjali Maharana; Yashrajsinh Mahida; Soumak Maitra; Joysankar Majumdar; Subhabrata Majumdar; Prajjwal Majumder; Sukanya Mallik; Sanidhya S Mallya; Ankush Mandal; Ashish Mandal; Prajakta Mane; Bari Maqbool; Sujay Vivek Mate; Sakshi Maurya; Poonam Mehta; Jay Rajesh Mestry; Preetish Kumar Mishra; Swagat Mishra; Satoshi Miyazaki; Meenakshi Mohan; Abhisek Mohapatra; Aditya Sow Mondal; Rakesh Mote; Sajal Mukherjee; Suvodip Mukherjee; Banibrata Mukhopadhyay; Mithun N.P.S.; Joe Philip Ninan; Amitesh Omar; Sreebala P.S.; Rishin P.V.; Hamsa Padmanabhan; Mayukh Pahari; Archana Pai; Main Pal; Satyajit Pal; Kanik Palodhi; Dimple Panchal; Divya Pandey; Sanjay Pandey; Brandon Panos; Mayank Pathak; Utkarsh Pathak; K.D. Patil; Rohan Pattnaik; B.C. Paul; Devraj Pawar; Ninan Sajeeth Philip; Alberto Roper Pol; Arbind Pradhan; Kumar Pranshu; Harikrishnan R.; Shyamala Bertina R.; Rohan Raha; Anisur Rahaman; Farook Rahaman; Suvendu Rakshit; M.C. Ramadevi; Dhananjay Raman; Gayathri Raman; Divya Rana; Vikram Rana; Arvind C. Ranade; A.R. Rao; Ajay Ratheesh; Divya Rawat; Zairemmawia Renthlei; Ketan Rikame; Emmanuel Rollinde; Kinjal Roy; Prabir Rudra; Krishnamurthy S; Nagabhushana S.; Namitha S.; Suhas S.S.; Sonali Sachdeva; Pradyumn Sadhu; Biju Saha; Pragati Sahu; Kavya Saravanan; Alphesunny Sarkar; Banashree Sen; Snigdha Sen; Rikpratik Sengupta; Shiv Sethi; Mohd Shahalam; Kalpana Sharma; Paryag Sharma; Pranav Sharma; Rohit Sharma; Subah Sharma; Vaibhav Sharma; Amit Shukla; Ashutosh Singh; Ramanshu P. Singh; Abisa Sinha; T. Sivarani; Chetan Sonthalia; S. Sridhar; Subham Srimani; C.S. Stalin; Hitesh Tanenia; Arun Thampan; Sarat Thomas; Neeraj Tiwari; Vaibhav Tiwari; Anshuman Tripathy; Garima Tyagi; Vishal Upendran; Thanya Uppal; Jithesh V.; Santosh Vadawale; Esther Vanlalramchhani; Vinu Vikraman; Francisco Villaescusa; M. Vivek; Nishron W.; Digvijay Wadekar; Gaurav Waratkar; Kanak Wasnik; Sarvesh Yadav; Michitoshi Yoshida; Andrzej Antoni Zdziarski; Rushikesh ; Shanmugam ; Sonali ; Sourav ; Stanzin ; Thouheeda ; Vaishnav.

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IUCAA

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