IUCAA

37th

ANNUAL REPORT
2024-25

अंतर–विश्वविद्यालय केंद्र : खगोलविज्ञान और खगोलभौतिकी

INTER-UNIVERSITY CENTRE FOR ASTRONOMY AND ASTROPHYSICS

(An Autonomous Institution of the University Grants Commission)

INSIDE

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[till 27.12.2024]
(Chairman, Governing Board)
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K. N. Satyanarayana
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Director,
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(Chairperson)

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Anupam Bhardwaj

Debarati Chatterjee

Subhadeep De

Gulab Chand Dewangan

Rajeshwari Dutta

Neeraj Gupta

Shasvath Kapadia

Sanjit Mitra

Surhud S. More

Dipanjan Mukherjee

Sowgat Muzahid

Vaidehi S. Paliya

Aseem S. Paranjape

Kanak Saha

Nishant K. Singh

Durgesh Tripathi

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[till 27.12.2024]

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[from 28.12.2024]

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IUCAA

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Niranjan Abhyankar,
SAO,
[Non-member Secretary]
[until 31.05.2024]

Senith Samuel,
SAO
(officiating)
[Non-member Secretary]
[from 01.06.2024 till 29.10.2024]

Cdr. V.K. Vijay Balaji (Retd),
SAO,
[Non-member Secretary]
[from 30.10.2024]

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R. Srianand,
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(Chairman)

A.N. Ramaprakash,
Dean,
Core Academic Programmes

Ranjeev Misra, Dean,
Visitor Academic Programmes

Niranjan Abhyankar,
SAO,
(Member Secretary)
[until 31.05.2024]

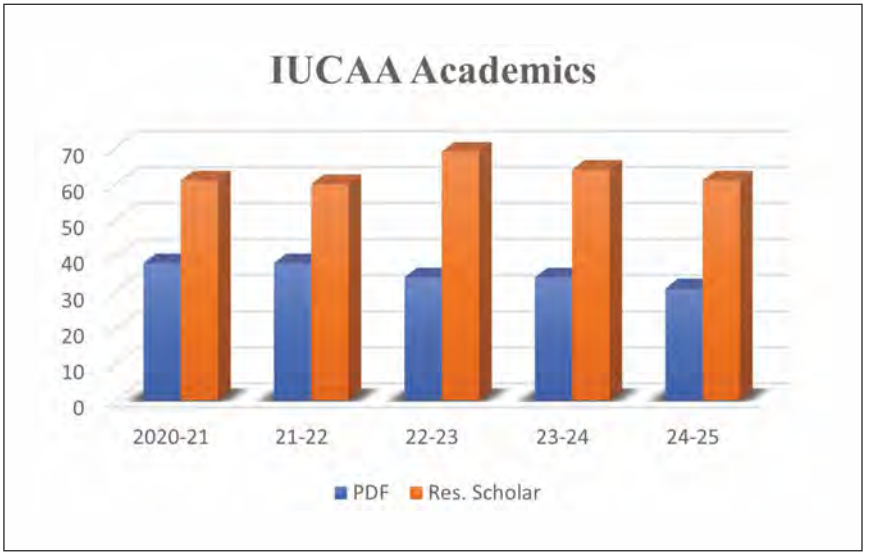
Senith Samuel,
SAO
(officiating)
(Member Secretary)
[from 01.06.2024
till 29.10.2024]

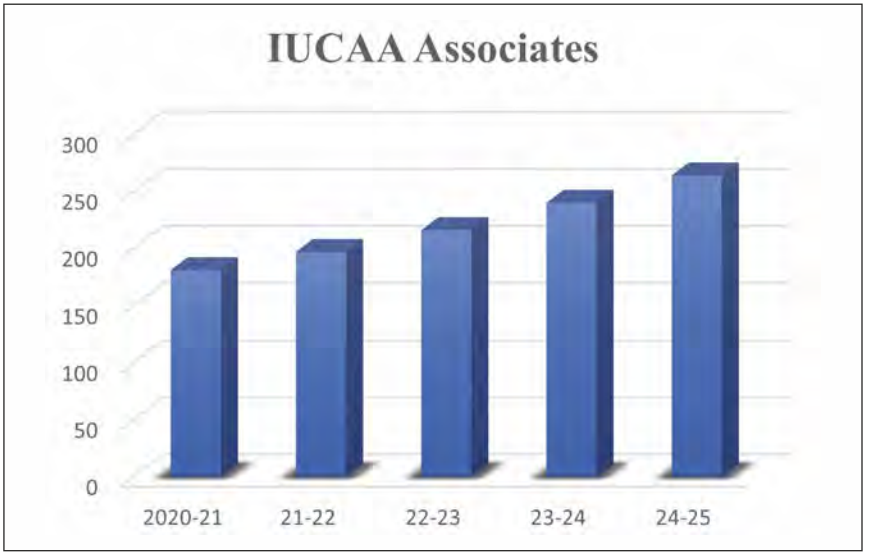
Cdr. V.K. Vijay Balaji (Retd),
SAO,
(Member Secretary)
[from 30.10.2024]

IUCAA IN NUMBERS

The IUCAA Family across the years

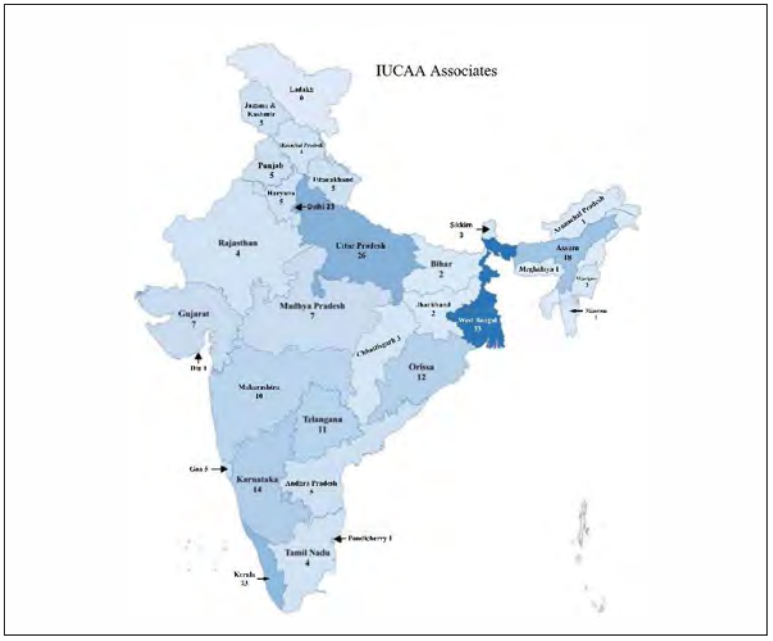
Since its inception, the IUCAA Research Scholars, Post-Doctoral Fellows and the Visiting Associates have seen a steady growth over time, with the academic strength today nearly thrice its original number





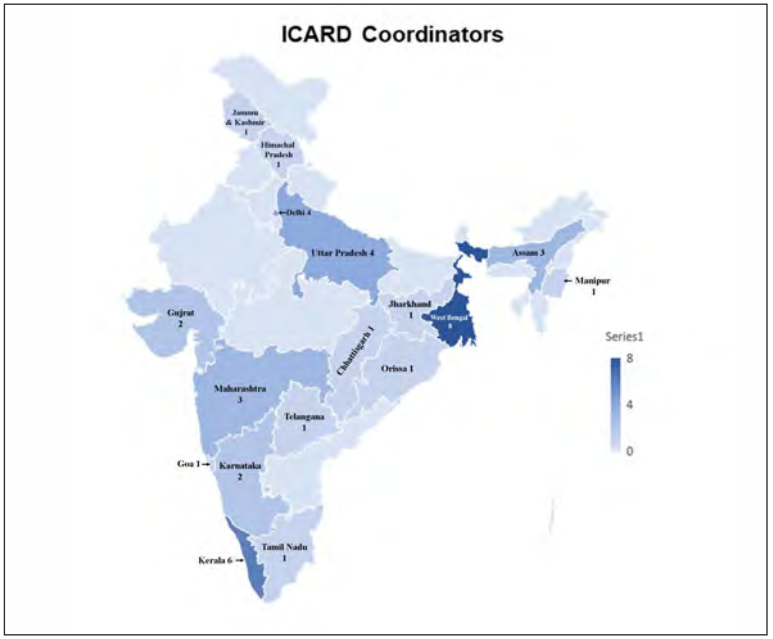
IUCAA Visiting Associates across India

The number of IUCAA Visiting Associates has continued to expand in numbers and geographically, with significant representation today from the remotest part of the country. The state-wise distribution of IUCAA Associates is depicted in the map. The number of Visiting Associates across India during 2024-25 was 264.



IUCAA Centre for Astronomy Research and Development (ICARD) across India

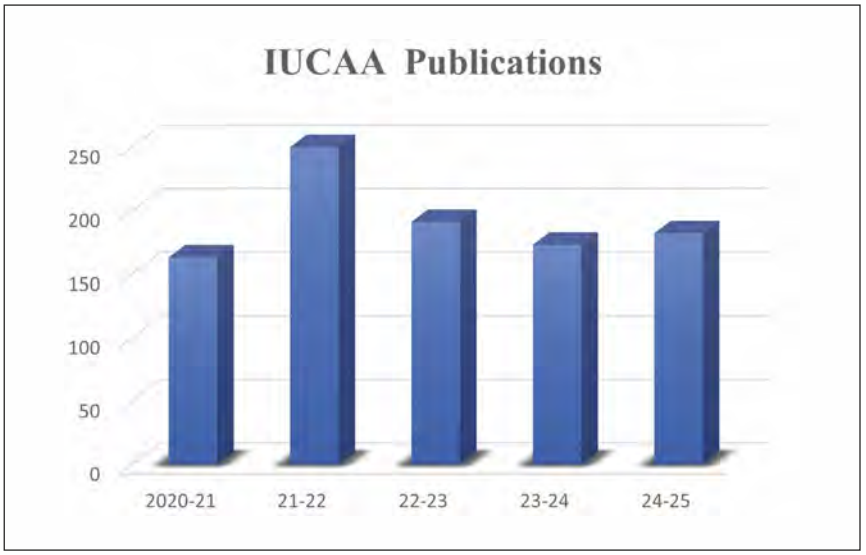
The number of ICARDs has continued to expand in numbers and geographically, with significant representation today from the remotest part of the country. The state-wise distribution of ICARDs is depicted in the map. The number of ICARDs across India during 2024-25 was 41.



Publications across the years

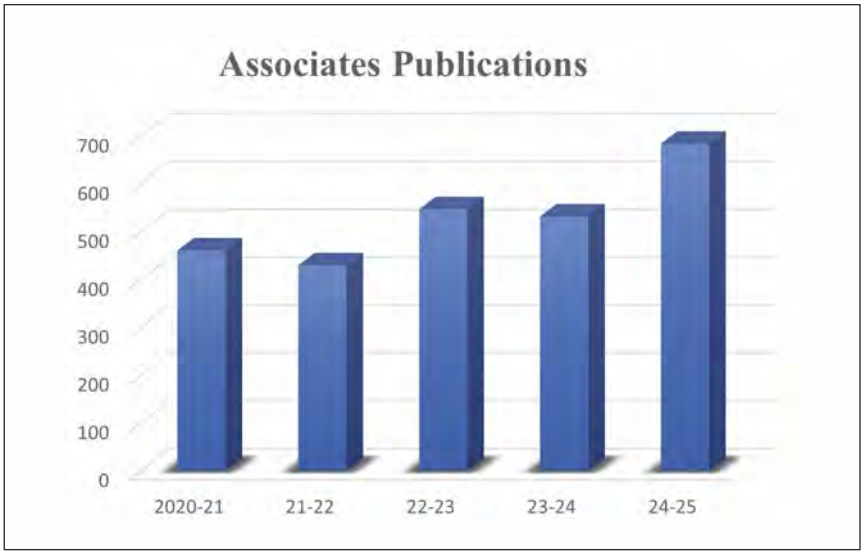
The plots depict the publications by IUCAA academics and Associates in the last five years. In 2024-25, there were 173 publications by IUCAA academics and 531 publications by IUCAA Associates.

The increasing academic strength has gone hand-in-hand with a corresponding increase in scientific output.

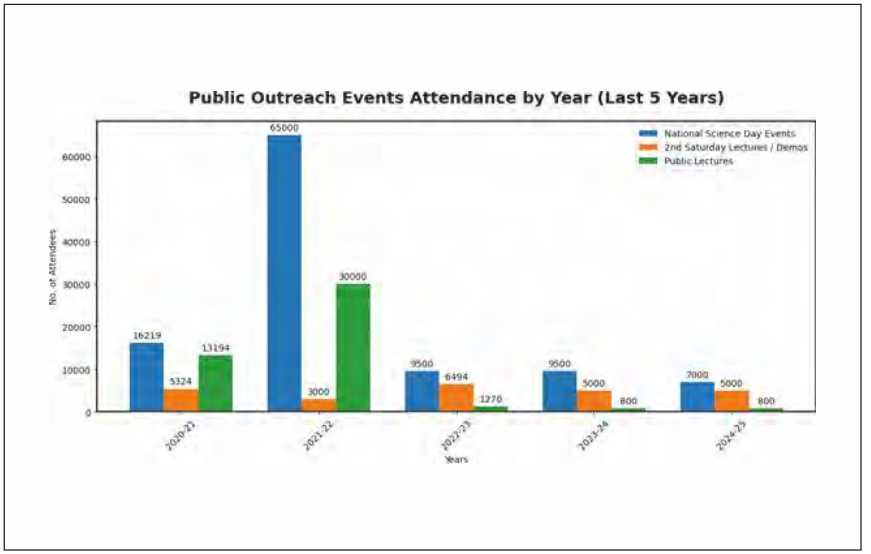


Publications across the year

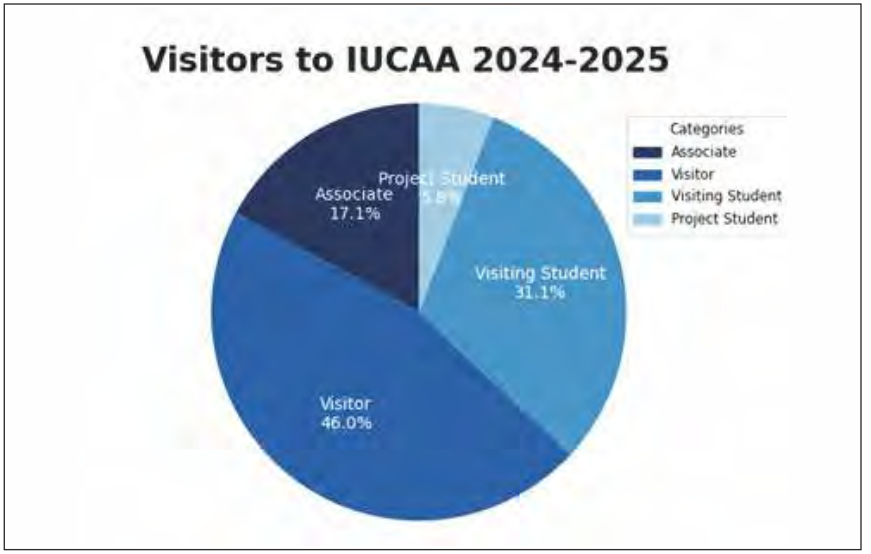
The number of publications by IUCAA associates has been has been steadily increasing over the past 5 years, with over 600 in the past academic year.



Public Outreach Events at IUCAA



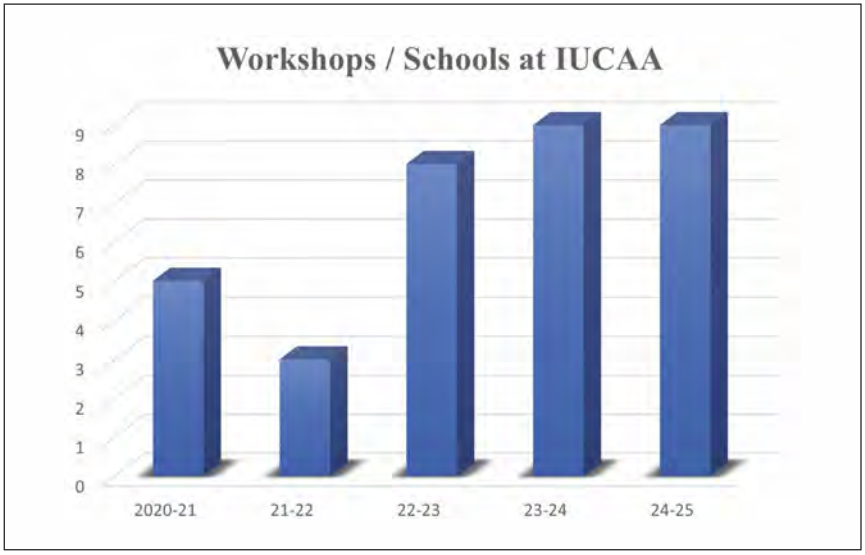
Visitors to IUCAA

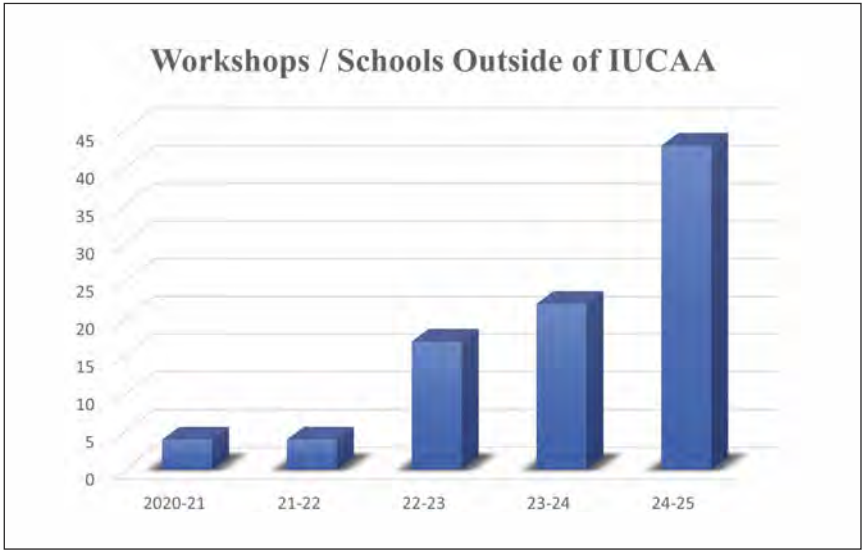


In addition to hosting Visiting Associates (17.1%), IUCAA hosted official visitors comprising of university academics (46%), students (31.1%) pursuing their Ph.Ds. from other universities / institutes, and project students (5.8%) working on projects supervised by IUCAA faculties. The total number of visitors in the period 2023-24 comprising the above-mentioned categories was 942.

Workshops/Schools in IUCAA and Outside IUCAA

IUCAA is committed to fostering astronomy and astrophysics in universities, primarily through an increasing frequency of workshops and schools, both at and outside IUCAA. The graph shows the distribution of workshops/schools held at IUCAA and outside IUCAA during the past five years, including 2024-25.





ORGANISATIONAL STRUCTURE OF IUCAA'S ACADEMIC PROGRAMMES

[As on March 31, 2025]

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Chairman (SCA, Infrastructural Facilities & SCCAP)

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Dean, Core Academic Programmes

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Head, Computing Facilities

Sanjit Mitra

Head, Instrumentation & IGO

A.N. Ramaprakash

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Head, Library

Kanak Saha

Head, Publications

Dipanjan Mukherjee

Head, Rajbhasha Committee

Vaidehi Paliya

Head,
Grievance Cell

Gulab C. Dewangan

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Nirupama Bawdekar

Chairman,
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Ranjeev Misra

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Observing Programmes (IGO and SALT)

Gulab C. Dewangan

Head,
Scientific Meetings and ICARDs

Durgesh Tripathi

Head,
Public Outreach Programmes

Nishant Singh

IUCAA ACADEMIC CALENDAR

Annual Events at IUCAA 2024-25

Refresher Course on Astronomy and Astrophysics
Date: May 13- June 14, 2024

Summer School on Astronomy and Astrophysics (online)
Date: May 13- June 14, 2024

Foundation Day
Date: December 29, 2024

National Science Day
Date: February 28, 2025

Meeting of the Scientific Advisory Committee
Date: April 22 – 26, 2024

Visit of the French Consul General and Consular team at IUCAA
Date: July 22, 2024

Events at IUCAA

GW Open Data Workshop (ODW) by the LIGO-Virgo-KAGRA collaboration.
Date: April 18-20, 2024
Coordinators: Apratim Ganguly | Sanjit Mitra
Participants: 30

Tutorial on IGWN-DHTC-OSG
Date: September 09 - 11, 2024
Coordinator: Sandeep Joshi | Sanjit Mitra
Participants: 30

Gravitational-Wave Instrumentation Workshop
Date: November 10 - 29, 2024
Coordinators: Shasvath Kapadia
Participants: 15

Baryons Beyond Galactic Boundaries - 2024
Date: December 02 - 06, 2024
Coordinators: Sowgat Muzahid | Raghunathan Srianand
Participants: 89

LIGO India All-hands
Date: December 10 - 11, 2024
Coordinators: Subhadeep De (IUCAA)
Participants: 45

17th Radio Astronomy Winter School
Date: December 14 - 24, 2024
Coordinators: Rajeshwari Dutta (IUCAA) and Subhashis Roy (NCRA)
Participants: 27

AI/ML Applications to Astronomy & Astrophysics
Date: January 06 - 10, 2025
Coordinators: Ajit Kembhavi | Kanak Saha | Arif Babul
Participants: 100 (in person) and 100 (online mode)

2nd Daksha Workshop: Indian Eyes on Transients Skies
Date: March 29 - 31, 2025
Coordinators: Gulab Dewangan (IUCAA) | Varun Bhalerao (IIT Mumbai)
Participants: 70

Events outside IUCAA

Introductory Workshop on Astrophysics and Cosmology
Place: Department of Physics, Integral University, Lucknow, Uttar Pradesh
Date: May 02 - 04, 2024
Coordinators: M. Shahalam (Integral University, Lucknow) | Aseem Paranjape (IUCAA, Pune)
Participants: 45

High-Performance Computing in Science
Place: ICARD, Department of Physics, University of Kashmir, Jammu and Kashmir
Date: May 22 - 24, 2024
Coordinators: Manzoor A. Malik (University of Kashmir) | Sanjit Mitra (IUCAA, Pune)
Participants: 60

Summer School in Theoretical (Astro) Physics
Place: Department of Physics & Electronics, St. Xavier's College (Autonomous), Ahmedabad
Date: June 03 - 08, 2024
Coordinators: Gurudatt Gaur (St. Xavier's College, Ahmedabad) | Sanjit Mitra (IUCAA, Pune)
Participants: 50

Workshop on Relativistic Cosmology: Theoretical and Data Analysis Techniques
Place: G. H. Raisoni College of Engineering, Nagpur
Date: July 15 - 17, 2024
Coordinators: Praveen Kumar Dhankar (G. H. Raisoni College of Engineering, Nagpur) | Surhud More (IUCAA, Pune)
Participants: 55

Introductory Workshop on Active Galactic Nuclei and Blazars
Place: Presidency University, Kolkata
Date: July 22 - 23, 2024
Coordinators: Ritaban Chatterjee (Presidency University, Kolkata) | Vaidehi Paliya (IUCAA, Pune)
Participants: 55

Conference on Blazars and Restless Active Galactic Nuclei (COBRA): A High Energy View
Place: Presidency University, Kolkata
Date: July 24 - 26, 2024
Coordinator: Ritaban Chatterjee (Presidency University, Kolkata) | Vaidehi Paliya (IUCAA, Pune)
Participants: 85

Probing Stars and Galaxies using Innovative Data Science Tools
Date: September 04 - 06, 2024
Place: Department of Applied Sciences, Gauhati University
Coordinators: Eeshankur Saikia (Gauhati University) | Anupam Bhardwaj (IUCAA)
Participants: 56

Contemporary Issues in Astronomy and Astrophysics
Date: September 13 - 15, 2024
Place: Shivaji University, Kolhapur, Maharashtra
Coordinators: Siba Prasad Das (Shivaji University) | Sanjit Mitra (IUCAA)
Participants: 130

2nd Himalayan Meet of Astronomers (HMA) 2024
Date: September 14 - 15, 2024
Place: Central University of Himachal Pradesh, Dharamshala
Coordinators: Hum Chand (CUHP) | Naseer Iqbal (University of Kashmir, Srinagar) | Ranjeev Misra (IUCAA)
Participants: 27

International Conference on 'Neutron star Equation Of State and Gravitational Waves' (NEOSGrav2024)
Date: October 01 - 04, 2024
Place: Goa, India
Coordinators: Debarati Chatterjee (IUCAA)
Participants: 45

Gravitational Waves and LIGO-India
Date: October 15 - 19, 2024
Place: BITS-Pilani, Pilani Campus, Rajasthan
Coordinators: Sajal Mukherjee (BITS-Pilani) | Apratim Ganguly (IUCAA)
Participants: 45

Workshop on Gravitation and Cosmology
Date: October 23 - 25, 2024
Place: DDU Gorakhpur University, Gorakhpur
Coordinators: Rajesh Kumar (DDU Gorakhpur University) |Shantanu Rastogi (DDU Gorakhpur University) | Apratim Ganguly (IUCAA)
Participants: 50

North East Meet of Astronomers (NEMA) - X
Date: October 23 - 25, 2024
Place: Tezpur University
Coordinators: Rupjyoti Gogoi (Tezpur University) | Ranjeev Misra (IUCAA)
Participants: 60

Conference on Classical and Quantum Gravity
Date: November 05 - 07, 2024
Place: Cochin University of Science and Technology, Cochin, Kerala
Coordinators: Joe Jacob (Newman College, Kerala) | Charles Jose (CUSAT, Kochi) | Dawood Kothawala (IIT, Madras)
Participants: 55

Empowering Teachers to Foster Scientific Curiosity in Students - A Joint Initiative of STEM & Space and ARIES
Date: November 11 - 13, 2024
Place: ARIES Nainital
Coordinators: Surhud More (IUCAA)
Participants: 20

Introductory workshop on Astronomy and Astrophysics
Date: November 13 - 15, 2024
Place: The Cochin College, Kerala
Coordinators: Sathya Narayanan (Cochin College) & Anupam Bhardwaj (IUCAA)
Participants: 48

General Relativity: A century of observations
Date: November 21 - 23, 2024
Place: Malda College, West Bengal
Coordinators: Dr Shyam Das (Malda College) | Surhud More (IUCAA)
Participants: 37

High Energy Astrophysics Workshop
Date: November 25 - 27, 2024
Place: Department of Physics, Banaras Hindu University, Varanasi
Coordinators: Raj Prince (BHU) & Vaidehi Paliya (IUCAA)
Participants: 70

Introductory Workshop on Solar Astronomy
Date: November 29 - 30, 2024
Place: Patna University, Patna
Coordinators: Sumita Singh | Sanjay Kumar (Patna University) | Durgesh Tripathi (IUCAA)
Participants: 50

IAU - Astronomy for Education Teacher Training Program 2025
Date: December 06 - 08, 2024
Place: Bishop Heber College, Tiruchirappalli, Tamil Nadu
Coordinators: Surhud More (IUCAA)
Participants: 35

Manipal-IUCAA Astrostatistics School-2024
Date: December 10 - 15, 2024
Place: Manipal Centre for Natural Sciences (MCNS), Manipal Academy of Higher Education, Manipal
Coordinators: Debbijoy Bhattacharya (MCNS-MAHE) & Ranjeev Misra (IUCAA)
Participants: 100

Gravity@2024
Date: December 18 - 20, 2024

Place: Cooch Behar Panchanan Barma University, Cooch Behar
Coordinators: Ranjan Sharma (Cooch Behar Panchanan Barma University) & Kanak Saha (IUCAA)
Participants: 60

Introductory Workshop on Astronomy and Astrophysics
Date: December 18 - 20, 2024
Place: Department of Physics, Dolphin (PG) Institute of Biomedical and Natural Sciences (DIBNS), Dehradun, Uttarakhand
Coordinators: Aasheesh Raturi (DIBNS) | Anupam Bhardwaj (IUCAA)
Participants: 35

National Conference on Data Science Innovation on Astronomy (NCDSIA)
Date: January 03 - 05, 2025
Place: Amity University, Kolkata
Coordinators: Abisa Sinha (Amity University) & Asis K. Chattopadhyay (University of Calcutta)
Participants: 70

Focused meeting on Cosmology and Gravitation
Date: January 08 - 10, 2025
Place: Gauhati University, Assam
Coordinators: Sanjeev Kalita (Gauhati University) & Kanak Saha (IUCAA)
Participants: 30

Radio Astronomy School
Date: January 13 - 18, 2025
Place: Fergusson College, Pune
Coordinators: Raka Dabhade (Fergusson College)
Participants: 40

Exhibition: On the Shoulders of Giants
Date: January 15 - 16, 2025
Place: Bamboo Garden, Fergusson College, Pune
Coordinators: Raka Dabhade (Fergusson College)
Participants: over 800 visitors

Regional Astronomy Meeting X -- Research in Astronomy -- Opportunities and Challenges
Date: January 31 - February 02, 2025
Place: The Department of Physics, Cochin University of Science and Technology, Kochi
Coordinators: Joe Jacob (Newman College) | Charles Jose (CUSAT) Ranjeev Misra (IUCAA)
Participants: 52

Workshop on Optical Astronomy
Date: February 28 - March 02, 2025
Place: The Department of Physics, St. Thomas College, Ranni
Coordinators: Joe Jacob (Newman College) | Sreeja S. Kartha (Christ University) | Ranjeev Misra (IUCAA)
Participants: 39

Tensions and Anomalies on the Sky: Quest for New Physics at Cosmological Scales
Date: March 06 - 08, 2025
Place: Centre for Theoretical Physics, Jamia Millia Islamia
Coordinators: Anjan Ananda Sen (Jamia Millia Islamia) | Anupam Bhardwaj (IUCAA)
Participants: 47

Workshop on Stellar Evolution and Pulsation Model
Date: March 24 - 25, 2025
Place: The Department of Physics | DDU Gorakhpur University, Gorakhpur
Coordinators: Apara Tripathi (DDUGU) | Prabhunath Prasad (DDUGU) | Anupam Bhardwaj (IUCAA)
Participants: 25

AWARDS AND DISTINCTIONS

- **Anupam Bhardwaj**
  - Professor M. K. Vainu Bappu Gold Medal 2024 awarded by the Astronomical Society of India.

- **Jayant V. Narlikar**
  - Acharya Kanad Award 2024 from Hindu Research Foundation, Mumbai, October 20, 2024.
  - Fellowship of the Breakthrough Science Society, Kolkata.

- **Vaidehi Paliya**
  - IOP Publishing awarded the top-cited publishing award to the following paper in October 2024: A Gamma-ray Emitting Collisional Ring Galaxy System in our Galactic Neighbourhood, Vaidehi S. Paliya and D. J. Saikia**The Astrophysical Journal Letters, 967, L26, 2024,** DOI: **10.3847/2041-8213/ad4999**

    AAS Nova released a scientific story for identifying the collisional-ring galaxy system, Kathryn's Wheel, as a γ-ray emitter **(https://aasnova.org/2024/08/16/monthly-roundup-rings-chains-and-bubbles/)**

- **Swarnim Shirke**
  - CSQCD Special Award for excellent presentation at CSQCD 2024 by Yukawa Institute of Theoretical Physics, Kyoto, Japan, October 2024

- **Durgesh Tripathi**
  - Young Career Award, Asia Pacific Solar Physics, 6th Asia Pacific Solar Physics Meeting, November 11 - 15, 2024, Guangzhou, China.

RESEARCH GRANTS AND FELLOWSHIPS

- **Anupam Bhardwaj**
  - PM Early Career Research Grant - Anusandhan National Research Foundation, India.
  - Team Leader, International Space Science Institute - Bern/Beijing International Team on EXPANDING Universe (https://teams.issibern.ch/expanding/).
- **Souradeep Bhattacharya**
  - DST-INSPIRE Faculty Fellowship.
- **Debarati Chatterjee**
  - Awarded the George Southgate Fellowship, University of Adelaide, Australia, 2025.
- **Subhadeep De**
  - Chanakya Doctoral Fellowship Project (2022-27), Synchronization of the optical atomic clocks located at IUCAA and IISER Pune by ultra-stable fiber optic channel.
  - VAIBHAV Fellowship (2024-27) Synergizing the trapped-ion technology with quantum information processing.
- **Samir Dhurde**
  - International Astronomical Union (OAO Grant).
- **Shasvath Kapadia**
  - DST SERB grant.
- **Ajit Kembhavi**
  - Pune Knowledge Cluster (PKC):
    - National Centre for Biological Science.
    - BASF Chemicals India grant:
    - For a mentoring and scholarship program for women in chemistry and sustainability - WEnyan.
    - A platform for Gamified Learning in Chemistry and STEM Education.
    - Lenovo India grant for Teach with Tech.
    - PKC Tree Project.
- **Ranjeev Misra**
  - ISRO Grant to set up the AstroSat Science Support Cell (ASSC).
  - DST SERB ANRF TARE Program
- **Sanjit Mitra**
  - LIGO India TDCB and DAE.
  - LIGO India SEED and DST.
- **Anupreeta More**
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- **Dipanjan Mukherjee**
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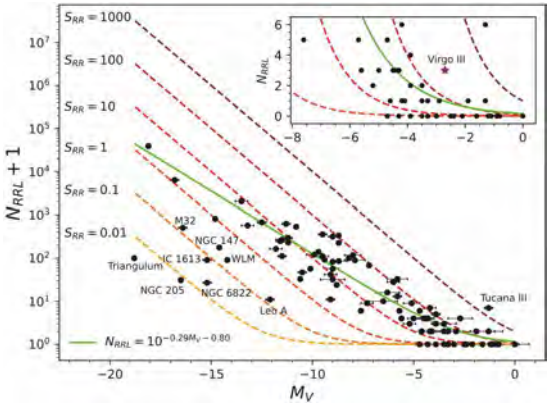
- **Sowgat Muzahid**
  - DST grant - The Role of Gaseous Halos in Galaxy Evolution.

- **A.N. Ramaprakash**
  - DST/DAE participation grant in Thirty Metre Telescope (TMT) Project at Mauna Kea, Hawaii, USA.
  - University of Crete, Greece: Institute of Plasma Physics Crete WALOP N.
  - Infosys Foundation Grant for Resurgent Caltech – IUCAA Collaboration for Advanced Instrument Development and Scientific Discoveries.
  - University of Arizona, USA: Institute of Arizona LBT1.
- **Kanak Saha**
  - ISRO grant for the project: Exploring the Nature of Lyman Continuum Emitting Sources in the AstroSat-UV Deep Field (AUDF).
- **Dhruba J. Saikia**
  - UGC Malaviya Mission Teachers Training grant.
- **Durgesh Tripathi**
  - ISRO Solar Flares P&F.
  - Indo-German (DST-Max Planck Society) Partner Group on Coupling and Dynamics of Solar Atmosphere.

RESEARCH AT IUCAA

Discovery of RR Lyrae in Ultra-Faint Dwarf Galaxies

Discovery and characterization of RR Lyrae variable stars in the ultra-faint dwarf galaxies (UFDs) is useful to probe their metallicities and distances. In collaboration with Chow-Choong Ngeow from National Central University, Taiwan, IUCAA faculty **Anupam Bhardwaj** discovered three RR Lyrae variables in a newly identified Virgo III UFD galaxy and determined its distance (Ngeow and Bhardwaj 2024). Similar to Virgo III, these authors carried out RR Lyrae search in Aquarius III and Sextans II UFD galaxies using both archival data from time-domain surveys and dedicated follow-up observations. While a candidate RR Lyrae variable was found in Aquarius III, there were no RR Lyrae stars found in Sextans II. The lack of RR Lyrae stars in Sextans II was consistent with other previously-known fainter UFDs with similar visual magnitude that do not have these variable stars. These studies also revisited the relation between absolute visual magnitude and the number of RR Lyrae found in local galaxies (Figure X), demonstrating that this empirical relation is better described with the specific RR Lyrae frequency.



Physics of Compact Objects

The group at IUCAA, led by **Debarati Chatterjee**, is involved in inferring fundamental physics under extreme conditions from studies of Neutron Stars (NS) using gravitational waves (GW). In the past year, the group made several remarkable contributions to research involving multi-disciplinary domains. Unstable oscillation modes in neutron stars can be important sources of GW, not only in binary systems but also in isolated NSs. With the increasing sensitivity of the current GW detectors or with the next-generation detectors, these stellar oscillation modes could become detectable, which may provide an excellent opportunity to investigate their complex interior. It was demonstrated how future fundamental, or f-mode, observations can be used to constrain the nuclear parameters and NS interior composition using inverse NS asteroseismology. The potential of probing the nature of the hadron-quark phase transition in the NS interior through future GW detections from f-mode oscillations in NSs was also investigated. They also studied how Dark Matter (DM), if present in the NS core, could affect its observable properties, including unstable oscillation modes, and extended it to incorporate astrophysically viable dark stars.

Figure X. *Number of RR Lyrae (N_{RRL}) as a function of visual absolute magnitude (M_V) for the 94 galaxies adapted from Ngeow & Bhardwaj (2024). The green solid curve represents the empirical relation derived in Martınez-Vázquez et al. (2019). The dashed curves are for the different selected values of specific RR Lyrae frequency SRR. The inset figure is the zoomed-in version for UFD galaxies with $N_{RRL} < 7$, where Virgo III is marked as a magenta star.*

Although NSs are in general assumed to be cold, in astrophysical scenarios such as newly born NSs or binary NS collisions, finite temperature effects may play an important role. A systematic investigation of the NS interior composition and thermal effects on NS properties and oscillation modes was also performed by the group.

During the collision of NSs, viscous processes in the stellar matter can damp out the tidal energy induced by the companion and heat up the star. A novel effect of tidal heating depending on the constituents in the NS interior was proposed, which can significantly heat up the star. If observed by current and future gravitational wave detectors, it could serve as a direct probe of the interior composition in neutron stars.

Precision & Quantum Measurement Laboratory (PQM-lab)

The Precision & Quantum Measurement Laboratory (PQM-lab) led by **Subhadeep De** is involved in (i) setting-up of a ytterbium-ion based optical atomic clock experiment (quantum clock) for fundamental science test, and (ii) developing a Reference Photon Dissemination System at 1550 nm wavelength (namely, RPDS1550) that has applications in gravitational wave detectors. In particular, we have carried out the following works in the last year.

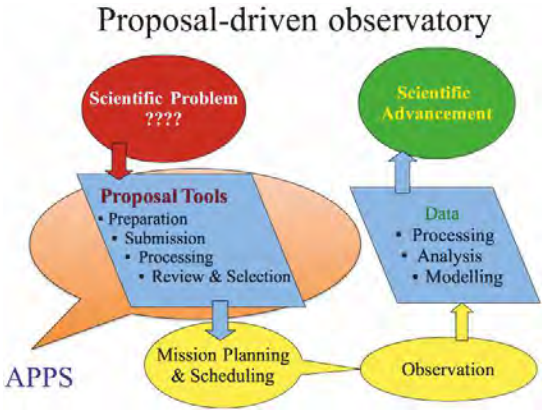
A. A coherent optical fiber system (namely the "PhotonSync™") for the dissemination of optical clock signals to remote locations.

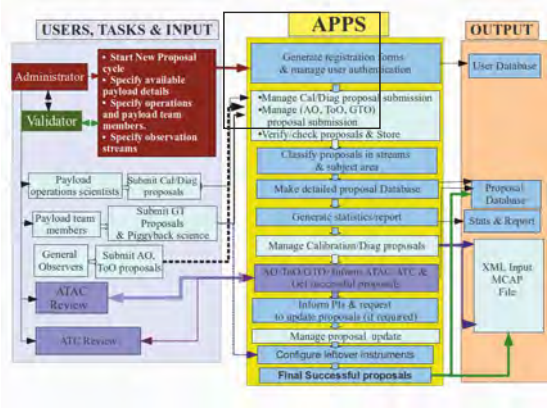
B. High-performance low-noise active temperature controller.

C. A low-noise current controller for driving an extended cavity diode laser.

AstroSat Proposal Processing System (APPS)

AstroSat is a multi-wavelength astrophysics observatory for a large scientific community. The effective operation of a space observatory such as AstroSat, leading to major scientific advancements, is a complex process. The five payloads onboard AstroSat have different scientific capabilities and technical constraints. The peer-reviewed, scientific proposal-driven operation of AstroSat is an intricate and challenging process. To facilitate the proposal-driven operation of the AstroSat mission, a web-based proposal processing software known as the "AstroSat Proposal Processing System (APPS)" has been designed and developed by IUCAA in collaboration with Persistent Systems Limited (PSL), Pune. APPS is available to the scientific community for the preparation and submission of AstroSat proposals and to the mission operation to extract the proposals database for scheduling of observation and command generation to perform the actual observations. The role of APPS in the proposal-driven operation of the AstroSat mission is depicted in figure below (on the left).





APPS is a web-based tool which assists scientists in proposal preparation, submission, scientific and technical review and the selection process. APPS can validate submitted proposals, including syntax checking, parameter ranges and proposal completeness, thus allowing proposers to detect errors. APPS provides a complete and flexible interface for users to specify instrument configurations appropriate to their science requirements. APPS also extracts important proposal information, including the instrument configuration, which is used for mission planning and scheduling of observations. An overview of the APPS architecture, along with the flow of various kinds of information into and out of the APPS, can be seen in the following flow diagram shown in the right panel.

APPS is currently deployed at the Indian Space Science Data Centre (ISSDC), ISRO, Bangalore. While the software is made available from ISSDC, IUCAA has been providing administrative, operational, maintenance and enhancement support continuously. IUCAA also plays a key role in providing support to the user community in proposal preparation and submission using APPS. APPS has been successfully used for proposal preparation, submission and selection for observations in the performance verification (PV) and the guaranteed time (GT) phase in the first year of the AstroSat mission. During this period, IUCAA has played a crucial role in the quick addition of new features as per the requirement, documentation, bug fixing and feature enhancement. IUCAA has also provided time-critical support on administrative activities, including proposal cycle creation, setting instrument configuration, handling proposal review during the GT cycle and revision of proposals, verifying and fixing issues with the mission control and proposals database (MCAP), which is used for mission planning, scheduling of observation and command generation. IUCAA has also provided support to the proposers from instrument teams for the submission of PV and GT proposals.

ATAC

The AstroSat Time Allocation Committee (ATAC) has been set up by ISRO to review the AstroSat GT and AO proposals. With the involvement in the development and maintenance of APPS software and two IUCAA faculties as the member of ATAC, IUCAA plays significant role in the review, revision, selection process and interfaces with the mission operation team at ISRO in the smooth flow of proposals data from APPS to the mission operation in the form of mission control and proposals database (MCAP) which is then used for scheduling of observations and command generation for actual observations.

AstroSat

IUCAA members, along with collaborators from Indian Universities and abroad, have been using the unique capabilities of India's first Space Observatory, AstroSat, to unravel the mysteries of

black holes and neutron star systems. The LAXPC instrument provides capabilities for studying rapid variability and spectra in the hard X-rays, while the SXT instrument provides good coverage for the lower energy, softer X-ray spectra. X-ray binaries have an accretion disc where the accretion of matter results in the emission of X-rays. The wide band spectral capabilities of AstroSat allow for tracking of the inner disc radius and accretion rate in the system, which can be correlated with rapid timing properties such as the high frequency quasi-periodic oscillations (QPOs) observed in these sources. For example, triplets of high-frequency QPOs were shown to correlate with each other just as predicted by Einstein's theory of gravity, allowing the group to constrain the structure of the neutron star system. The group have now expanded the utility of AstroSat data by combining it with complementary data from other observatories, such as NICER, which provides rapid timing signatures at lower energies than LAXPC and NuSTAR, which provides high-quality spectra in higher energies. Data from AstroSat and other observatories have also been used to study Active Galactic Nuclei, which harbour super-massive black holes. For this analysis, the UV data from the UVIT instrument in AstroSat have been critical in our understanding of the variability of these sources. Such analyses have provided critical information regarding the radiative processes and the geometry of the inner regions of the system near the black hole.

Swadesh Chand and **G. C. Dewangan** from IUCAA, along with their collaborators, conducted a broadband (0.7–100 keV) spectral analysis of five hard-state observations of the black hole X-ray binary GX 339–4 using AstroSat data from three outbursts between 2019 and 2022. Among these, only the 2021 outburst was a full transition to the soft state, while the 2019 and 2022 outbursts remained in the hard state. Our spectral modeling required two distinct Comptonizing components, each with its own reflection and associated soft X-ray excess. The harder component dominated the bolometric output, while the softer one was relatively weaker. We observed that the inner disk radius decreased with rising luminosity, although the disk remained truncated at all epochs (~ 2%–8% of Eddington luminosity). The soft X-ray excess, modeled as a disk blackbody, might instead originate from structural inhomogeneities in the disk or corona. Timing analysis revealed that the break frequency in the power density spectra increased with luminosity, with derived inner disk radii consistent with those from reflection modeling, thereby reinforcing the truncated disk interpretation in the hard state.

An international team involving **G. C. Dewangan** from IUCAA used NASA and ISRO missions and observed a rare and dramatic cosmic event where a massive black hole, after tearing apart a star in 2019, created a disk of stellar debris that has since expanded and is now colliding with another nearby object—possibly a star or a stellar-mass black hole—orbiting the larger black hole. This interaction causes bursts of X-rays every ~48 hours as the orbiting object plunges through the debris disk, much like a diver repeatedly splashing into a pool. Detected using NASA's Chandra, Hubble, NICER, and Swift telescopes, along with India's AstroSat, this event, AT2019qiz, provides the first direct connection between tidal disruption events (TDEs), where stars are torn apart by black holes, and quasi-periodic eruptions (QPEs), mysterious repeating X-ray flares. The discovery reveals that these eruptions only begin a few years after a tidal disruption, once the debris disk grows large enough to intersect the orbit of another object. This breakthrough enhances our

understanding of the dynamics around supermassive black holes and could aid future searches for gravitational wave sources.

G. C. Dewangan and his PhD student **Shrabani Kumar** led a study where they analysed five sets of simultaneous AstroSat observations of the active galaxy NGC 4151, covering near-ultraviolet (NUV) to hard X-rays (0.005–80 keV) taken between 2017 and 2018. After accounting for extinction and other emissions, the intrinsic light from the accretion disk was extracted, revealing a bluer UV continuum when the galaxy was brighter. This could be due to changes in the disk or the amount of UV reddening. Using earlier Hubble data, the intrinsic reddening was estimated as $E(B-V) \approx 0.4$. The X-ray spectra were modeled using components like thermal Comptonization, absorption, and reflection, revealing much higher X-ray absorption than expected from UV measurements. To explain this, two models are proposed: one with separate dusty and dust-free layers divided by the dust sublimation radius, and another with dense clouds in a diffuse medium, where the X-rays are blocked by clouds, but the UV light mostly passes through. Additionally, a link was observed between stronger X-ray absorption and changes in UV brightness and color, suggesting stronger winds could be triggered by the brighter, bluer UV light.

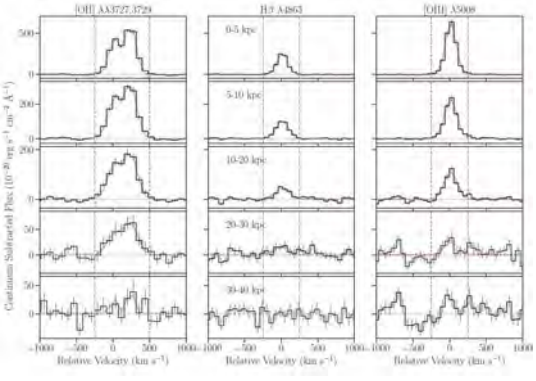
In a collaborative effort between Guru Ghasidas Vishwavidyalaya (Pragati Sahu, Parijat Thakur and Subhasish Das), IUCAA (**Swadesh Chand**, **G. C. Dewangan**), ISRO (Vivek Agrawal), and Chhattisgarh State Forensic Science Laboratory (Prakash Tripathi), perform temporal and wide-band spectral study of black hole X-ray binary H1743–322 using observations performed with AstroSat and Swift/XRT during the 2017 outburst. The study revealed that, unlike the successful outburst in 2016, the 2017 event was a "failed outburst," where the source didn't make a transition to a soft state. A type-C quasi-periodic oscillation (QPO) at ~0.4 Hz was detected in both AstroSat and Swift/XRT data, with a higher harmonic at ~0.9 Hz seen only in AstroSat. A small frequency shift (~0.08 Hz) occurred over three days. Comparing the failed outbursts of 2017 and 2018, soft time lags (where lower-energy X-rays arrive later) were found at the QPO frequencies in both years, possibly linked to reflection from the accretion disk. Spectral modeling shows the source remained in a low/hard state, with a truncated accretion disk located at least 27.4 gravitational radii away from the black hole, while the system's luminosity was only ~1.6% of the Eddington limit.

Piyali Ganguly, **G. C. Dewangan**, and **Priyanka Rani** used high-resolution images from AstroSat's Ultra-Violet Imaging Telescope (UVIT) to study the area around the Seyfert galaxy IC4329A in both near- and far-ultraviolet light. These observations, taken over five sessions, represent the deepest UV images of this region so far, with very sensitive detection limits (NUV magnitude 26.2 and FUV magnitude 25.7). Thanks to UVIT's sharp imaging capability, Ganguli et al. identified 4,437 sources in the NUV and 456 in the FUV, many of which had not been seen before. We measured the exact positions and brightness of all these sources. By comparing the UVIT sources with those in Gaia and XMM-Newton catalogues, the team found matches for 651 optical and 97 X-ray sources. They also discovered 28 ultraviolet sources that vary in brightness, with three showing changes in both NUV and FUV bands. Additionally, based on their UV and optical properties, it was found that two objects previously classified as white dwarfs were likely misidentified. Some galaxies in the UVIT images

show unusual shapes, like rings, multiple bright centres, or split spiral arms. Further optical and multi-wavelength observations are needed to better understand these intriguing objects.

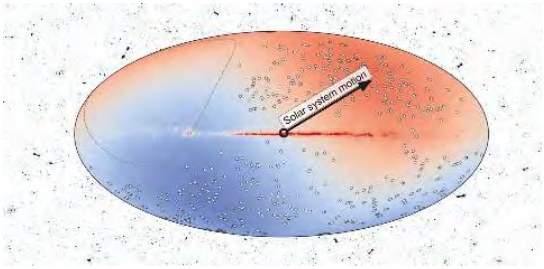
Galactic and Extragalactic Astronomy

Galaxies are surrounded by diffuse haloes of multiphase gas termed the Circumgalactic Medium (CGM) that play a crucial role in galaxy evolution by regulating the cycle of baryons in and out of galaxies. However, it has been challenging in the past to probe the CGM of galaxies at cosmological distances directly using emission lines due to the low gas density. Recently, thanks to sensitive, wide-field optical integral field unit spectrographs such as the Multi-Unit Spectroscopic Explorer (MUSE) on the Very Large Telescope (VLT), it has become possible to detect the CGM directly in emission. **Rajeshwari Dutta** and collaborators characterised, for the first time, the average extended emission in multiple lines around a statistical sample of 560 galaxies by stacking the MUSE 3D data cubes from two large surveys. By analysing the stacked emission line ratios and comparing with models, they studied how the average physical conditions of the gas such as metallicity and ionization parameter are varying from the centre to the disk-halo interface.



Testing cosmology using the deep radio continuum surveys

(The second data release from the MeerKAT Absorption Line Survey (MALS)



A map of the sky overlaid on a portion of single MeerKAT pointing containing a few thousand radio sources. In the sky map, circles mark positions of 391 pointings containing a total of 971,980 sources. The arrow shows the direction of the cosmic dipole originally established by measurements of the cosmic microwave background radiation (CMBR). The dipole effect will make the sources appear more numerous (red portion) in the direction of the motion and less in the opposite (blue portion).

The MeerKAT radio telescope in South Africa is currently the most sensitive radio telescope and IUCAA researchers are using it to detect millions of normal and active galaxies. The MeerKAT Absorption Line Survey (MALS) is a large survey that observes the sky and the team led by IUCAA has released a million source catalog. This is the largest catalog produced by a MeerKAT survey thus far, one of only a handful of radio catalogs with a million or more sources. It represents the

Figure: *Stacked spectra showing the [O II], Hβ, and [O III] emission lines around galaxies in different annular regions, 0–5 kpc, 5–10 kpc, 10–20 kpc, 20–30 kpc, and 30–40 kpc, from top to bottom. These allow us to study the spatially-resolved average physical conditions in the CGM around galaxies (Dutta et al., 2024, A&A, 691A, 236).*

second of several radio continuum and spectral line data releases to come from MALS and making this data release has been a team effort. The MALS catalogs and images are publicly available at https://mals.iucaa.in. The MALS team is an international collaboration of researchers from around the world. The project is led by **Neeraj Gupta** from IUCAA, India. The MeerKAT telescope is a facility of the National Research Foundation (NRF) in South Africa and is operated by the South African Radio Astronomy Observatory (SARAO).

The MALS team has used this catalog to test the cosmic dipole effect which makes sources appear brighter in one portion of the sky than the other (details in figure). While many other measurements in the past 10 years have disagreed with the original measurement based on the CMBR, the MALS team's findings are consistent with the prediction, a surprising result in itself. Measuring the dipole is an extremely important test of cosmology, and can tell us whether our fundamental assumptions about the structure of the Universe are correct. To get to these deep images from the large amounts of raw data produced by MeerKAT, a sophisticated processing pipeline and data storage facility has been set up at Inter-University Centre for Astronomy and Astrophysics (IUCAA) in India. The depth and the expanse of this continuum catalog holds a unique position among modern radio continuum surveys. The public release will enable the community to address a wide range of issues associated with the evolution of galaxies and the Universe.

Summary of GW-Astro@IUCAA group's research

Shasvath J. Kapadia is leading the GW-Astro@IUCAA group. His group consists of four PhD students and one postdoc. The group focuses on various aspects of gravitational-wave (GW) data analysis and astrophysics. This includes:

- Reconstructing the environment's properties that host mergers of compact binaries, from the motion of their centres of mass. Our group has shown, for the first time, that detailed information of the gravitational potential of the compact binary's host environment, including its radial profile, can be extracted, on a single event basis. See the figure below for a schematic of a particular environment.

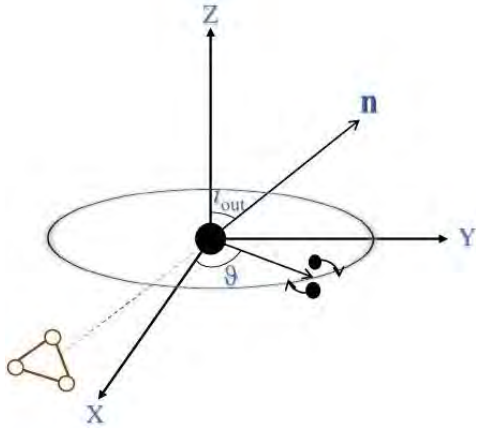


Figure: *A schematic representation of a binary orbiting around an SMBH (or, any center of potential) in a circular orbit. Here, ι_{out} is the angle between our LOS n and the angular momentum vector of the outer orbit, which is along e_z*

- Constraining the abundance of Galactic objects from the non-detection of continuous GWs, as well as their properties, such as birth spins and magnetic fields.
- Developing GW data analysis tools to identify gravitationally lensed GWs, and using GW

lensing to: enhance GW early warning, and constrain cosmological parameters.

- Use GWs from eccentric binaries to test general relativity in the context of compact binary inspirals.

X-ray Binaries

Ranjeev Misra's group along with collaborators from Indian Universities have been studying the nature of X-ray binaries which harbor black holes or neutron stars as well as Active Galactic Nuclei having super-massive black holes. They do so by measuring the timing behavior of these variable sources along with the broad band spectra. Such studies are now possible using data from Indian space-observatory AstroSat along with data from other observatories. X-ray binaries have a disc where matter accretes towards the black hole or neutron star, resulting in the production of X-rays. They could track the evolution of the spectral state, which allows for measurements such as the inner disc radius and the mass accretion rate and correlate these values with the temporal properties. In particular, the variation of the frequency of the quasi-periodic oscillations with the inner disc radius provides strong support to the interpretations based on Einstein's General theory of relativity in the strong regime. The group also studied Active Galactic Nuclei and modelled the broad band spectral properties (which includes optical, X-ray and Gamma-ray data) for different flux states. For systems where a strong jet is directed towards us (called blazars), they could put constraints on the radiative mechanisms and estimate the power of these jets.

LIGO-India

The LIGO-India project received cabinet approval in April 2023. Since then several activities have taken place on multiple administrative and technical fronts to take the project forward with the target to start taking science data in 2030. IUCAA members have contributed to essentially all these activities in various capacities. Last year a detailed working group structure for the project was formed and the respective activity leads were identified. IUCAA members with relevant skills have been identified to contribute to each of these working groups. Some of the groups have started regular meetings, while the others are in the preparatory phase. At this point IUCAA is primarily responsible for computing facilities, coordinating research and training, and education and public outreach. IUCAA continues to provide the Sarathi High Throughput Computing facility and various other IT services to national and international gravitational wave (GW) research community. A multi-level training program is ongoing at IUCAA primarily to train undergraduate and PhD students and young researchers in GW instrumentation. Multiple laboratories and instrument modules have been developed for that purpose. IUCAA also organised a three week long GW Instrumentation Winter Workshop during November 10 - 29, 2024, where fifteen students from different parts of the country participated. IUCAA is also coordinating a program through which research institutes and universities in India can contribute to GW instrumentation research overseen by the LIGO-India Scientific Management Board (SMB) chaired by Director, IUCAA. A number of workshops and outreach events were also conducted by the EPO team at different parts of the country and online throughout the year.

Observational Cosmology and Galaxy Formation

The research group led by **Surhud More** at IUCAA

has been active in observational cosmology, and galaxy formation and evolution, as well as studies in astronomy research education over the past year. The group consisted of 6 Ph.D. research scholars, two postdoctoral scholars who played important roles in carrying out the research. In the field of observational cosmology, the group has had a two pronged focus on the two current problems of the standard cosmological model. First, the group has developed methods to use Gravitational wave data to constrain the expansion rate of the Universe. Secondly, the group has also been active in using gravitational lensing to understand the clumpiness in the present day matter distribution of the Universe. This clumpiness is a result of the competition between dark matter and dark energy, and thus is useful to constrain the behaviour of these mysterious components.

In extragalactic astronomy, the group has studied the connection between galaxies and their dark matter halos and the impact of the environment on the properties of this connection. Some of the new contributions to the scientific literature from the group included the study of the weak gravitational lensing signal around satellite galaxies in galaxy clusters, as well as central galaxies in the Subaru Hyper Suprime-cam survey, to establish the connection between galaxies and their dark matter halos. Finally, some part of the research also contributed to the intersection of astronomy and society. The group contributed significantly to a white paper which examined critical areas of astronomy outreach and education in India, and proposed actionable recommendations to enhance public engagement, inclusivity, and institutional support. This work aims to shape the future relationship between astronomy and broader society, recognizing its unique potential to inspire and educate across generations.

Computational Astrophysics

Supermassive black holes at the centres of galaxies often generate fast winds that impact the gas of the host on a wide scale. Researchers at IUCAA have simulated the impact of such on dense potentially starforming gas clouds through a suite of resolved simulations. A key inclusion in these simulations was the use of the new in-house developed Poisson solver for the astrophysical code PLUTO. Using this novel numerical module, researchers found that self-gravity of the clouds significantly affect the evolution of the clouds, helping them retain their

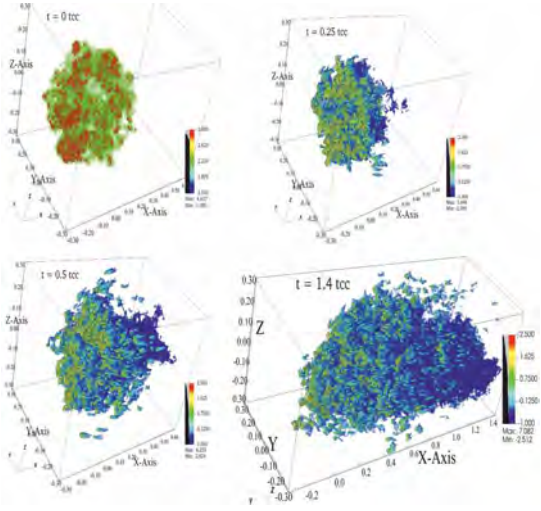


Figure : *A volume rendering of different evolutionary stages of a gas clouds evolution due to the impact of a fast AGN driven wind. The colors represent the number density of the clouds. The cloud undergoes an initial phase of compression, followed by rapid ablation, which eventually leads to large scale disruption of the cloud into smaller cloudlets and an elongated comet-like tail.*

shape, preventing ablation. Such conclusions were not probed earlier for such systems due to lack of the relevant numerical tools, which were implemented in this work. Some of the major conclusions of this study are: a) self-gravity can significantly affect cloud dynamics and prevent large scale cloud destruction, b) moderate cloud porosity helps in cloud-break up more than very low or high values, c) various statistical analysis indicate that the clouds go through different evolutionary stages with different wind powers affecting the starformation rate differently, d) the wind-cloud interaction leads to a multi-phase outflow, which can potentially explain the observed correlations between mass-outflow rates and wind power.

Observational Astrophysics

Cosmic web filaments are fundamental predictions of modern cosmological hydrodynamical simulations based on the Lambda Cold Dark Matter model, which is the most robust framework for understanding the cosmic evolution of the universe. However, directly detecting these filaments has proven to be exceptionally challenging due to their extremely low densities. Identifying such tenuous and filamentary structures remains one of the most significant challenges in observational astrophysics.

With the advent of state-of-the-art integral field spectroscopy (IFS), it is now possible to investigate cosmic filaments around massive objects such as quasars with unprecedented precision. The IFS technique enables astronomers not only to target specific regions of the sky where such filaments are likely to exist but also to focus on the precise wavelength range where the expected emission signal can be detected.

A team of IUCAA researchers has discovered a giant cosmic web filament stretching nearly 850,000 light-years by analysing light emitted 11.7 billion years ago. This filament is connecting seven Lyman-alpha emitting galaxies. To put this in perspective, this length compares to roughly 10 times the size of the Milky Way's stellar disk and one-third of the distance between the Milky Way and our nearest neighbor, Andromeda. The discovery was made possible using the VLT/MUSE IFS instrument.

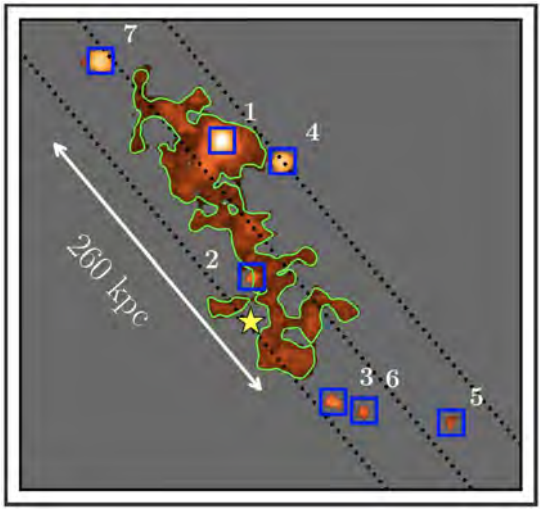


Figure: *The seven galaxies, highlighted in blue boxes, detected with MUSE exhibit a striking linear alignment, indicating an underlying filamentary structure. This alignment is remarkably mirrored by a 260-kpc-long Lyman-alpha nebula emanating from the giant filament. The yellow star pinpoints the location of the background quasar, whose light served as a probe to measure the metallicity of the filament, confirming its primordial nature.*

The filament is the first of its kind for which they could successfully constrain the metallicity of the gas using complementary absorption line

techniques, revealing its primordial nature. Additionally, in contrast to previously known systems, none of the seven galaxies linked to the filament show any evidence of quasar-like properties. The search for these elusive structures and the detailed characterization of their properties will stand as one of the foremost scientific objectives in the era of next-generation 30-meter-class telescopes. This discovery represents a pivotal first step toward this transformative exploration, laying the groundwork for future breakthroughs in this field.

Radio Morphology of Gamma-ray Sources

The extragalactic gamma-ray sky is dominated by relativistic jets aligned to the observer's line of sight, i.e., blazars. A few of their misaligned counterparts, e.g., radio galaxies, are also detected with the gamma-ray satellites, albeit in a small number (~ 50), indicating the crucial role played by the jet viewing angle in detecting gamma-ray emission from jets. These gamma-ray emitting misaligned active galactic nuclei (AGN) provide us with a unique opportunity to understand the high-energy emission production mechanisms from a viewpoint different from the more common blazars. Keeping in mind the ongoing wide-field, sensitive radio surveys covering both GHz and MHz frequencies, e.g., VLASS and LOFAR, we carried out a systematic search of gamma-ray detected misaligned radio sources, i.e. AGNs whose jet viewing angle is expected to be large (>10 degrees). Since the gamma-ray emission strongly depends on the viewing angle due to Doppler boosting effects, this project may pave the way to explore the radiative processes (leptonic/hadronic) responsible for the observed gamma-ray emission from AGN. 149 gamma-ray emitting misaligned jetted AGNs were identified, increasing the sample size of such objects by three. This catalog has been published in the Astrophysical Journal.

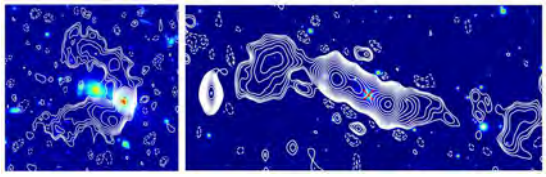


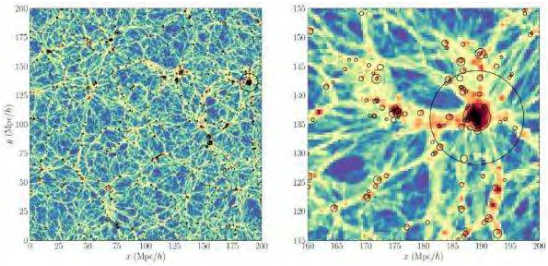
Figure: *Radio contours of a two gamma-ray emitting radio galaxies overplotted on the optical image. Adapted from Paliya et al. (2024, ApJ, 976, 120).*

Sahyadri summary

Cosmological observations reveal that galaxies and gas in the Universe are distributed in a vast, filamentary network known as the Cosmic Web, extending across hundreds of megaparsecs (Mpc). This structure is believed to have evolved from tiny density fluctuations seeded by quantum processes in the early Universe. Over time, these perturbations grew primarily under the influence of gravity. While astrophysical processes play an important role on small scales, gravity dominates structure formation on larger scales. N-body simulations form an important tool in studying the formation and evolution of this large-scale structure. These simulations model the gravitational interactions of a large number of particles — representing dark matter and, indirectly, galaxies — over billions of years.

At IUCAA, we are creating a suite of N-body simulations using the HPC cluster Pegasus, with variations in key cosmological parameters: the densities of regular and dark matter, the dark energy content, the Hubble constant (which quantifies the Universe's expansion rate), and the nature of primordial fluctuations. The suite is

organised into a lower-resolution set named Sinhagad (which is now complete) and a higher-resolution counterpart named Sahyadri (which is in progress).



The Figure shows a slice through one Sahyadri simulation, with the colour showing the density of matter on a logarithmic scale and with dark matter halos (potential hosts for galaxies) marked by circles. A slice through one of the Sahyadri simulations. The right panel zooms into an interesting and dense filamentary network.

These simulations are vital for interpreting observational data and testing cosmological models using surveys such as DESI and Euclid, which are already producing results, and also for making predictions for future surveys. By studying how varying parameters affect structure formation, we aim to refine our understanding of the composition and evolution of the Universe.

Extragalactic Astronomy / Observational Astronomy

Galaxy Research@IUCAA

The AstroSat UV Deep Field (AUDF) is an imaging survey carried out with the wide-field Ultraviolet Imaging Telescope (UVIT) on AstroSat in two broad bands - F154W (1300 - 1800 \AA) and N242W (2000 - 3000\AA). AUDF South (PI: Kanak Saha) cover ~ 236 arcmin2 of the sky area, including the Great Observatories Origins Deep Survey (GOODS) South field. These observations reached a 3\sigma depth of 27.2 and 27.7 AB mag with a 50% completeness limit of 27 and 27.6 AB mag in the F154W and N242W filters, respectively in about 63000 sec of exposure time. A similar imaging survey called the AstroSat UV Deep Field North were carried out centered on the GOODS North field in three filters, namely, F154W (34000 sec), N245M (15500 sec) and N242W (19200 sec) of UVIT. AUDF North (**PI**: **Kanak Saha**) reached a 3\sigma depth of about 27 AB mag (see Mondal+2023, ApJS). With the acquired depth, AUDF South and North are the deepest far- and near-UV imaging data covering the largest area known to-date at 1.2–1.6 arcsec spatial resolution. Two primary catalogs were constructed for the F154W and N242W filters, each containing 13495 and 19374 sources brighter than the 3σ detection limit, respectively. The galaxy counts distribution defined with a power-law slope of ~0.43 dex/mag in the N242W filter matches well with Hubble Space Telescope/Wide-Field Camera 3/UVIS observations. A wide range of extragalactic science can be achieved with this unique data, such as providing a sample of galaxies emitting ionizing photons in the redshift range of z ~ 1–3 and beyond, constraining the UV luminosity function, investigating the extended UV emission around star-forming galaxies and UV morphologies for z < 1. The UV catalog will enhance the legacy value of the existing optical/IR imaging and spectroscopic observations from ground- and space-based telescopes on the GOODS South field. This work has been published in **Astrophysical Journal Supplementary Series**, 2024, Vol. 275, p.28. (Saha+2024, ApJS).

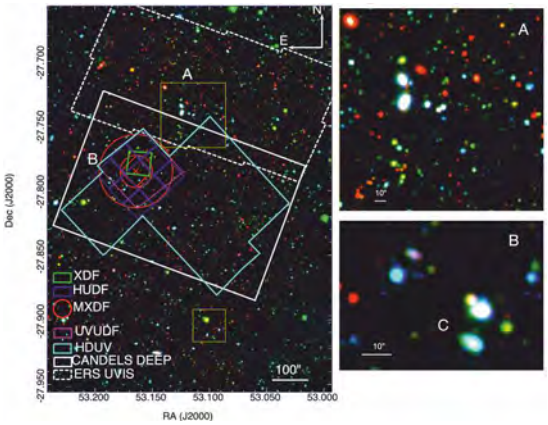


Figure: *False colour RGB image of the AstroSat UV Deep Field South. Red, Green and blue filters used to create the image are HST/WFC/F606W, UVIT/N242W and UVIT/F154W. All three images are PSF matched and at the same pixel scale. Zoom-in regions show the quality and astrometry of the UVIT Deep field images.*

Accretion Physics

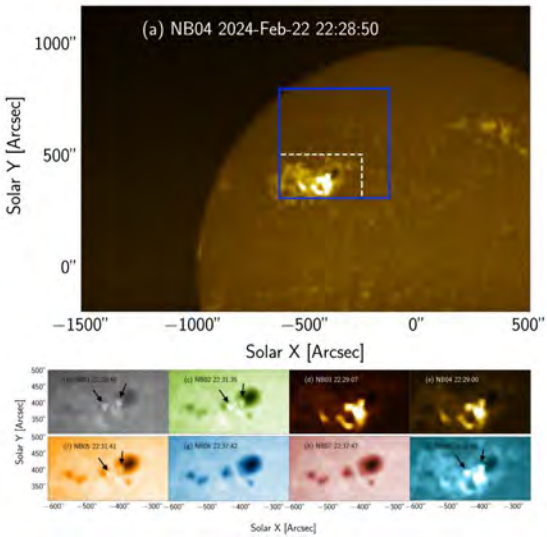
Reversals of toroidal magnetic field in local shearing box simulations of accretion disc with a hot corona

Presence of a hot corona above the accretion disc can have important consequences for the evolution of magnetic fields and the Shakura-Sunyaev (SS) viscosity parameter α in such a strongly coupled system. In this work, **Nishant Singh**, together with an IUCAA Associate from S D College, Alleppey and his Ph.D. student there, have performed three-dimensional magnetohydrodynamical shearing-box numerical simulations of accretion disc with a hot corona above the cool disc. Such a two-layer, piece-wise isothermal system is vertically stratified under linear gravity and initial conditions here include a strong azimuthal magnetic field with a ratio between the thermal and magnetic pressures being of order unity in the disc region. Instabilities in this magnetized system lead to the generation of turbulence, which, in turn, governs the further evolution of magnetic fields in a self-sustaining manner. Remarkably, the mean toroidal magnetic field undergoes a complete reversal in time by changing its sign, and it is predominantly confined within the disc. This is a rather unique class of evolution of the magnetic field which has not been reported earlier. Solutions of mean magnetic fields here are thus qualitatively different from the vertically migrating dynamo waves that are commonly seen in previous works which model a single layer of an isothermal gas. Effective α is found to have values between 0.01 and 0.03. They have also made a comparison between models with Smagorinsky and explicit schemes for the kinematic viscosity (\nu). In some cases, with an explicit \nu they find a burst-like temporal behavior in \alpha.

Sun@IUCAA: Research Activities

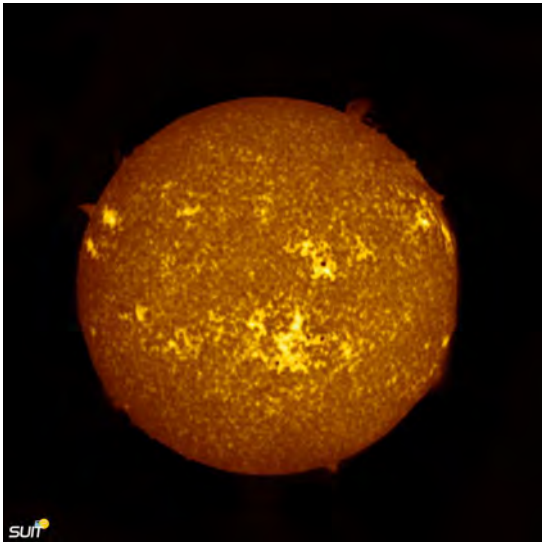
The solar physics research group led by **Durgesh Tripathi** is actively engaged in a broad range of projects to understand the dynamic coupling of the magnetised solar atmosphere. The team heads the Solar Ultraviolet Imaging Telescope (SUIT) on Aditya-L1, India's first space-based solar observatory, launched on Sep 02, 2023. This telescope was designed, developed and built under the leadership of the group. Presently, IUCAA hosts SUIT's payload operation centre (POC), and the group develops dedicated image calibration modules. It is involved in designing and deploying various algorithms for the SUIT data processing pipeline. Members also support SUIT's day-to-day operations and performance monitoring, including observation planning and

tuning onboard modules such as the automatic flare detection system.



Caption for image1.png: *X 6.3 solar flare on 2024 February 22 as observed by SUIT on Aditya L1 in near and mid UV wavelengths. (Panel a) Part of the Sun in the Mg II h line, showing the flaring region and sunspot. (Panels b i) SUIT narrowband images recorded at the peak of flares in the respective filters in the region depicted by the white dashed box in panel (a)*

A major area of research in the group is the study of solar flares, active region evolution and formation and acceleration of solar wind. The members use Multiwavelength observations to investigate the complex mechanisms underlying flare initiation and evolution. Additionally, machine learning approaches, particularly deep learning, are being explored for predicting solar flares, an essential step toward forecasting space weather events. Group members are examining the source regions of solar wind using remote sensing observations and deviations in the interplanetary magnetic field from the theoretical



Caption for Image2.jpg: *Image of the Sun recorded in the Mg II k line with the Solar Ultraviolet Imaging Telescope (SUIT) on board Aditya-L1. SUIT is the first instrument ever to record such full dЯisk images of the sun in the NUV wavelength band of 200-400 nm. The features protruding beyond the disk of the Sun are prominences.*

Parker spiral using in-situ data from the Parker Solar Probe. These variations are statistically linked to features in the solar atmosphere, shedding light on solar wind origin and transport. The team is also delving into solar chromospheric dynamics in active regions, as well as the chromospheric counterpart of the footpoints of polar plumes that play a role in the mass and energy transfer from the chromosphere to the corona. Together, these activities reflect the group's commitment to advancing our understanding of the Sun, contributing to national space missions and the broader field of solar physics.

PEDAGOGICAL

IUCAA-NCRA graduate school

The IUCAA-NCRA graduate school (conducted jointly with the National Centre for Radio Astrophysics (NCRA), Pune) is meant for the Ph.D. students of IUCAA and NCRA. Coursework is divided into two semesters (four terms) over one year. Each term is roughly seven weeks in duration. Students are taught relevant advanced courses in physics and are also introduced to courses in astronomy and astrophysics.

- Astronomical Techniques - I
- Electrodynamics and Radiative Processes I
- Extragalactic Astronomy I
- Interstellar Medium
- Introduction to Astronomy and Astrophysics
- Introduction to Astronomy and Astrophysics II
- Methods of Mathematical Physics II
- Quantum and Statistical Mechanics I
- Quantum and Statistical Mechanics II
- Research Methods and Statistical Techniques

Number of students enrolled in the graduate school: IUCAA - 05, NCRA - 04

SPPU-IUCAA JOINT M.Sc. (PHYSICS WITH ASTROPHYSICS) PROGRAMME and The DEPARTMENT OF PHYSICS, SPACE SCIENCES, SPPU, M.Sc. (ASTRO)

- Astrolab-II
- Astronomical Techniques
- Astrophysical Dynamics
- Astrophysics Laboratory I
- General Relativity and Cosmology
- High-Energy Astrophysics
- Introduction to Astronomy and Astrophysics I and II
- Relativistic Electrodynamics and Radiation Processes

Number of students enrolled in the SPPU-IUCAA Joint M.Sc. (Physics with Astrophysics) Programme: 11

Supervision of PhD Thesis

- Ph.Ds. awarded: 15
- Ongoing Ph.Ds.: 39
- Ph.Ds. awarded (other than IUCAA): 07

Seminars/ Colloquia /Posters/Lectures

- Number of invited talks: 44
- Number of Seminars/Colloquia/Posters: 32
- Lectures delivered by IUCAA academics in courses/workshops: 65
- Popular talks delivered by IUCAA Academics: 23

PUBLIC OUTREACH ACTIVITIES

Summer Astronomy Camps

Summer Astronomy Camps were conducted at IUCAA in three batches during the dates listed below:

- April 29 - May 03, 2024
- May 06 - 10, 2024
- May 14 - 16, 2024 (Rural)

National Space Day Celebrations

IUCAA conducted and collaborated on various outreach events across the country to mark the first nationwide celebration of National Space Day on August 23, 2024. An exhibition was organised in collaboration with the Department of Physics, Savitribai Phule Pune University (SPPU), for school and college students.

Chandra Public Lectures

The public talk series at IUCAA has been renamed **"Chandra Public Lectures"** in honour of **Prof. Subrahmanyan Chandrasekhar**, after whom the venue — the **Chandrasekhar Auditorium** — is also named. The following talks were conducted as part of this series:

August 23, 2024: **Kanak Saha** delivered a lecture titled '***Exploring the Cosmic Re-ionisation with India's AstroSat***'.

August 29, 2024: **Jeremie Lasue** (IRA, France) presented a talk titled '***The European Space Exploration of Comets: From Giotto to Comet Interceptor***'.

September 26, 2024: **Hamsa Padmanabhan (University of Geneva**) delivered a lecture titled **'Mapping the First Billion Years: Secrets from Our Invisible Universe'.**

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

1. **Arif Babul** (University of Victoria, Canada) presented a lecture titled '***How Did the Universe Come to Look the Way It Does?***'.
2. **Michitoshi Yoshida** (Vice-Director General, National Astronomical Observatory of Japan) delivered a talk titled **'*Striking Gold with Gravitational Waves*'**.

Additional talks and demonstrations held under this series include:

- July 13, 2024: *"Decoding Our Universe Through Spectroscopy"* by **R. Srianand** [English].
- August 10, 2024: *"Exploring Habitability and Our Sun"* by **Sneha Pandit** [English & Marathi].
- September 14, 2024: **"Cosmic Dawn: Birth of the First Stars" by Atrideb Chatterjee** [English].

In-Reach activities for IUCAA Members:

September 19, 2024 – A special hands-on session on DIY Spectroscopy was initiated by Debarati Chatterjee and Samir Dhurde and conducted by the SciPop team for IUCAA-NCRA Graduate School students. Sixteen students participated, gaining practical experience in constructing low-cost, effective spectroscopes and using them to observe real spectra. The session also introduced the students to IUCAA's outreach programmes, sparking interest in their future involvement.

Talks:

November 21, 2024: Talk by Nigar Shaji (ISRO, Bengaluru) titled *"A Vision for Future Indian Space Missions"*.

December 03, 2024: Talk by Jane Charlton (Penn State University, USA) titled *'The Life of a Quark'*.

December 05, 2024: Talk by Lutz Wisotzki (Leibniz-Institut fьr Astrophysik Potsdam (AIP)

titled '*The Cosmic Time Machine – What the Light from Distant Galaxies Can Tell Us*'. This talk was organised in collaboration with Jyotirvidya Parisanstha.

January 02, 2025: A special session for IUCAA Post-Doctoral Fellows featured an interactive discussion on outreach opportunities, followed by a sky watch session. The event aimed to encourage greater engagement in public science communication among early-career researchers.

Public Astronomy Events

Mar 28, 2025: Messier Marathon, Parut Village, Mahabaleshwar (10 amateur astronomers).

IAU-Related Outreach

Samir Dhurde actively participated in and conducted workshops at several events supported by the International Astronomical Union (IAU) Office of Astronomy for Education (OAE):

- IAU OAE FRESCO Residency Meeting (October 13–15, 2024) held in Istanbul, Turkey, where two new astronomy board games were developed. These games are currently being tested by IUCAA's SciPop team with various school audiences across India.
- Mediterranean Regional SHAW-IAU Workshop on Astronomy for Education (MASTED) (October 16–20, 2024) in Istanbul, Turkey.
- 1st Asian Regional SHAW-IAU Workshop on Astronomy for Education 2024 (December 19–21, 2024) held in Kathmandu, Nepal.
- As a co-National Outreach Coordinator (co-NOC) for India under the IAU, Samir Dhurde contributed to the international "Equal Day" pilot events on March 20, 2025. Supported by the IAU OAE, this global initiative registered 135 events worldwide and marked a significant milestone in promoting astronomy education and public engagement.

In addition, Samir 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 challenges related to preserving dark skies, addressing issues such as light pollution and advocating sustainable sky watching practices.

Outreach for Associates and ICARDs

As part of its outreach support for 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. Proposed by S. B. Gudennavar (ICARD, Christ University), the workshop was conducted by Samir Dhurde and Tushar Purohit. It engaged 70 students and 10 teachers and successfully resulted in the making of 23 telescopes.
- During Astro Week at IIT Gandhinagar, organised by Anand Sengupta, Samir Dhurde delivered a lecture and led amateur astronomy activities, including a public Sky watch 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.

Teacher Workshops & Special Trainings conducted: 06

Special Interactions & Talks: 02

Astronomy Workshops: 12

Sky watch / Sky Observation Sessions: 09

Telescope-Making Workshops: 17

National Science Day 2025

IUCAA celebrated **National Science Day 2025** with a series of engaging outreach activities throughout February, culminating in a vibrant **Open Campus Day** on **February 28**, themed *"Science & Innovation at IUCAA."* Over **7,000 visitors** from across Maharashtra participated.

The Open Campus Day featured:

- Live demos, hands-on exhibits, and public talks across the IUCAA campus.
- Attractions like the Foucault Pendulum, solar observations, quantum science demos, and exhibits on LIGO-India, ADITYA-L1, and AstroSat.
- A special aeromodelling show by Madhav Khare.
- Multilingual public lectures by researchers and an "Ask a Scientist" session.
- School-level exhibits, science puzzles, and storytelling by Prof. Jayant Narlikar.
- A public Sky watch event at the SPPU sports ground, which drew large crowds.

Preceding events included:

- Competitions for rural students on **February 01, 2025,** at Awasari, involving fifteen schools.
- Inter-school science competitions in Pune on **February 22, 2025**, with 180 students from thirty-six schools.
- A special "Human Orrery" demo for teachers by Emmanuel Rollinde and Surhud More.

The celebrations successfully fostered public engagement, scientific curiosity, and student participation across age groups.

Office of Astronomy for Education (OAE) Center – India

Activities undertaken during April – June 2024

Objective: Professionalise astronomy education

The IAU OAE office called for teacher training proposals (TTP) from teachers and astronomers worldwide.

Objective: Provide access to good resources: Resource Translations:

The Big Ideas book has been translated into Marathi by OAE Center India.

New Resources:

The OAE Center India is involved in making astronomy glossary cards containing the IAU astronomy glossary and related images.

Objective: Promote astronomy in curricula:

The OAE Center India finished the project of the baseline survey in Astronomy, where the status of astronomy education among school students was analysed.

(Khagol 133, July 2024)

Activities undertaken during July – September 2024

Objective: Professionalise astronomy education

The OAE, India Center assisted the IUCAA SciPop team in organising a Teachers' Training workshop on the campus during August 23-24, 2024. The workshop was attended by thirty teachers from rural areas in the state and comprised lectures, hands-on activities, and sky observations. A lecture on the lifecycle of stars was delivered during the program.

Objective: Provide access to good resources: Resource Translations:

The OAE Center - India undertook the English translation of the Marathi book titled 'Khagol Goshthi'(on positional astronomy). The Center completed the review of the Marathi version of the book 'Big Ideas' and plans to print copies for distribution in the schools.

Distribution of Resources:

The OAE Center - India team has created user guides for the books 'Big Ideas in Astronomy', 'Khagol Goshti', and 'Jantar Mantar' to assist the teachers in using the books effectively in class. The Center has distributed approximately 100 sets of Marathi books in the schools. They have received a request for three hundred books, which is in the process of distribution.

Objective: Promote astronomy in curricula:

The OAE Center - India conducted a baseline survey for the status of astronomy education throughout the country over the last year and the manuscript based on the results is currently under peer review. The OAE Center - India is working on the analysis of the survey data to investigate the differences in astronomy education among different states of India. The preliminary results show there is a large variance in the understanding of astronomy concepts and the availability of resources among the states. The Center also conducted a public astronomy survey during the Science Day activities over the past two years. The data analysis will help understand the public perception of astronomy and prepare a manuscript on the same.

Objective: OAE Networking:

The OAE Center - India assisted in the organisation of the 6th SHAW IAU workshop (A virtual international workshop held from November 12 - 15, 2024). Also, as a part of the Astronomy Education Research Scientific Organising Committee, the OAE Center - India team reviewed the submitted abstracts and helped to create the program. The Center also volunteered for the JWST session of the workshop.

(Khagol 134, October 2024)

Activities undertaken during October – December 2024

The OAE Center India funded three teacher training workshops from October to December 2024, at Tiruchirappalli, Tamil Nadu, Nainital, Uttarakhand, and Nehru Planetarium, Mumbai, Maharashtra. The workshops benefited a number of teachers, and all of them included pedagogical as well as practical aspects of teaching astronomy in schools.

The office printed several sets of three astronomy books for school students: '*Big Ideas in Astronomy*'(in English and Hindi), 'Khagol Goshti' (Astronomy Tales - in Marathi), and 'Jantar Mantar' (Historic Indian Observatory - in English, Hindi, and Marathi). These books, together with user guides for teachers on how to use these books in their classes effectively, have been distributed in about four hundred schools. The office also completed an English translation of the book '*Khagol Goshti*', which is now at the vetting stage.

Our team performed a secondary analysis of the baseline survey on Astronomy education in order to assess state-to-state differences and similarities within India. We observed substantial disparities in performance across states. The insights gained offer important implications for comparing state-level teaching standards and guiding the development of a more effective national astronomy curriculum. These results were presented at the epiSTEME-10 conference held at HBCSE, Mumbai, and the summary of this work will be published in the conference

proceedings.

Finally, the OAE Center India also helped in the organisation of the annual SHAW IAU workshop this year, with members acting as part of the SOC of the Astronomy Education Research part as well as in the technical organisation of the workshop.

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 × 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
- Hingoli Rural School Outreach
- Hingoli Star Fest
- Fergusson College Outreach

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

PH.D. DEGREES AWARDED

S. No.	Title	Name of the Student	Supervisor
1	Exploring the Nature of Dark Matter using Cosmological and Astrophysical Probes	Bhaskar Arya	Aseem Paranjape
2	Gravitational Lensing: Galaxy-Dark Matter Connection and Cosmology	Navin Lalta Prasad Chaurasiya	Surhud More
3	An unbiased view of cold atomic gas associated with radio loud AGNs	Partha Pratim Deka	Neeraj Gupta
4	Constraining Neutron Star Equation of State using Multi-disciplinary Physics and its application in studying various aspects of Gravitational Wave emission	Suprovo Ghosh	Debarati Chatterjee
5	Measuring Cosmological Parameters with Gravitational-Wave Observations	Tathagata Ghosh	Sukanta Bose (until 26.07.2024) and Gulab Chand Dewangan (since 27.07.2024)
6	Gravitational lensing in galaxy clusters	Amit Kumar	Surhud More
7	AstroSat view of accretion discs in Active Galactic Nuclei	Shrabani Kumar	Gulab Chand Dewangan
8	Modelling the Impact of AGN driven Outflows on the Star Formation Activity in Galaxies	Ankush Mandal	Dipanjan Mukherjee
9	Simulating effects of AGN-driven outflows on galactic scales and predicting their observable signatures.	Meenakshi	Dipanjan Mukherjee
10	Exploring Wave Effects in the Lensing of Gravitational Waves from Chirping Binaries	Anuj Mishra	Gulab Chand Dewangan
11	Characterizing the Properties and Constitution of Compact Objects in Gravitational-Wave Binaries	Samanwaya Mukherjee	Surhud More
12	Study of the effect of Neutron Star composition on fluid oscillation modes and Gravitational Wave emission	Bikram Keshari Pradhan	Debarati Chatterjee
13	Interplay of galaxy formation and the evolution of dark matter haloes in the cosmic web	Premvijay V.	Aseem Paranjape
14	An Investigation of Beamed Emission from Binary Accreting X-ray Pulsars	Parisee Sunil Shirke	Dipanjan Mukherjee
15	Efficient searches for compact binary coalescences and science in the LIGO-India era	Kanchan Soni	Sanjit Mitra

FACILITIES AT IUCAA

COMPUTING FACILITY

The IUCAA Computing Facility offers state-of-the-art computing hardware and a technology-rich environment for IUCAA members, associates and visitors. It also extends an array of specialised High-Performance Computing (HPC) environments to the academic community for their research.

The hardware and devices currently managed by the computing facility include about 350+ servers and desktops, 100+ laptops, 80+ printers and scanners, three large High-Performance Computing systems and over 9.5 PiB of storage, in addition to diverse equipment deployed for an extensive, high-throughput, wired and wireless campus-wide network. The number of registered Wi-Fi devices is over 900, and e-mail accounts served by the computing facility are nearly 825.

IUCAA provides e-mail services to its members and associates, with a total of nearly 825 accounts.

In the year April 2024 - March 2025, emphasis was given to the implementation of:

- **Expansion of the Pegasus cluster**
  The Pegasus cluster, deployed in 2019, consists of two head nodes, four login nodes, two graphics nodes, four GPU nodes, 2560 compute cores, and 2PiB Parallel File System (PFS) storage. Several new users have been added in the last two years, and all users use the cluster extensively. The average cluster utilisation is more than 90%, resulting in a considerable wait time for many jobs. To cater for the ever-increasing need for computing power for large-scale computational jobs and reduce the wait time, the Pegasus cluster was augmented by adding 20 compute nodes.

- **Replacement of OLD C-Power L&T Air Circuit Breakers**
  IUCAA has two dedicated 1250 Amps C-Power L&T Air Circuit Breakers, providing power supply to the new data centre; IT and non-IT equipment are 12+ Years old and declared at the sale's end, thus finding it difficult to replace the parts and maintenance, leading to recurring failure of the power supply results in a power outage in the new data centre affecting the services hosted in the data centre. Considering the future power requirement and improving the power supply stability in the data centre, the existing C-Power ACB L&T Circuit Breakers were replaced with two new, higher-capacity (1600A) C-Power L&T Air Circuit Breakers.

- **Constitution and Implementation of Time Allocation Committee (TAC) for Pegasus cluster**
  IUCAA has a dedicated cluster to support IUCAA members, associates, and their students across the inter-universities with their high-performance computing execution and data processing. IUCAA associates and international users highly utilize the HPC cluster. As the number of users, projects, and the complexity of the problems being addressed continue to grow, the computing demands are escalating rapidly and significantly. To streamline the usage and ensure equitable prioritisation of both projects and groups/users, the Computer Users Committee has approved a bi-annual proposal for the allocation of HPC resources, divided into two periods: January-June and July-December. A time allocation committee was formed to deliberate and allocate

resources efficiently across the various project groups/users, and implemented on IUCAA HPC to allocate the resources.

- **Renewal of Astronomical software services.** Scientists at IUCAA carry out research in a wide range of Astronomy and Astrophysics, such as Classical and quantum gravity, Cosmic magnetic fields, cosmology, large-scale structure, Galactic and extragalactic astronomy, Gravitational waves, High energy astrophysics, Instrumentation for astronomy, Observational Astronomy (Optical, UV, X-ray, and Radio), Quantum metrology for precision measurements, Solar Physics, and many more. Many of these fields require high-level data visualisations from complex numerical data. To help create such meaningful visualisations, IUCAA procured the licenses for Mathematica, MATLAB, and IDL software services.

The Computer Centre continues to provide technical support to IUCAA associates, project students, as well as visitors from universities and institutions within India and abroad. The Computing Facility employs 10 personnel who assist on a wide variety of IT and computing related activities for regular IT needs of the institution as well as providing active support and management for HPC and other computing systems.

High Performance Computing

IUCAA currently has three major independent HPC clusters dedicated to different applications, namely Pegasus, SARATHI and VROOM.

The Pegasus Cluster is to serve the general computing requirements of the astronomy community associated with IUCAA. It has 100 compute nodes, 4 GPU nodes with 32 cores and 384 GB (on old) & 512GB RAM (on new). It uses InfiniBand EDR (100 Gbps) as an interconnect, and Portable Batch System (PBS) as a job scheduler. For visualisation purposes, there are two dedicated graphics nodes equipped with NVIDIA Tesla P100 GPU cards. The cluster consists of more than 2600 Physical cores. The cluster is attached to a 2 PiB parallel file system (Lustre), which is capable of delivering 15 Gbps throughput. The theoretical computing speed of the Pegasus Cluster is 150 TF. The Pegasus cluster has been utilised by about 70 high-volume users from IUCAA and various Indian Universities, running applications for Molecular Scattering, Molecular Dynamics, Stellar Dynamics, Gravitational N-Body Simulations, Cosmic Microwave Background Evolution, Fluid Mechanics, Magnetohydrodynamics, Plasma Physics, and the analysis of diverse astronomical data.

The Sarathi Cluster is primarily used for gravitational wave research and is mostly used by national and international members of the International Gravitational-Wave Observatory Network (IGWN), previously known as the LIGO Scientific Collaboration (LSC), which includes many IUCAA members and Associates. The cluster is comprised of heterogeneous compute servers, and it is built in three phases. The cluster consists of more than 8000 Physical cores. The theoretical peak performance of the compute node CPUs of the cluster is nearly 530 TFlops. The cluster has 2PiB PFS storage with 30Gbps write and read (1:1) throughput.

The Vroom cluster is used solely for the MeerKAT Absorption Line Survey (MALS). This cluster has 21 compute nodes, 2 MDS nodes, 4 GPU nodes

and 2 head nodes, which deliver 25 TF computing speed and have a parallel file system of 3.5 PiB usable capacity attached to it. The cluster is also attached to 2 PiB archival storage for archiving/serving the processed data to the international community.

HPC clusters listed in the Top Supercomputers in India

Sarathi Cluster Phase III, Pegasus Cluster, and Sarathi Cluster Phase II are listed at 36th, 50th and 53rd rank, respectively, in the list of top Supercomputers in India published on January 31, 2024. The list is maintained and supported by CDAC's Tera scale Supercomputing Facility (CTSF), CDAC, Bangalore. The list is available at https://topsc.cdacb.in/filterdetailstry?page=60&slug=January2024

THE IUCAA LIBRARY

The IUCAA library provides users access to a comprehensive collection of books and journals in astronomy, astrophysics, and related areas. The library acquired 31 new print titles and 380 eBooks from the Springer Physics and Astronomy collection for 2024-25 and renewed the subscription to Annual Reviews. The library maintained its renewals to the Grammarly Premium software and the Overleaf software, a collaborative cloud-based LaTeX editor for writing, editing and publishing scientific documents. The library renewed its subscriptions to 48 journals for 2024. Courtesy of the E-Shodh Sindhu Consortium for Higher Education Electronic Resources, MHRD, Government of India, the library continued to receive access to seven e-resources, along with two NSDL e-resources as below:

1. **American Institute of Physics**
2. **American Physical Society**
3. **Institute for Studies in Industrial Development (ISID) Database**
4. **JGate Plus (JCCC)**
5. **Springer Link 1700 Collection and Nature Journal**
6. **Taylor and Francis**
7. **Web of Science**

NDL e-Resources

1. **World e-Book Library (Now available through NDLI only)**
2. **South Asia Archive (SAA) (Under National Licensing (Perpetual)**

Implementation of One Nation One Subscription (ONOS)

The Government of India launched the One Nation One Subscription (ONOS) scheme that aims to provide nationwide access to international scholarly journals for students, faculty, and researchers in centrally and state-managed higher education and research institutions. With ONOS, IUCAA has access to content from 30 major international publishers (listed below) beginning January 1, 2025, for an initial phase lasting through 2027. The access is coordinated by the INFLIBNET Centre, UGC, and journals are accessible via a unified portal: https://www.onos.gov.in.

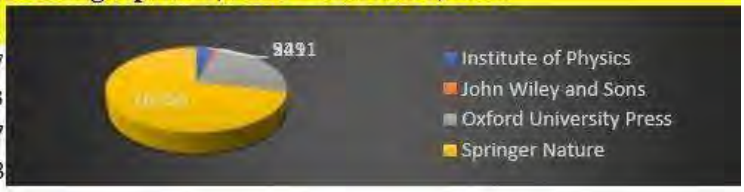
List of 30 Publishers under ONOS

1. Elsevier ScienceDirect
2. Springer Nature

3. IEEE (IEL Online - Complete)
4. Wiley Blackwell Publishing
5. Taylor and Francis
6. Lippincott Williams & Wilkins (Wolters Kluwer)
7. Institute of Physics
8. American Chemical Society
9. Cambridge University Press
10. American Physical Society
11. Oxford University Press
12. BMJ Journals
13. American Institute of Physics
14. ASCE
15. Project MUSE
16. IndianJournals.com
17. ASME
18. Bentham Science
19. Cold Spring Harbor Laboratory Press
20. ACM Digital Library
21. Annual Reviews
22. ICE Publishing
23. American Society for Microbiology
24. American Association for the Advancement of Science
25. American Institute of Aeronautics and Astronautics (AIAA)
26. American Mathematical Society
27. Emerald Publishing
28. SAGE Publishing
29. SPIE Digital Library
30. Thieme Medical Publishers

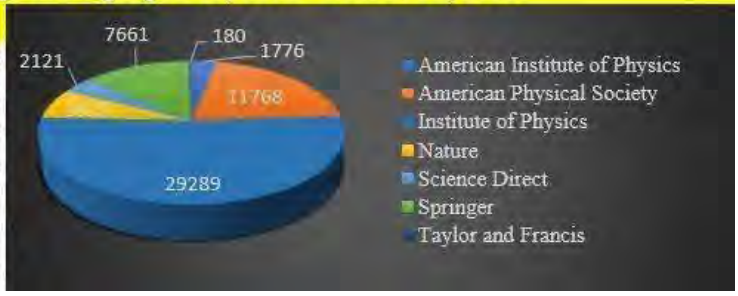
E-Books usage during April 01, 2024 - March 31, 2025

Publisher	Count
Institute of Physics	757
John Wiley and Sons	593
Oxford University Press	227
Springer Nature	21788



E-Journals usage during April 01, 2022 - March 31, 2023

Publisher	Count
American Institute of Physics	1776
American Physical Society	11768
Institute of Physics	29289
Nature	3813
Science Direct	2121
Springer	7661
Taylor and Francis	180



The library facilitates off-campus access to the following e-resources via the Remotlog software.

- American Association of Physics Teachers
- American Institute of Physics
- American Scientist
- Annual Review of Astronomy and Astrophysics
- Applied Optics
- American Physical Society
- Cambridge University Press
- EDP Sciences
- Institute of Physics
- Nature
- New Scientist
- Physics Today
- Physics Education
- Popular Science
- Science Direct
- Springer Nature
- Taylor and Francis
- The Web of Science
- World Scientific

In addition to the usual library business, the library team of five professionals facilitated the following activities and services:

- **VIDWAN:** The library created the profile of five academic members on the VIDWAN portal (https://vidwan.inflibnet.ac.in/) this year, taking the total profiles to forty-eight. VIDWAN is developed and maintained by the Information and Library Network Centre (INFLIBNET) with financial support from the National Mission on Education through ICT (NME-ICT).
- **IRINS** (https://iucaa.irins.org/) supports R&D institutions in curating and showcasing scholarly communications and activities through this web-based platform.
- **Open Journal System (OJS):** The library manages and maintains the IUCAA Annual Report, Khagol and Vyom issues on the IUCAA website using OJS (http://publication.iucaa.in/).
- **Document Delivery Service:** The library fulfilled 193 article requests from 85 users.
- **Inter-library Loan Service:** The library facilitated the loan of six books on inter-library loan to three libraries.
- **Publication Charges and Memberships:** The library processed twenty-eight publication charge requests and renewed its arXiv membership for 2024-25.
- **Plagiarism Reports:** The library provided plagiarism reports using the DrillBit software for the Ph.D. thesis of fifteen students. It also provided plagiarism reports for research articles using the 'Check-for-Plag' software.
- **YouTube Channel:** The library YouTube channel https://www.youtube.com/iucaalib) features 174 videos with 8.63K subscribers and 56.2K views.
- **Publications Assistance:** Assistance to the Publications Department in compiling the Annual Report and Khagol-related content, including the list of publications by IUCAA Academics and Visiting Associates, compilation of the reports received from the various IUCAA Centres for Astronomy Research and Development (ICARD), for the 37th Annual Report.

ASTRONOMY CENTRE FOR EDUCATORS

The Astronomy Centre for Educators (ACE) at IUCAA, conducted a series of educational programs in 2024-2025 to enhance astronomy education and research across India. The online workshop "Advances in Astronomy: Integrating Technology in Astronomy Research," held from April 1–5, 2024, with Vishwakarma Institute of Information Technology, Pune, aimed to explore astronomy fundamentals, engineering applications, and advanced technologies like artificial intelligence and data science. Around 80 participants, including faculty and researchers, engaged in hands-on sessions on instrumentation, signal processing, and astronomical data analysis. The "Refresher Course on Astronomy and Astrophysics" took place on campus from May 13 to June 14, 2024, alongside an online Summer School, covering topics such as radiative processes, compact objects, gravitational lensing, and mega projects like LIGO and Aditya-L1. Eighteen participants from higher education institutions attended and also got the opportunity to visit IUCAA's laboratories.

The 17th Radio Astronomy Winter School (RAWS), organized by IUCAA and NCRA-TIFR from December 14–24, 2024, selected 10 educators and 27 students from over 560 applicants. It introduced radio astronomy, observation techniques, and topics like pulsars and galaxy clusters, featuring experiments on detector noise and 21-cm Hydrogen emission observations, plus a guided tour of the Giant Metrewave Radio Telescope. Four online National Education Policy (NEP) Orientation and Sensitization Programmes under the Malaviya Mission were held in May, July, September, and November 2024, focusing on themes like skill development, inclusive education, and academic leadership, with 30-200 participants each. Additionally, "Astronomy, Science, and Society" workshops in April and September 2024, and February 2025, organized with Maharashtra State Faculty Development Academy, engaged around 40 faculty members each, fostering interdisciplinary education and discussions on inclusivity through lectures, hands-on sessions, and observatory visits.

IUCAA CENTRE FOR ASTRONOMY RESEARCH AND DEVELOPMENT (ICARDs)

37th ANNUAL REPORT 2024-25

ICARDs have been established at various Universities and Colleges with the primary functions as follows:

1. To contribute to the development of innovative teaching methods designed for Astronomy. This includes the development of up-to-date course structures and new kinds of experiment/data analysis sessions, which can be a part of a starting or existing Astronomy course in a university. They will try to inculcate distance learning programs and come up with suggestions as to how they can be implemented.
2. To hold frequent workshops/schools/meetings at various levels at the host University/College and in nearby regions.
3. To have an active public outreach program for Astronomy.
4. To be visiting the Centre, where nearby Astronomers can visit.

List of ICARDs

1. Department of Physics, Assam University (A Central University), Silchar
2. Department of Physics, Gauhati University, Guwahati, Assam
3. Department of Physics, Tezpur University, Tezpur
4. Department of Physics and Electronics, Christ (Deemed to be University), Bengaluru
5. School of Studies in Physics and Astrophysics, Pandit Ravishankar Shukla University, Raipur
6. Centre for Theoretical Physics, Jamia Millia Islamia (A Central University), New Delhi
7. Department of Physics, Indian Institute of Technology, Delhi
8. School of Physical Sciences, Jawaharlal Nehru University, New Delhi
9. Sri Venkateswara College (South Campus), University of Delhi, New Delhi
10. School of Arts and Sciences, Ahmedabad University, Ahmedabad
11. St. Xavier's University, Ahmedabad, Gujarat
12. Department of Physics and Astronomical Sciences, Central University of Himachal Pradesh (CUHP), Dharamshala, Himachal Pradesh
13. Department of Physics, BITS Pilani, Hyderabad
14. Department of Physics, University of Kashmir, Srinagar, Jammu and Kashmir ICARD
15. Department of Mathematics and Computing, Indian Institute of Technology (ISM), Dhanbad, Jharkhand
16. ICARD- Manipal Centre for Natural Sciences (MCNS), Centre of Excellence, Manipal Academy of Higher Education (MAHE)
17. Department of Information Technology, School of Information Science and Technology, Kannur University, Kerala
18. Department of Physics, Bharata Mata College (Autonomous), Kochi, Kerala
19. Department of Physics, Cochin University of Science and Technology, Cochin
20. School of Physical and Applied Sciences, Goa University, Goa
21. Department of Physics, Providence Women's College, Kozhikode, Kerala
22. Department of Physics, University College Thiruvananthapuram, Kerala
23. Department of Physics, Newman College Thodupuzha, Kerala
24. Dayanand Science College, Latur, Maharashtra
25. School of Physical Sciences, Swami Ramanand Teerth Marathwada University, Vishnupuri, Nanded
26. Department of Physics, Fergusson College (Autonomous), Pune, Maharashtra
27. Department of Physics, Manipur University, Manipur
28. Department of Physics, Indira Gandhi Institute of Technology, Odisha
29. Department of Physics, Central University of Tamil Nadu, Thiruvarur
30. Department of Physics, D.D.U. Gorakhpur University Gorakhpur, Gorakhpur, Uttar Pradesh
31. Department of Physics, University of Lucknow, Lucknow
32. Centre for Cosmology, Astrophysics and Space Science (CCASS), GLA University, Mathura
33. Department of Physics, Institute of Science, Banaras Hindu University, Varanasi,
34. ICARD, Department of Physics, Cooch Behar Panchanan Barma University (CBPBU)
35. Department of Statistics, University of Calcutta, 35, Ballygunge, Kolkata
36. Department of Physics, Aliah University, Kolkata
37. ICARD at Relativity and Cosmology Research Centre, Department of Physics, Jadavpur University, Kolkata
38. School of Astrophysics, Presidency University, Kolkata
39. ICARD-Department of Physics, Malda College, Malda, West Bengal
40. Department of Physics, Visva-Bharati, Santiniketan, West Bengal
41. Department of Physics, North Bengal University, Darjeeling, Siliguri, West Bengal

PUBLICATIONS BY IUCAA ACADEMICS AND IUCAA ASSOCIATES

PUBLICATIONS BY IUCAA ACADEMICS:

Number of Publications: 182, Impact Factor: 5.61

Journal Titles/ Number of articles

1. Astronomical Journal (6)
2. Astronomy & Astrophysics (29)
3. Astronomy & Computing (01)
4. Astrophysical Journal (48)
5. Astrophysical Journal Letters (9)
6. Astrophysical Journal Supp. Series (2)
7. Astrophysics and Space Science (1)
8. Advances in Space Research (1)
9. Classical Quantum and Gravity (2)
10. Current Science (1)
11. Division for Planetary Sciences (1) *
12. European Physical Journal C (3)
13. Experimental Astronomy (3)
14. IEEE Transactions on Instrumentation and Measurement (1)
15. Journal of Astrophysics and Astronomy (2)
16. Journal of Astronomical Telescopes, Instruments, and Systems (2)
17. Journal of High Energy Astrophysics (6)
18. Journal of High Energy Physics (1)
19. Journal of Communications (1)
20. Journal of Cosmology and Astroparticle Physics (5)
21. Living Reviews in Relativity (1)
22. Monthly Notices of the Royal Astronomical Society (30)
23. Nature (1)
24. The Open Journal of Astrophysics (3) *
25. Physical Review C (1)
26. Physical Review D (17)
27. Publications of the Astronomical Society of Australia (1)
28. Publications of the Astronomical Society of Japan (1)
29. Research in Astronomy and Astrophysics (1)
30. Solar Physics (1)

**The total number of publications is 177, of which the impact factor value of four journals (marked with *) (06 articles) is not available. Hence, the impact factor is calculated for (177-06), i.e. 171 publications only.*

PUBLICATIONS BY IUCAA ASSOCIATES

Number of Publications: 681, Impact Factor: 4.08

Journal Titles/ Number of articles

1. ACS Omega (01)
2. Advances in Space Research (04)
3. Analytical Chemistry (01)
4. Annalen der Physik (01)
5. Annals of Physics (14)
6. Applied Radiation and Isotopes (01)
7. Astronomical Journal (05)
8. Astronomy and Astrophysics (15)
9. Astronomy and Computing (05)
10. Astroparticle Physics (08)
11. Astrophysical Journal (28)
12. Astrophysical Journal Letters (05)
13. Astrophysical Journal Supplement Series (01)
14. Astrophysics (03)
15. Astrophysics and Space Science (04)
16. Atoms (01)
17. Biophysical Reviews (02)
18. Brazilian Journal of Physics (02)
19. Bulletin de la Societe Royale des Sciences de Liege (02)
20. Bulletin of the American Physical Society (01)
21. Canadian Journal of Physics (04)
22. Chaos (02)
23. Chemical Papers (01)
24. Chemistry Europe (2) *
25. Chinese Journal of Physics (16)
26. Chinese Physics C (06)
27. Classical and Quantum Gravity (06)
28. Colloids and Surfaces A: Physicochemical and Engineering Aspects (02)
29. Communications in Statistics - Simulation and Computation (01)
30. Communications in Statistics: Case Studies, Data Analysis and Applications (01) *
31. Communications in Theoretical Physics (03)
32. Computational Condensed Matter (1)
33. Earth and Space Chemistry (01)
34. European Physical Journal C (69)
35. European Physical Journal Plus (16)
36. Europhysics Letters (02)
37. Experimental Astronomy (01)
38. Few-Body Systems (01)
39. Foundation Of Chemistry (01)
40. Fortschritte der Physik (05)
41. Frontiers in Astronomy and Space Sciences (01)

42. Galaxies (01)
43. General Relativity and Gravitation (08)
44. Georgian Mathematical Journal (01)
45. Gravitation and Cosmology (08)
46. High Technology Letters (01)
47. International Journal of Geometric Methods in Modern Physics (25)
48. IEEE Transactions on Plasma Science (01)
49. Indian Journal of Physics (14)
50. International Journal of Modern Physics A (09)
51. International Journal of Modern Physics B (01)
52. International Journal of Modern Physics D (09)
53. International Journal of Speech Technology (1)
54. International Journal of Theoretical Physics (05)
55. Iranian Journal of Astronomy and Astrophysics (01) *
56. Iranian Journal of Mathematical Chemistry (01)
57. Iranian Journal of Physics (01) *
58. Jordan Journal of Physics (01)
59. Journal of Applied Polymer Science (01)
60. Journal of Astronomical Telescopes, Instruments, and Systems (01)
61. Journal of Astrophysics & Astronomy (07)
62. Journal of Atmospheric and Solar-Terrestrial Physics (01)
63. Journal of Cosmology and Astroparticle Physics (21)
64. Journal of High Energy Astrophysics (25)
65. Journal of High Energy Physics (03)
66. Journal of Holography Applications in Physics (04) *
67. Journal of Molecular Graphics & Modelling (01)
68. Journal of Physics A: Mathematical and Theoretical (01)
69. Journal of Plasma Physics (01)
70. Journal of Quantitative Spectroscopy and Radiative Transfer (01)
71. Journal of Subatomic Particles and Cosmology (02) *
72. Journal of Taibah University for Science (01) *
73. Journal of the Chemical Society, Dalton Transactions (02)
74. Journal of Theoretical and Applied Physics (01)
75. Journal of Xidian University (01) *
76. Macromolecular Symposia (01)
77. Malaysian Journal of Science (02)

78. Materials Science and Engineering B (02)
79. Mathematics (01)
80. MAUSAM (01)
81. Measurement (01)
82. Modern Physics Letters A (15)
83. Monthly Notices of the Royal Astronomical Society (61)
84. Nature (01)
85. Scientific Reports (NatSR) (01)
86. New Astronomy (15)
87. Nonlinear Dynamics (01)
88. Nuclear Physics B (21)
89. Open Astronomy (01)
90. Open Journal of Astrophysics (03) *
91. Optical Materials (01)
92. Optical and Quantum Electronics (01)
93. Palestine Journal of Mathematics (01)
94. Particles (03)
95. Physical Review C (01)
96. Physical Review D (08)
97. Physics Educator (01) *
98. Physics Letters A (05)
99. Physics Letters B (11)
100. Physics of Fluids (01)
101. Physics of Particles and Nuclei Letters (01)
102. Physics of Plasmas (04)
103. Physics of the Dark Universe (54)
104. Physics Scripta (27)
105. Pramana (04)
106. Publications of the Astronomical Society of Australia (06)
107. Pure and Applied Geophysics (01)
108. Research in Astronomy and Astrophysics (01)
109. Radiological Physics and Technology (01)
110. Results in Physics (01)
111. Romanian Astronomical Journal (01) *
112. Proceedings of the Royal Society of London Series A (01)
113. Solar Physics (03)
114. Space Weather (02)
115. Spectrochimica Acta, Part A: Molecular and Biomolecular Spectroscopy (01)
116. Theoretical and Mathematical Physics (04)
117. Universe (01)
118. Viruses (01)

**The total number of publications is 681, of which the impact factor value of eleven journals (marked with *) (18 articles) is not available. Hence, the impact factor is calculated for (681-18), i.e. 663 publications only.*

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