February 2026, Issue 11

DOOT

A student's initiative from the Indian Institute of Astrophysics, Bengaluru

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February 2026

IIA Publications No.: IIA/PhD/DOOT/09/Feb/11

Team DOOT

Invitation Call for Articles

We invite your insightful contributions to **DOOT** under the following categories:

Review: Scientific and technical publications are invited, including recent publications in academic journals from the IIA family, IIA technical reports, breakthroughs in Astronomy, book reviews, journal club discussions, and milestones of IIA projects. Articles should be written in simple and accessible language. Project interns and summer school project students are also encouraged to submit an overview of their work. *(Word limit: 2000 words)*

Experiences: This section welcomes narratives of personal experiences such as working on a scientific project or experiment, attending a conference or workshop, collaborative visits, observatory visits, or even an informal coffee break with an eminent scientist. We also invite interesting stories from our substations at Hanle, Kodaikanal, Kavalur, and Gauribidanur, highlighting ongoing activities and cherished memories. *(Word limit: 1400 words)*

Science Made Easy: For this section, we invite articles that discuss interesting concepts in Science and Technology (S&T) in a simple, engaging, and enjoyable manner, avoiding excessive technical jargon. The objective is to make S&T accessible to a wider audience by presenting complex ideas in a way that readers, regardless of their technical background, can understand, relate to, and appreciate their significance. *(Word limit: 1400 words)*

Alumni: We warmly invite our former students and retired staff and faculty to share their invaluable experiences from their time at IIA. This column provides an opportunity to reflect nostalgically on your journey and to share insights into your career path after IIA, the challenges you faced, and the impact IIA had on your professional and personal life. *(Word limit: 1400 words)*

Creative Corner: Unleash your creativity here! We invite artistic contributions including, but not limited to paintings, poems, short stories, sketches, and graffiti. *(Word limit: 800 words)*

Note: Please attach a brief author biography along with the article. Submissions should be in editable text formats (`.doc` or `.odt`). High-resolution images should be submitted separately, with filenames corresponding to the figure numbers (e.g., `Fig1.jpg`).

Disclaimer: All submissions will be published only after a strict screening process. The decision of the Chief Editor will be final. Submission of an article to DOOT implies the author's consent to edit and publish the article and confirms that the work is bona fide.

We would like to improve the content of the magazine. Please send your generous feedback and contributions for next editions to **doot@iiap.res.in**

From the Editor

Dear Readers,

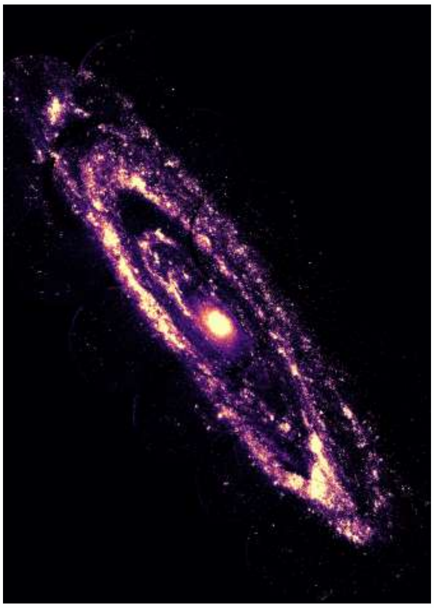
We are delighted to share that the student-led e-magazine of IIA, **DOOT**, has completed five successful years of publication. Over this period, the magazine has brought out 10 issues, featuring more than 130 articles that include research-based reviews, simplified explanations of interesting physics concepts, stories of personal experiences, invaluable experiences of alumni members, interviews, creative expressions, and astrophotography. This journey would not have been possible without the unwavering support of the Director, Dean, Faculty Advisors, DOOT team members, contributors, and readers. Their encouragement has helped DOOT gain visibility at national platforms such as the Astronomical Society of India meetings and other scientific gatherings.

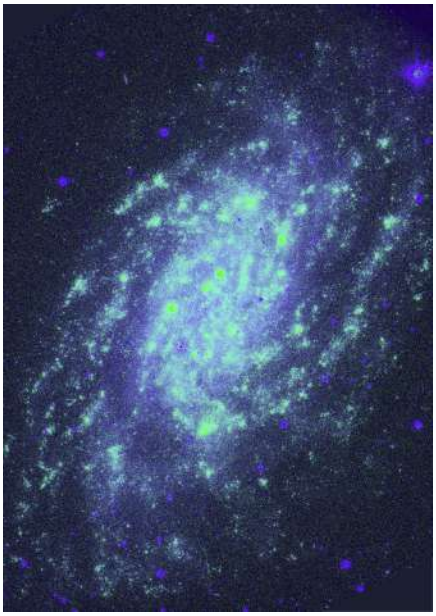
I am pleased to present the 11th issue of DOOT, a special edition celebrating 10 years of the Ultra Violet Imaging Telescope (UVIT). This issue has received enthusiastic contributions from the community, particularly from young researchers who have recently begun their journey at IIA. It features a diverse collection of articles highlighting scientific results, along with interviews, reviews, creative contributions, and astrophotography that reflect the breadth and enthusiasm of our community.

As DOOT continues to evolve, we remain committed to enhancing both the quality and diversity of its content. We warmly invite our readers to share their feedback and suggestions, which play an essential role in shaping the future of the magazine. We hope this special issue both informs and inspires, while celebrating the spirit of curiosity and collaboration that defines our community. We look forward to continuing to share many engaging articles with you in the years ahead.

Saili Keshri
Chief Editor, *DOOT*

The cover pictures (from the incomparable UVIT)





LEFT: This striking mosaic presents the Andromeda Galaxy (M31) as seen in the far-ultraviolet (FUV), assembled from 19 individual observations taken between September 2017 and December 2020. The images were taken by the Ultraviolet Imaging Telescope (UVIT) on board AstroSat, India's first dedicated multi-wavelength space observatory launched in 2015. The data were obtained using the CaF2 (F148W) filter, which covers a wavelength range of 1481 ± 500 angstrom, and were part of an observing program led by Prof. Denis Leahy from University of Calgary. Individual exposure times span a wide range, from about 3,300 seconds to over 17,000 seconds, allowing both bright and faint ultraviolet structures to be captured across the galaxy. Together, these multiple pointings provide a deep and wide FUV view of M31, making it ideal for studying recent star formation and diffuse ultraviolet emission on galactic scales.

In the FUV, Andromeda's familiar spiral structure is transformed. Bright emission traces young, massive O and B-type stars, highlighting regions of recent star formation across the disk and spiral arms. Beyond these stellar nurseries, diffuse FUV light arises from gas, dust-scattered radiation, and transient sources such as novae. Together, these components probe star formation over the last 100 million years and offer key insights into how gas, dust, and stars shape the ongoing evolution of galaxies like M33.

Credit: Judhajeet Basu, Post-doctoral researcher, IIA

RIGHT: This picture shows the FUV and NUV color-composite image of the majestic spiral galaxy NGC 2403. It was observed by the UVIT under the proposal ID G08_060T01 submitted by Prof. Annapurni Subramaniam. The FUV and NUV filters of the UVIT observed this galaxy for 5400 and 6000 seconds, respectively and the superposition of these observations helped create this image. Located at a distance of 3.2 million parsecs, its patchy, flocculent spiral arms span approximately 27,000 parsecs which makes this galaxy slightly smaller than our own Milky Way galaxy. NGC 2403 is an actively star-forming galaxy, hosting millions of UV-emitting young, massive O- and B-type stars. This galaxy presents an excellent laboratory for understanding star formation and spiral structure.

Credit : Shashank Gairola, Senior research fellow, IIA

CONTENTS

Beyond Research: A Journey of Team Spirit, Energy, and Bonding

Nitish Singh

Sports, when we talk about this, it's not just about competition or physical fitness; it's about energy, teamwork, discipline, and the spirit of togetherness. The Indian Institute of Astrophysics (IIA) campus is always buzzing with enthusiasm, with regular matches of badminton, volleyball, and cricket bringing people together. Indoors, games like table tennis, carrom, and chess are equally popular among students and staff. Sports at the IIA reflect the discipline, joy, and togetherness that define our vibrant campus life. However, in a research institute like IIA, sports are often seen as secondary to academics. Most students and staff here are deeply focused on their research, long working hours, and academic responsibilities. While they certainly have the interest, energy, and capability, many hesitate to step out and participate in physical activities. As a result, we sometimes face limited participation—and there are occasions when we don't have enough players to form complete teams. To change this and to promote physical activity across the campus, IIA organizes various sports events that bring the community together.

Some of the key events include the Karnataka Rajyotsava Sports Tournament, the Inter-IIA Cricket Tournament, and friendly matches with students from other institutes. Over the past two years, I have had the privilege of serving as the Student Sports Representative at IIA, and it has been a truly memorable experience. I was fortunate to organize the Karnataka Rajyotsava Sports Tournaments both in 2023 and 2024, as well as the Inter-IIA Cricket Tournament. In 2023, over 150 participants took part in various events, and in 2024, that number grew to more than 200. The Inter-IIA Cricket Tournament alone saw participation from around 70 members, including students, faculty, and staff members — highlighting how sports can bring the IIA community together across roles and disciplines.

The 2024 Karnataka Rajyotsava Sports Tournament was officially inaugurated by IIA Director, Prof. Annapurni Subramaniam, along with the Administrative Officer (AO), Mr. Shripathi K (see Picture 1). The tournament included outdoor games such as badminton, volleyball, cricket, and football, as well as indoor games like table tennis, carrom, chess, musical chairs, and a quiz competition.

The tournament kicked off with the chess tournament, and over the course of two weeks, we successfully conducted a wide range of indoor and outdoor events, ensuring enthusiastic participation and smooth coordination throughout (see Picture 2).

Sports bring out much more than just physical skill—they reveal aggression, friendship, teamwork, leadership, resilience, and the true spirit of competition. These qualities were clearly visible throughout the tournament, both on and off the field, making every event a valuable learning and bonding experience for all involved. I still clearly remember one of the most exciting matches from 2023. My partner Ravi (IIA alumni) and I reached the badminton doubles final, and we were feeling confident. To our surprise, our opponents in the final were none other than a faculty team—Prof. Maheshwar Gopinathan and Dr. Nagaraju. We assumed we had the upper hand

Picture 1: *Inauguration of the Karnataka Rajyotsava Sports Tournament 2024 at IIA Bengaluru. The event was inaugurated by IIA Director Prof. Annapurni Subramaniam and Administrative Officer Mr. Shripathi K.*

due to our energy and speed, but once the match began, we quickly realized how wrong we were. Their skills, strategy, and shot placement were on another level. We lost the first set, barely scraped through the second, and by the third set, we were completely exhausted. They won the match, and rightfully so—their experience and control of the game were truly admirable. That match wasn't just a game; it was a moment that boosted the energy of the entire audience. Everyone was cheering, and the match became one of the highlights of the tournament.

While the number of women participants in the tournaments was lower compared to men, we were lucky to have some very talented women players on campus. They played with the same energy, spirit, and confidence. Their performance was very inspiring and showed how strong, enthusiastic, and capable they were in sports. One of the most memorable highlights was when our women's cricket team won a cricket match against a team from another research institute in Bengaluru. The energy, joy, and celebration from the team at that moment were on another level—it was a proud and unforgettable experience for everyone present. We truly hope to see even greater participation from women in upcoming tournaments, especially in outdoor games. A few moments capturing the spirit and involvement of women in IIA sports activities are shown in Picture 3.

While organizing the tournament in 2024, I am truly thankful to everyone who helped to make it a success. To ensure smooth execution of the events, we formed a dedicated team of students and staff members, each responsible for coordinating a specific game. Cricket was managed by Rishab and Ajay; football by Judhajeet; volleyball by Shashank and Prajwal; badminton by Shubhangi and Sunit; table tennis by Sriram; chess by Manjunath; carrom by Sunit; musical chairs by Pavithra; and quiz by Ameya and Lupamudra. Their efforts in planning, scheduling, and conducting the matches ensured that everything ran efficiently and with great enthusiasm. I would also like to

***Picture 2:** Highlights from the Karnataka Rajyotsava Sports Tournament 2024 – Indoor and Outdoor Events at IIA Bengaluru. The collage shows various sports activities, including chess, cricket, football, badminton, volleyball, table tennis, carrom, and fun indoor events. Students, faculty, and staff members participated with great enthusiasm, making each game a celebration of energy, teamwork, and community spirit.*

sincerely thank the staff and faculty members, including Prof. Maheswar Gopinath, Accounts Officer S. B.Ramesh, Manjunath Hegde, Muralidhara S V, Bhaskara Achari A V, Jagannathan N, Ravichandran A, Ravichandra. J and V. Suresh, who supported us throughout the tournament by coordinating with the administration and assisting with overall organization. Special thanks go to our housekeeping and gardening teams, led by SelvaKumar, for cleaning and preparing the grounds before each match. Their hard work behind the scenes played a crucial role in the success of the tournament.

After the tournament concluded, the award distribution ceremony was held, led by our Director and AO. Awards were given for each sport, recognizing the winners and participants for their efforts and enthusiasm. I am also happy to share that I received appreciation from our Director for my efforts in organizing the tournament, which was a truly encouraging moment for me, as shown in Picture 4.

In the end, I truly believe that sports play a vital role in refreshing our minds and bringing balance to our busy academic and research lives. Participating in games is not a waste of time; rather, it enhances our focus, promotes good health, and builds a strong sense of teamwork and community. Through this tournament, we not only experienced the thrill of competition but also strengthened friendships, learned to support one another, and celebrated each other's talents. The energy and enthusiasm shown by everyone—from players to organizers—made this event memorable. I hope such sporting events continue to grow and become an even more integral part of life at IIA.

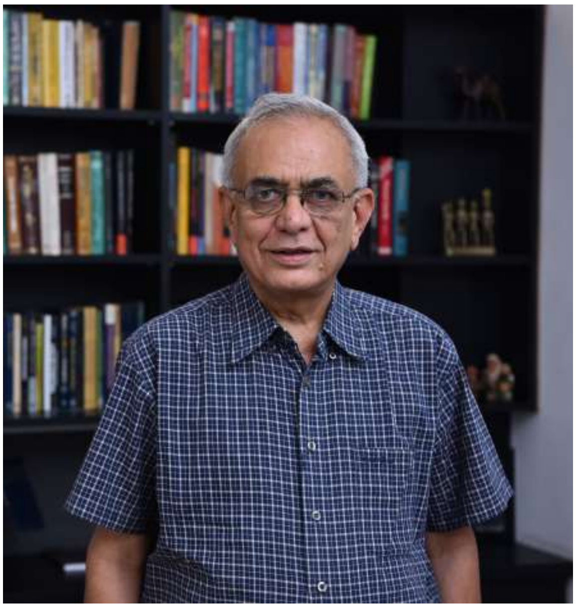
Picture 3: *IIA Women's Cricket Team – after winning a cricket match against another research institute in Bengaluru. The photos show the IIA women's cricket team celebrating their hard-earned victory with joy and pride. Their energy, unity, and sportsmanship were truly inspiring. The trophy ceremony was graced by faculty and staff, making the moment even more special.*

Picture 4: *Appreciation award presented to me by our Director during the closing ceremony of the sports tournament.*

Author's Bio:

Nitish Singh is a PhD student at the IIA, working under the guidance of Dr. Bharat Kumar Yerra and Dr. S. Sriram. His research focuses on the complete workflow of astronomical instrumentation—from design to fabrication and on-sky testing—including Wide-Field Correctors, Integral Field Units, Fiber Positioners, and both Integral and Multi-Object Spectrographs.

Interview with Prof. Ajit Kembhavi



Prof. Ajit Kembhavi is a Professor Emeritus and former Raja Ramanna Fellow at the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune. He was the Director there until August 2015. He earned his PhD from TIFR, Mumbai, with Professor Jayant Narlikar and was a postdoctoral fellow at the Institute of Astronomy, Cambridge. He has played a pivotal role in advancing astronomy as a research field in India. As a Dean of Visitor Programmes in IUCAA, he was responsible for the growth and sustenance of several programs held in IUCAA and across India, for the development of astronomical research. As the director of IUCAA, he took a leadership role in securing India's involvement in several major international projects, such as the Southern African Large Telescope (SALT), the Thirty Meter Telescope (TMT), and the Laser Interferometer Gravitational-Wave Observatory (LIGO). A significant achievement by Ajit Kembhavi is the establishment of the Indian chapter of the Virtual Observatory, a project supported by funding from the Ministry of Communications and Information Technology. His contributions have significantly strengthened India's presence in global astronomical endeavours.

Rishabh: I'll introduce you to DOOT, as the meaning of the name conveys, it is a messenger. DOOT is an entirely student-led initiative from the Indian Institute of Astrophysics (IIA). We publish an e-magazine every 6 months. We have been running the magazine successfully for the past five years with the help of students ranging from junior to senior level. Apart from publishing science-based review articles, we publish first-hand experiences of past and present people associated with IIA. We have also conducted several interviews in astrophysics and physics in general. Today brings us to another short interview in this series - I, Rishabh Singh Teja, and my co-panellists, Saili and Renu, welcome you all.

Prof. Ajit: Before we begin, I should say that this is really an exemplary initiative. You can put a lot of information and data, which gives everyone a sense of identity and belonging, and others can read it. You should keep it going as it spreads very fast these days. After a year or two, the older it becomes, the more important it will be. We have seen people coming back and looking at an issue that was published 20 years ago. So, just keep it up!

Rishabh: Thank you, Sir.

Saili: You have worked in multiple domains of astronomy and cosmology (Gravity, Pulsars, X-ray binaries in globular clusters, Galaxies, Quasars, etc). What motivates you to switch to a different domain and start working anew, and how challenging is this transition?

Prof. Ajit: I've been working on topics that align with the interests of my neighbours. For example, one day, I was discussing pulsars with a professor from the Tata Institute of Fundamental Research (TIFR), and he mentioned a particular problem: In globular clusters, there is an excess of X-ray binaries. Specifically, there are four known X-ray binaries in globular clusters, which is higher than predicted when comparing the mass of the cluster to the mass of the galaxy. So, how do these form? There was a very interesting paper by Fabian et al. (1), which stated that when a star comes close to a neutron star, tidal forces make it oscillate, causing it to lose energy and get captured. The paper also included a formal calculation. We thought it would be interesting to explore further calculations, so we did, and wrote a series of interesting papers.

Picture 1: *During the visit of the President: Dr. A.P.J. Abdul Kalam, President to IUCAA on 28.05.2003. L-R: Dr. A.P.J. Abdul Kalam, Prof. Jayant Narlikar, Prof. Naresh Dadhich, and Prof. Ajit Kembhavi.*

I became interested in elliptical galaxies at the suggestion of my friend S.K. Pandey, who was affiliated with the School of Studies in Physics, Pt. Ravishankar Shukla University, and who later became its Vice-Chancellor. That's how I started performing observations. For the next 10 to 15 years, we worked on the elliptical galaxies. I also did a lot of work with Dr. Sudhanshu Barway (IIA), who was first a student of Prof. S. K. Pandey in Raipur and later a postdoc at IUCAA. It was a matter of opportunity. The important thing is that I am interested in all of astrophysics and am glad to work in any area of it. It's quite interesting to move from one field to another.

Rishabh: How challenging is it for early-career researchers like us to switch to a different domain?

Prof. Ajit: Taking on a new problem as you reach the end of your PhD is extremely important. In my case, I was working on gravity with Prof. Jayant Narlikar, who was a remarkably benign supervisor. He allowed me to do what I wanted. He suggested a couple of problems to me. Finally, I decided to work on a problem based on space-time singularities. At the same time, I started working in astronomy and astrophysics, but I did not know any computer programming. So, I started collaborating with people who knew that. It was my fortune or misfortune that I got a job at TIFR while doing my PhD. I applied for postdocs at a few places. There was a famous relativist (well-known gravitational physicist), Prof. Jürgen Ehlers, in Germany, with whom I started working on gravity. I also applied for a fellowship to work at the Institute of Astronomy, Cambridge, UK. At the time, I knew nothing about the Institute of Astronomy except that my supervisor had once worked there. Fortunately, I was awarded the fellowship and started working with Andrew Fabian in X-ray astronomy. And just like that, opportunities kept unfolding - it's a reminder of how important these phases in life can be!

When postdocs join IUCAA, I always ask them what they are doing. They reply, "We are writing the papers on the work we did in our PhD days". Then I ask them, "What new things are you working on?" And they say, "No, we will first write the papers", and they sometimes spend 2 to 3 years writing papers and don't start anything new, which is not alright. What you need to do is choose a new problem. You must also be aware that when you apply for a postdoc or a job, people judge your work. If you work on only one problem, it's not enough. If you worked on four different things, they would say, "You're not focusing on anything". I don't know where to laugh or to cry when

I hear these things. But you have to strike a golden mean in some matters. Please do think of new problems and new areas.

Rishabh: Let's go down memory lane. As we look at your illustrious career life, spanning multiple decades and, of course, with a wide impact in various astrophysical systems, beautifully summarized by Saili. We're curious if there was a eureka moment in your life, or a particular work project or discovery that holds a special place for you.

Prof. Ajit: First of all, how did I get interested? I had teachers who were highly encouraging. I mean, they were not necessarily scientists themselves, or even doing anything beyond their own thing. But when I said I wanted to do something new, they said, "Yes, you go ahead and do it." When I talked to my parents and said, I want to do this, they said, do whatever you like. But for others, they said, go for medicine, go for engineering; otherwise, complete your graduation here and take a job. But I got interested in things, and I felt like doing nuclear physics because that's the only thing I had heard of. I sometimes wonder if I have heard of other things, for example, economics, would I have taken to those areas? In the early 1970s, many people who were leading economies all over the world, who had received Nobel Prizes, etc, were all working in Delhi. So, I'd have gone to Delhi, and then I could have become an economist. But I did not know about all these things. I remember one very important incident in my life when I was in the 8th standard. There was a piece of news about a new theory given by Jayant Narlikar and Fred Hoyle. I still remember from their theory that there is a negative sign attached to the gravitation constant, indicating that gravity is attractive. In hindsight, it was a remarkably well-written paragraph. Later, at school, our physics teacher asked, "Have you heard of something sensational and important?" I simply recited that paragraph. Everybody was very happy, and it sparked my interest. This curiosity eventually led me to speak with Narlikar himself, and through a series of coincidences, it became a reality. So, there are moments like that.

As I mentioned above, my work aligns with my neighbours whatever they're interested in. Let me tell you one incident: there's a very senior person, Prof. G. Ambika. For many years, she was at IISER Pune, then at IISER Tirupati. She worked on "Chaos." She had a student, who is now retired, working on variable stars. She became a Visiting Associate of IUCAA, and on one of her visits, I suggested to her, "Look, you have got these variable stars, and how about you look for chaos in the variability? They tried, but it did not work too well.

After that, Ranjeev Mishra joined IUCAA to look at X-ray variability. Ambika and her student, Harikrishnan, looked at the X-ray variability and got extremely good results. So, we wrote a couple of papers together. Recently, just after COVID, Harikrishnan came to my office and said, "I'm glad to tell you that I just submitted the 19th paper, which came out of the idea at that time." Also, I used to interact very closely with people who are Visiting Associates of IUCAA. They come from different universities with all kinds of interests.

Picture 2: *Early days of IUCAA: Outside the Aditi shed (administrative office of IUCAA) with Prof. Jayant Narlikar, Prof. N.C. Wickramasinghe and Prof. Naresh Dadhich.*

Twenty-five years ago, I interacted with a Professor, Prof. Ninan Sajeeth Philip. His son, Joe Philip, is a great expert on Artificial Intelligence (AI) and is at TIFR now. I, along with Prof. Sajeeth Philip, wrote many papers on artificial neural networks. Although they were very nice papers, AI was not very well known at that time. Some years ago, I was in Seattle, and it was my grandson's birthday. There were mainly grown-up people in the room, all talking about Deep Learning. I asked them, What is deep learning? Then, the next day, one of them gave me a book based on Deep Learning, and I got interested in it. Sajeeth Philip then applied deep learning to biology and did very beautiful work. Like that, things happen.

Renu: You have been part of IUCAA since its foundation. What is your perspective on how IUCAA, and more importantly, astronomy in India, have evolved over the years?

Prof. Ajit: When IUCAA was first started, we were all theorists. I liked to do data analysis and computing, but my other two colleagues, Prof. Narlikar and Prof. Naresh Dadhich, were complete theorists. Dadhich is a great expert in gravitational physics. The early people who joined were all mainly theoretically inclined. Then we had the sense that we must bring in people who work in observations and experiments. I then got a Charge-Coupled Device (CCD) to get it installed on the Vainu Bappu Telescope (VBT). But quite soon, other people with expertise in instrumentation started joining, and I began to put a lot of emphasis on computing-related matters and creating top-class computing facilities at IUCAA. I first thought we should buy a very high-end VAX computer. Then, Prof. Subramaniam Ananthakrishnan, of the National Centre for Radio Astrophysics (NCRA), which is located just opposite IUCAA, brought to my notice that networks of workstations with a central server were the emerging technology, so with the agreement of my colleagues, that is the architecture which I adopted for our computing facility. IUCAA was the first institute in India to create an institute-wide network on which the scientific, as well as service and administrative work was done.

To run the CCD at Kavalur, I bought an image processing system, and it was cumbersome, large and very expensive. It needed detailed programming, which I had to do by myself, and I programmed it. At one point, I needed machine-level support, and a colleague from TIFR gave that to me. Then I went to the Massachusetts Institute of Technology (MIT), where I was walking in a laboratory, and suddenly I saw a picture of Einstein on a Sun workstation's screen. I decided that I must buy these Sun computers as part of the IUCAA network. At that time, it took a long time to get permission from the Government of India to import the workstations and much longer to get permission from the USA to export them. But the facility we acquired at a very reasonable cost was worth the wait.

Saili: How has astronomy evolved all over India through the visiting associate programme?

Prof. Ajit: We started the visiting associate programme in 1989. At that time, if you looked at Kerala, it had produced a small number of very distinguished astronomers, like Prof. M. G. K. Menon and Prof. R. R. Daniel. But astronomy was not widespread at all. Through IUCAA, we started conducting a yearly meeting so that young people from Kerala who wanted to work in astronomy could learn about it from experts. We also had a lot of such activity in different places in Kerala, and soon there were several students working jointly with their supervisor in Kerala and a co-supervisor in IUCAA. Also, several physicists in universities and colleges in Kerala started working on astrophysical problems. Now Kerala has a flourishing astronomical community well known for its work at the national and international level. This is also true in Assam and Jammu & Kashmir (J&K) as well. I think astronomy has become as common in the university sector in

India as other subjects, like biology, chemistry, and physics, though the numbers in astronomy are still comparatively small. That is a very good contribution that we have made.

Also, one important project that I was involved in, which helped this process, is that we started something called the IUCAA Research Centres (IRCs) in the universities. The idea was to give them a phone and then to provide them with an Internet account for looking at the existing literature of the field. I got another idea, and I said, “Look, IUCAA is getting all these journals; how about providing journal subscriptions for 10 to 20 astronomy centres in the university?” At that time, I thought we needed Very Small Aperture Terminals (VSATs) for enabling this. So, I went to Prof. Arun Nigvekar, who was then the chairman of the University Grants Commission. I told him that I would like to do this and provide these journals to ten universities and astronomy centres. He said, “No, I cannot support that kind of a project because it is too limited, but if you are willing to take on the challenging job of providing all journals to all universities, I’ll support it.” I immediately set up such a programme with funds from the UGC. I formed a group of interested people to decide on the contours of the programme. At that time, about 20 years ago, these e-subscriptions were not known. They were just starting; there are some publishers, particularly Springer, who helped us very much. They agreed to give us the mass subscriptions at a concessional rate, and then all the universities could have all the journals. The programme was considered to be a great success.

Rishabh: You are currently leading the “Big Data” project supported by the National Knowledge Network (NKN). With the advent of AI and machine learning in astrophysics, how do you think these technologies will use this data and transform our ability to study and understand cosmic phenomena?

Prof. Ajit: I was involved in data analysis in different ways because I was interested in it. I started doing it, but then I found the virtual observatory. The virtual observatory project was started around 2002 or 2003. I first heard about it from my friend George Djorgovski, who is a Professor at Caltech. We discussed it, and I attended a meeting that I liked very much. I thought that we should write a project. In Pune, there is a company called Persistent Systems, and the owner of that company, Anand Deshpande, had arrived in Pune the same year that I did. That was in 1989, and he had got his PhD and wanted to set up a company and desperately needed to use email. And IUCAA was the only organisation in Maharashtra outside Bombay that had access to email. So, he used to come to IUCAA to send and receive emails. That’s how I got to know him. And when I got the virtual observatory idea, I talked to him. At that point, his company had grown, and he was employing 300 people. So he said, “Yes, I like this project.” We wrote a project proposal to the Information and Communications Ministry, which responded positively because of the intervention by Pramod Mahajan, who was the concerned minister. Anand Deshpande gave me six software engineers. And then, we started working on the virtual observatory, which went extremely well. We worked together for about 15 years. I think we did a lot of work for the virtual observatory with very limited resources.

Then, the next thing was the AI part. As I told you, we are working on AI, and these are just simple projects, mainly related to galaxy morphology, the classification of spectra, and X-ray binary sources. We are working on a large number of projects, and most of them are done by interns. In my time, we used to call them project students, but now the word is intern. It took me a long time to make that shift. Interns can be very clever, and they are quite happy working on the projects and getting publications. But I still feel that we had to become much more systematic in it. Every day, there

***Picture 3:** With research scholars and senior colleagues.*

is a new thing that is coming up, and I am not very familiar with generative AI, but over the last month, I have been studying it quite extensively. Although I am in the initial learning stage, there are a lot of people who help me write the programs since I don't get much time to do so myself. So I feel that it is going to be extremely important to spend time on AI, and every institute must have half a dozen people who are experts in it. Please believe me, India is the only major astronomy country in the world that has no AI people systematically appointed. It is very important to develop expertise in AI; it is not just another tool.
We are going to have an interesting meeting at IUCAA in January 2025, and some real experts from all over the world will come. It is a one-week workshop on AI that involves the most modern applications of AI. And I feel that there should be many more such workshops. But we could have online courses too, so that you can go to YouTube and get all the lectures. You can get lots of online courses, but when you're sitting like this and talking, it's completely different. Right? You're actively working together. I would very much like to lead that effort. To create such hybrid courses for astronomers, I've been trying to get some funding for it.

Renu: Yeah. I also agree with your statement. Like, we should progress with time, and keep updating ourselves along with the forthcoming advanced technology.

Prof. Ajit: Yes. And then, you don't have to go to the latest in the morning and evening, because you see that there's a lot of hype associated with AI. If you see, the stock market, AI-related companies are going up and down right now, and AI is slowly falling from favour. Because it does not immediately give the expected returns. But, fortunately, you're not bothered about that part of it, and all of you should study it.

Rishabh: Like, in the general public, there are too many diverging views about AI. So there are some sceptics, do you have any comments on that? Is there any downside to AI in Google?

Prof. Ajit: What's the downside? It is very easy to use because all this software is available for free. And I have seen fairly clever people jumping on it and doing it improperly. It is like you have got all these Python notebooks. So you can run the programs and do whatever you want. And then, because it is a very intricate thing, you do not know what you are doing, you do not know how the classifications are taking place. It needs real expertise to develop insights like that.

Renu: You've been actively involved in promoting science. How important is it for scientists to engage with the public, and how can this be improved in India?

Prof. Ajit: Oh, I think that it is incredibly important to increase interaction with the public. And working on all these projects, like the Virtual Observatory and Pune Cluster Network, they let you talk to the public. If you look at the early photographs in the history of modern science in India, you see photographs with some leading scientists with the Prime Minister. The scientist is showing them something, and both parties thought it was a privilege. At such times, the scientist could bring forth a new idea, like starting work on space, which could very well get funded. But practical questions can also come, like what is the use to the public and the economy of your discovery in science? How are scientists paying for the great investment made in scientific programmes?
If you are in a teaching institute, you are teaching, and in return, you get funds to do your research (as well as a salary), but you really have very little time left for it. But if you go to an IISER or an IIT, there is a lot of teaching to be done, but it is still within limits. These institutes also allow you time to do research. But the teaching is tough. It's not because teaching means collecting papers from 300 people in the class, but there are many other things. However, teaching is not available at pure research institutes, and scientists have to find other ways to return to society.
I feel that everybody should have a purpose in life, which is for the public good. The research that we do does help the public, but sometimes very indirectly. So then, what can we do that directly? Now, public outreach makes people happy, hence it is very important. On the other hand, now data science comes to your rescue because it is applied everywhere. Astronomers are great experts in data science and can contribute directly to its development and applications for the general good.

Rishabh: Even for DOOT, we started with a similar limelight to give back to the public in some way, at our level, at the student's level.

Prof. Ajit: Yes, it is very important to do so.

Saili: Scientific thing, but for the general public.

Prof. Ajit: Yes, and you have to do it very seriously. The public knows whether you are doing it right or not. They do not have to scientifically understand what you are saying, but they can develop a feel for how good you are at your work and how genuinely you are interested and involved in it.

Renu: I think we should figure out that question again: how to do it properly.

Prof. Ajit: Yes, what is the importance of your research work, and how interesting is it? All these things help because, you see, when we started IUCAA, we started all our programs immediately. An important programme was public outreach, and as a part of it, we started lectures for school students on Saturdays. One lecture is in Marathi or Hindi, and one is in English. Our auditorium holds about 500 people. So lakhs of students have attended these lectures, because we've been going on for 33 years now, and greatly benefitted from them.
I think that, overall, my message is to work hard. It's a tough life, but you need to work

extremely hard. And you must understand that your ability to learn starts diminishing quite soon. You start as a research student, then you go to postdoc years, and then you are a young faculty member. I feel that you must be reading books at all these stages. Now, of course, during my travels, I cannot carry textbooks. But because I've bought the book, I do not mind downloading the PDF file of the book. There is great joy in reading books. Papers, of course, you have to read. You have to write papers as well. On the other hand, you could also write books. All that is very, very important.

Saili: At the end of this interaction, I have one last question. We often watch science fiction movies that are inspired by actual science. Is there a piece of sci-fi technology or concept you'd love to see become reality?

Prof. Ajit: Yes, I suppose everybody would like to go through a wormhole. Then you do not have to sit at the airport for three hours. I do not know whether wormholes connect Pune to Bangalore, and you could make more exciting wormholes. In general, I am not a great believer in time travel. But wormholes should be there. Can you have a wormhole without time travel? I don't know.

Rishabh: But, in other books, like the Dune or Foundation series, they have different interstellar travel technologies.

Prof. Ajit: You know, you asked me if there are moments that suddenly change your thinking. I have this habit of not sleeping without reading something. And that can't be something like course-related. It has to be a thriller. I used to visit the Indian Institute of Science (IISc) when I was a student. And then, I used to visit other institutes sometimes, but live in IISc as a parasite. I had a friend in IISc called Niranjan Joshi, who was a graduate student, and I used to stay in his room when I was not officially visiting IISc. One night when I was in his room, I did not have anything to read. I found that Niranjan had a book by Isaac Asimov. I opened it, and the first story was Nightfall. I read it, and I wondered, "Why have I been missing this?" It is one of the greatest science fiction stories of all. It was just a pure accident that I stumbled upon this story on my first attempt to engage with science fiction; it could have been a very boring story, which would have put me off the genre forever.

Rishabh & Saili: Thank you for such an interesting conversation! If you are okay with it, could we all take a picture with you?

Prof. Ajit: Yeah, sure. Thank you so much. It was a great pleasure meeting all of you.

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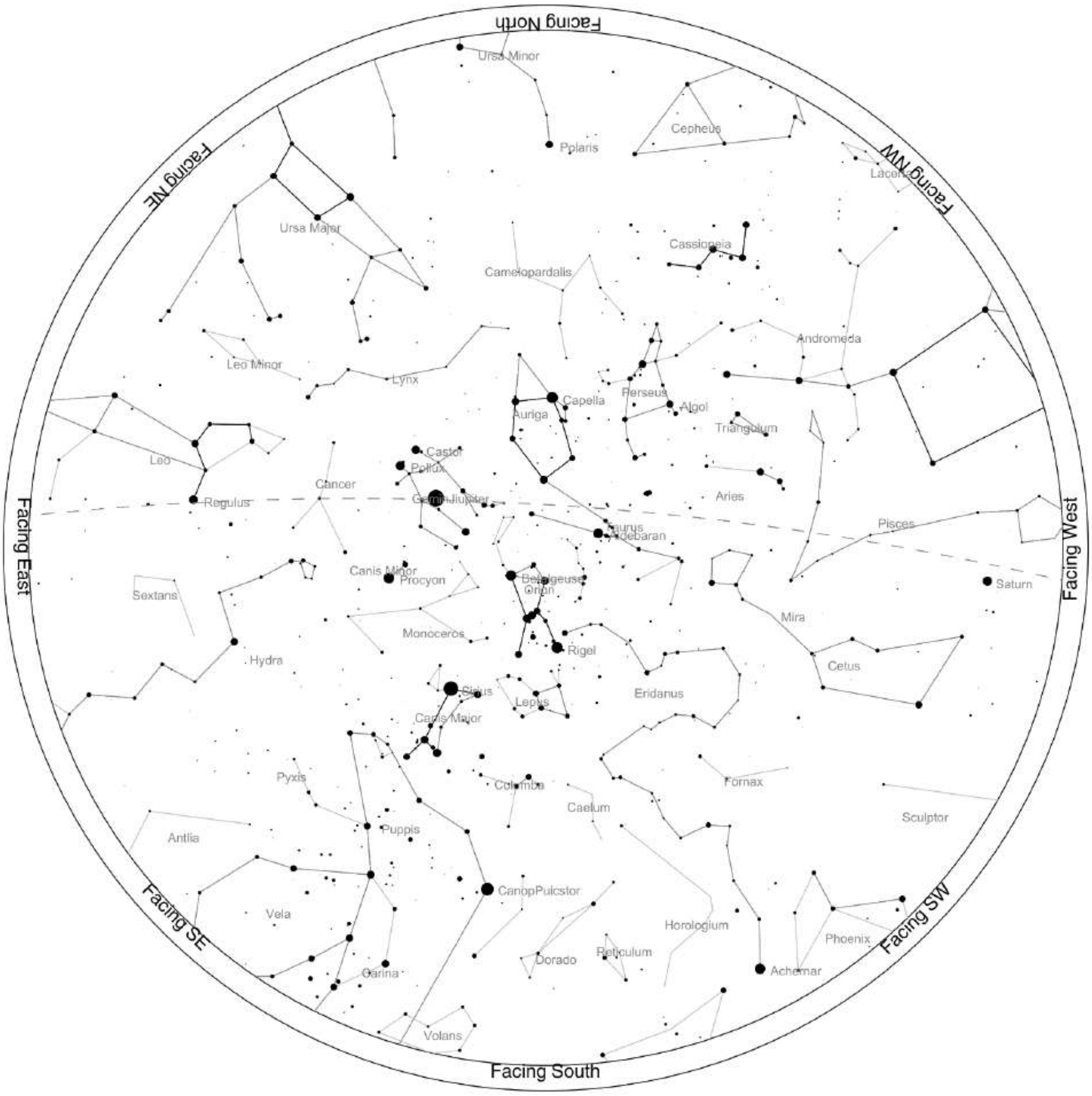
Prof. Ajit Kembhavi with DOOT team

An attempt to capture the beauty of the most beautiful object visible in the universe — a galaxy. Funny how I am inside a galaxy, and inside my sketchbook, there is a galaxy — a full circle of creation indeed.

Art by Muskan Shaw, a Junior Research Fellow (JRF) at IIA



Location: Banglore Latitude: 13° 36' N, longitude: 77° 57' E Time: 2026 February 15, 20:00 (UTC +05:30)

Skychart February 2026

February 17 – Annular Solar Eclipse: An annular solar eclipse occurs when the Moon is too distant to completely block the Sun, leaving a bright ring of sunlight. However, this eclipse will be annular only over Antarctica and the southern Indian Ocean.

Bappu, As I Remember Him

Arvind Paranjpye

In late 1978, Dr M. H. Gokhale, one of the first senior faculty members at the Indian Institute of Astrophysics (IIA), introduced me to the institute. At the time, I was in my second year of B.Sc. at the Government Arts and Science College, commonly known as GAS College. Dr Gokhale was our family friend and, knowing my interest in astronomy, had asked me to attend a semi-popular lecture on astronomy.

I remember cycling from the GAS College to IIA via Double Road, Wilson Garden, Christ College (it was not a University then), and crossing over to the St. John's Medical College, Bengaluru, to reach IIA. It was my first-ever entry to the IIA campus. The lecture was in the auditorium on the first floor of the old building. The lecture hall was quite full but not overflowing. The podium was to the left of the first door as one entered from the library side.

About a minute before the start of the lecture, two people entered the hall. One of them was tall with an athletic body, dressed immaculately. The other person looked shorter but looked 'important'. He was probably the speaker and a very important 'official' to have a well-built bodyguard with him. The moment they entered, complete silence descended in the hall. The tall man escorted the 'official' to his seat, went back to close the door behind them, and walked to the dais. It was clear from what he said that he was introducing the speaker. When the speaker took the podium, he thanked Prof Vainu Bappu for inviting him to deliver this lecture. This was my first time seeing the legendary man "Manali Kallat Vainu Bappu". Soon, I was a regular visitor to IIA. Ms Vageswari and Ms Christina were very kind in giving me all the privileges of the IIA staff. I could borrow books in the name of Dr Gokhale.

Once, I asked Bappu if I could use a telescope. I was immediately permitted to use the beautiful 6-inch Carl Zeiss Schmidt telescope. I started using it on nights when I had no college the next day. My first night of observation was on a Saturday. I had cycled from home in 8th Block, Jayanagar, and was at IIA just as the sun had set. I was to meet A. V. Raveendran, then a young, upcoming photometrist, who would help me get familiar with the instrument. The telescope was placed outside the admin building. The security guard instructed me to tuck the legs of my pants into my socks in case some snake might think that my pants were a good warm shelter from the cold dew that would descend as the night progressed. Poor Raveendran - he went home for dinner and came back later to check if I was doing okay. Then, he slept on a bed of newspapers on the floor of the admin building.

Not long after, I was asked to report to the Director the next time I was at IIA before starting my observations. I was told to go to his office by about 5:30 p.m. His office was on the first floor above the library. It had two doors - through one, you could directly enter his office, and the second was through his personal secretary. I chose the direct entry. This was my first direct meeting with him. He asked me about my observing programme. Without taking out my diary, I told him about the objects I planned to see that night. One of the objects I was going to observe was the Pleiades.

I don't remember how I pronounced 'Pleiades' then, but the pronunciation was undoubtedly incorrect. He asked me to repeat it. Idiot that I was, I said the Pleiades, seven sisters, or Messier 45, and with some emphasis, I added 'Kritika' (Sanskrit name), thinking that he probably did not know its English name. He could read my mind. With a faint smile, he told me the name would be pronounced 'play-a-dees' and made me repeat until I got it correct. After a few more questions, I asked him if I could go as I was late for my observations. This time, the smile was seen clearly, and with a nod, I was dismissed. Come to think of it, you don't tell the Bappus of this world that you are getting late. But the observer in him had sensed my urgency to go to the telescope.

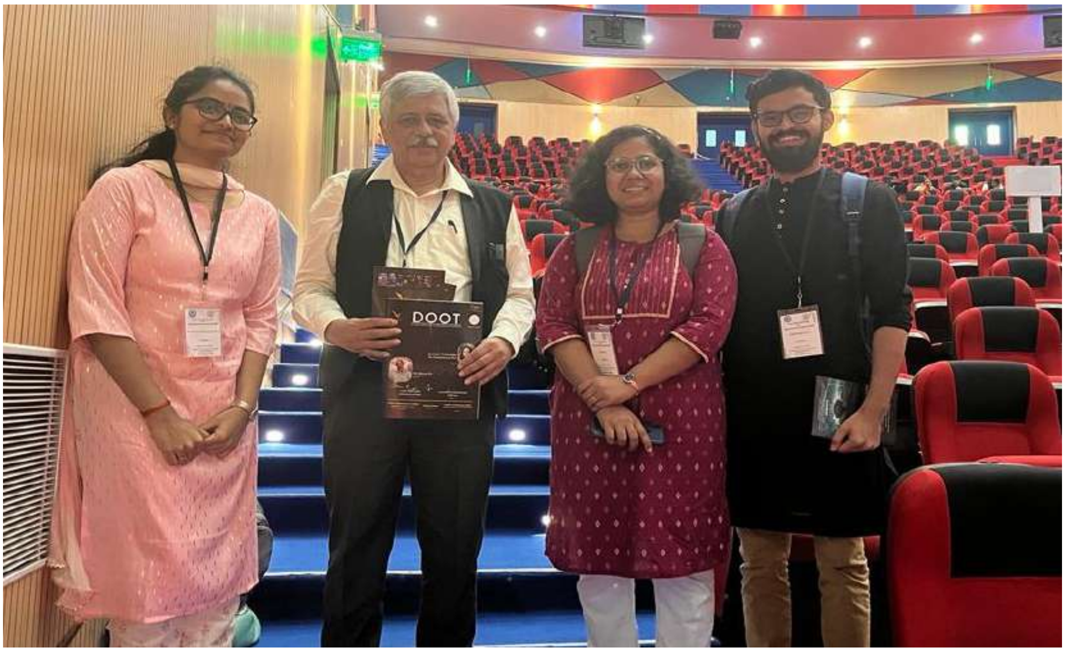
Thanks to him and Raveendran, I enjoyed using the 6-inch Carl Zeiss Schmidt telescope. The skies were very good those days. There were no buildings around - though even then, we cribbed about the light pollution, which was nothing compared to what we have today. I had made a Scotch Mount to take long-exposure photographs. I had purchased a portable enlarger (to project an image onto photographic paper for printing) from the junk market and made it work. So, one day, I took a print of a large field picture of the Orion constellation to Bappu. He was standing at the reception desk. I showed him the photo. He asked me all the details, starting with the mount. He then said that it is good to see 'black stars on a white background'. When I told him I couldn't do that at home, he opened the door to the photographic lab, where I would later work for nearly ten years.

That afternoon, I learned two things about him. First, his deep knowledge of the sky. When he asked if I had the negative, I handed it over. He took out an eyepiece from his pocket, carefully examined the film, and told me I had reached the 8th magnitude. He then advised me to use the star maps in the library to compare my image. Secondly, I saw his appreciation for a 'job well done'. As he examined my film, an astronomer happened to pass by. Bappu glanced at him and remarked that he had seen the spectra the astronomer had left on his table. Then, with a sharp yet subtle remark, he added, "The observer was probably dozing while taking the spectra." The astronomer vanished from the scene. In just one sentence, Bappu conveyed what could have taken paragraphs.

He always seemed to carry an eyepiece in his pocket, using it to carefully examine every photographic plate—whether of spectra or a star field—handed to him. If the plate was well exposed and the image was sharp, he would take his time to admire it, much like an art lover gazing at the Mona Lisa in the Louvre Museum (Paris).

Listening to him was always a pleasure. His keen eye for detail extended beyond photographic plates to his public talks, which were nothing short of excellent. He chose his slides very carefully, and one would never find a fingerprint on his slides. That was the photographic era; PowerPoint presentations came more than two decades later.

I remember one such occasion at Jyoti Nivas College (Bengaluru), where a science fair had been organised. I had a smooth entry into this girls' college because I was helping Sudha,



Doot team with Mr Arvind Paranjpye at the IIT Indore auditorium during ASI 2023.

daughter of Prof K. R. Sivraman, who was the third director of IIA after Jagadish Chandra Bhattacharyya (JCB), with some demonstrations testing telescope mirrors using Foucault's method. Bappu delivered the inaugural talk from the college's courtyard, which was completely packed. Many girls listened to him as they stood outside their classrooms, which overlooked the courtyard. An exception with Bappu is not using a slide set during a talk on astronomical topics. But then Bappu was an exception himself. The entire 50 minutes of his lecture were delivered, standing erect, both hands locked behind his back. Only his neck moved. Occasionally, he scanned his audience from the top floor to the ground – not like a swinging fan, but randomly.

He had a subtle way of conveying his messages. One astronomer got invited to be a member of an IAU commission. She told Bappu about it and told him what she would like to do as a commission member. He then told her that she had just stepped into a new room. She should stand at the door, look around, and understand what is going on inside the room before making her move. This was such wonderful advice that everyone should keep in mind. I always remembered this, and it proved most helpful when I took up my present job.

There was another incident that I would like to share. One would find three longish rooms to the right as one enters from the door at the northern end of the library building corridor. The first one had a binding section. The third one had a photocopying setup. Dr R. K. Kochhar and Dr Jagdev Singh were in the middle of it. Kochhar himself told this story. One afternoon, he was sitting in his room, legs propped up on the table, while Bappu sat on a chair to his left. During their discussion, Mrs Kochhar walked in. Seeing her, Bappu promptly stood up and greeted her. Kochhar, however, did not make any changes to his posture. After Mrs Kochhar left, Bappu had a one-liner: *"When a lady enters your room, you should give her the due respect, even if she is your wife".*

Bappu also had a strong sense of decorum when it came to attire. On one occasion, he saw a young faculty member wearing a T-shirt. He asked the young faculty member to go home and change into a 'proper shirt'. At that time, I was unaware of Bappu's demand for a dress code. In those days, I wore only jeans, and when I learned about Bappu's demand that one should be dressed appropriately, I always wondered why he spared me. There is also a story of S. Mohin. Mohin had a loud mouth with a golden heart. In his college days, he aimed to be a politician. He ended up becoming an astronomer. After Kavalur started functioning, Bappu was looking for another site for an observatory. He, with Mohin and Unnikrishnan, travelled quite a bit in the mid regions of nearby Jawadhu Hills (also known as Javadi Hills). Mohin had become very close to Bappu. Unnikrishnan was relatively conservative with his stock of words. Mohin was not only free with his words but also used what was left by Unnikrishnan. One day, back in Bengaluru, Bappu saw Mohin wearing sandals in the office. In very polite words, Bappu told him that shoes were the proper attire in the office. After that, Mohin never wore any footwear other than shoes and never forgot to polish them.

Bappu hand-picked his team to work at the observatory. And he looked after their needs. He knew the Indian Bureaucracy would not allow him to construct rooms for the astronomers to sleep after a whole night's observations. This was not a luxury but a necessity. He also knew that he would not get money to build a hostel or accommodation for the observers. But he would manage to get the necessary funds to build laboratories. That is how Lab A and Lab B came into existence in Kavalur Observatory. This is also why every office room of the 'new' building has a water tap, a sink, and an industrial three-pin socket.

After the observation became routine at Kavalur, with the 40-inch telescope working flawlessly, the local residential staff wanted a recreation room. The volleyball court was there, but they wanted an indoor area. No one would dare ask him directly, so the request was mooted to him through the observers from Bengaluru. Bappu's one-line answer was, '*I have given you 100 acres of the recreational area; what else do you want?*' For him, astronomy was more than just work. It was his passion. Dr M. G. K. Menon did not call him Jai Singh (a reference to Maharajah Jai Singh II, who built modern India's Jantar Mantar in the early 18th century) for no reason. His love and understanding of astronomy were truly unparalleled.

He deeply valued dedication and perseverance in scientific work. His respect for meticulous observation and hard work was evident in the way he supported researchers. One technical assistant at the Japal-Rangapur Observatory of Osmania University (Telangana) had taken a series of observations of some stars for many years. Based on these observations, he did some analysis and submitted his work as a thesis for the PhD degree. His defence was held at IIA. After his talk during the Q&A session, someone asked him what he had gotten from his observations. Before this man could even say a word, Bappu got to his feet and said that maintaining consistently high-quality observations over such a long period was itself worthy of a PhD. No further questions were asked.

Beyond academia, he also extended his support to individuals in his personal life. He had taken a small boy to work in his house. He was not a house help, just a boy in the house. Bappu tried to educate him, and when the boy reached his age and learned enough to work, Bappu asked me if he could work in the lab and if I would teach him the darkroom techniques. A request of the King is an order given politely. I slowly started teaching him how to develop and print photographic material. One day, Bappu walked to the lab and asked me, 'Can I borrow xxx for some time?' He could have sent someone to call this boy for whatever work he wanted this boy to do. But that was Bappu; he was a complete individual.

I could continue with more anecdotes, but I will end this narration with one last story—one that involves me directly. My direct interactions with him were rare and brief, but they left a lasting impression. Dr S. Chandrasekar was to deliver a public talk at Raman Research Institute (RRI), Bengaluru. I was unsure if I could join the IIA faculty in the vehicle arranged to go to RRI. I went to JCB, and he said the vehicle had no space. He then told me that Bappu was going later, and if I wished, I could ask him. It was impossible to pass through the director's secretariat. Instead, I went to the reception desk on the ground floor, picked up the intercom phone, and pressed '1' for the director. There were then only 10 intercom numbers. I asked him if I could go with him to RRI. He said yes, I could, but then asked, 'What if I said no?' I replied that I would cycle to the venue but would have to leave much earlier, and I added that I would request my boss, Jagdev Singh, to permit me to leave early. He then told me to be at 'The Tree' and said he would proceed if he did not see me there. He also told me I would have to return alone as he had other plans after the talk. I was at the tree a few minutes before 3 p.m. On the dot of 3, he was there driving his black Ambassador. I chose to sit on the left side, behind him, to hear any questions he may ask. My going with him became a topic of great sensation at IIA.

Looking back, these are the recollections of someone at one of the lowest rungs of the hierarchical ladder. Those who work with Dr M. K. V. Bappu are fortunate, and I think they should hammer down the keyboards of their computers and record memories of this legendary man.

Disclaimer: What I mentioned here is what I have recollected from my memories. Someone might remember it differently, but the message is clear. Secondly, not many would remember some of the people I mentioned here.

Author's Bio:

Mr Arvind Paranjpye joined the photographic laboratory of the IIA in December 1981, after receiving his B.Sc. from Government Science College. During his stint at the IIA, he conducted site surveys in Leh from 1984 to 1986 for a high-altitude infrared observatory. He later worked on the Kalki project, which aimed to find minor bodies in the solar system. In early 1988, his team discovered the asteroid 4130 Ramanujan, the first by an Indian group. In 1990, Asteroid 17446 Mopaku was named after him and two other team members. In April 1991, he joined the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, where he developed low-cost astronomical instruments and carried out site survey observations. Later, he was put in charge of the Public Outreach Programme. Since December 2011, he has been the Director of the Nehru Planetarium in Mumbai. He received the Astronomical Society of India's Medal in 1996 for discovering an asteroid and the Zubin Kembhavi Award in 2023 for his contributions to Public Outreach and Education in Astronomy.

Cosmic Soot and a Shape-Shifting Disk: The Story of PAHs and T Chamaeleontis

Arun Roy

If you have ever smelled the smoky tang of a campfire or watched the faint blue flicker atop a candle, you have brushed shoulders with a family of molecules that also fill the spaces between the stars. These carbon-rich compounds are polycyclic aromatic hydrocarbons (PAHs), sometimes called "cosmic soot." They are flat, honeycomb-like sheets of carbon and hydrogen (networks of benzene rings) that thrive wherever intense ultraviolet (UV) light meets dust and gas. Over the past half-century, PAHs have transformed from a curious spectral riddle into a powerful toolkit for understanding the environments where stars and planets are born.

What are PAHs?

PAHs are long-chain molecules built from hexagonal rings of carbon atoms, with hydrogen atoms at the edges; you can imagine them as a tiny, two-dimensional patch of graphene. Their flat shape and delocalized electrons make them superb at absorbing energetic UV photons. After a PAH absorbs such a photon, it quickly redistributes the energy across its chemical bonds, and then it emits that energy back out in the mid-infrared (MIR) wavelength through various vibrational modes (e.g., C–H and C–C vibrations). These vibrational modes give PAH signatures at wavelengths near 3.3, 6.2, 7.7, 8.6, and 11.2 microns (Table 1), among others. Because of different PAH sizes and charge states (neutral vs. ionized), the shape of the PAH spectrum changes slightly with the increase in the UV light intensities (Figure 1). PAHs are found naturally in crude oil, coal, and tar deposits, as well as in emissions from forest fires, volcanic activity, and incomplete combustion processes like vehicle exhausts and industrial activities. They accumulate in soil, water, and air, particularly in urban areas, and can bioaccumulate in organisms such as fish and shellfish. PAHs are used industrially as precursors for dyes, plastics, and pesticides, as well as in material science for organic electronics such as semiconductors and nanotechnology applications. Incidentally, they are universal in the Universe!

A detective story: the 'unidentified infrared bands'

The PAH story in astronomy began as a mystery. The advent of infrared space observatories in the 1970s and 1980s revolutionized astronomy by overcoming atmospheric interference. The launch of the Infrared Astronomical Satellite (IRAS) in 1983 was a pioneering joint mission between the U.S., U.K., and the Netherlands that conducted the first all-sky infrared survey and detected numerous celestial sources. During this period, unidentified infrared (UIR) bands were observed ubiquitously across diverse astronomical environments, including circumstellar regions, interstellar media, star-forming areas, planetary nebulae, and extragalactic objects, manifesting as discrete emission features at wavelengths such as 3.3, 6.2, 7.7, 8.6, 11.2, and 12.7 microns. Astronomers speculated extensively on the origins of these bands in the 1980s, proposing carriers such as hydrogenated amorphous carbon (HAC) grains (Duley and Williams 1981 [1]), anthracite grains, and notably PAHs (Leger and Puget 1984 [3]), though no definitive identification was confirmed at the time despite laboratory and theoretical efforts. In the 1985 study

Wavelength (μm)	Mode / Feature	Diagnostic Use
~3.3	Aromatic C–H stretch	Strong in fresh UV-lit regions
~6.2	C–C stretch	Enhanced in ionized PAHs, harder radiation fields
~7.7	C–C stretch	Same as 6.2 μm; grows in ionized PAHs
~8.6	C–H in-plane bend	Complements the 7.7 μm band
~11.2	C–H out-of-plane bend	Stronger in neutral, somewhat larger PAHs

Table 1: *The table lists the major features of PAHs, their wavelengths, corresponding vibrational modes, and their significance.*

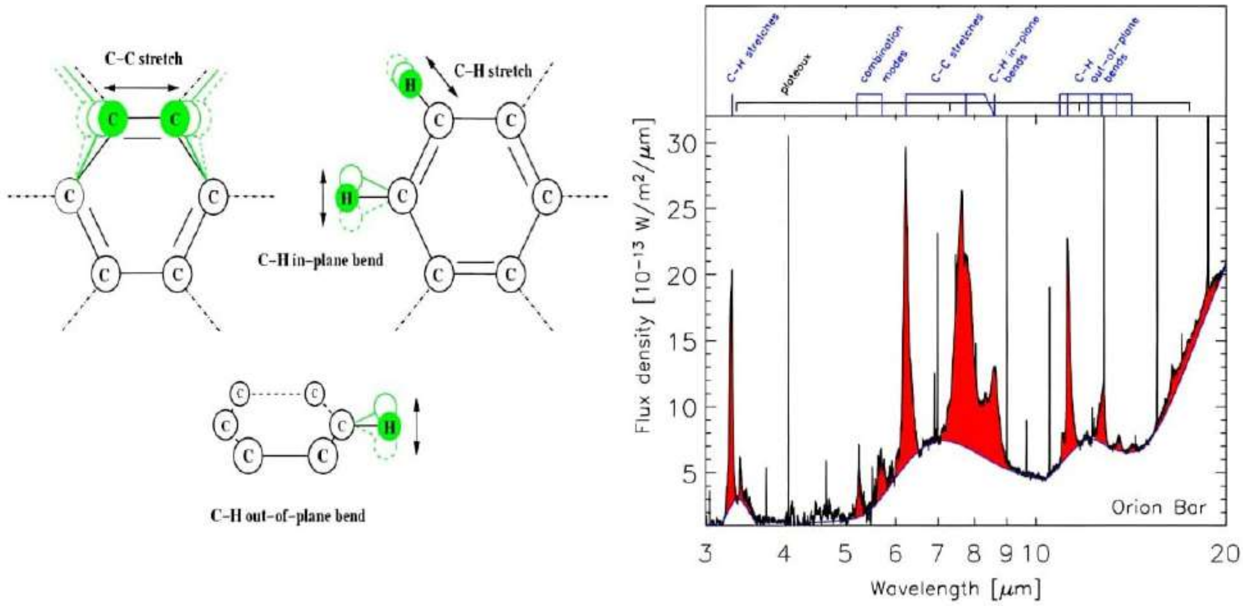


Figure 1: *PAH schematic: Bending and stretching modes, and PAH spectra of Orion Bar (Peeters et al. 2004)*

by Louis Allamandola, Alexander Tielens, and John Barker, titled "Polycyclic Aromatic Hydrocarbons and the Unidentified Infrared Emission Bands: Auto Exhaust Along the Milky Way [6]," the researchers demonstrated that the infrared emission spectrum from motor vehicle exhaust closely matched the observed UIR bands in astronomical sources, proposing that free-floating PAH molecules or ions in space are excited by ultraviolet light and emit in the infrared. By the late 1980s, a consensus emerged: PAHs (likely a family of many related molecules rather than one single species) were the best explanation for the UIRs. The hypothesis didn't just match the wavelengths, it explained the ubiquity of the bands, their behavior under UV light, and their ability to survive in harsh interstellar environments. The first direct confirmation of PAHs as carriers of the UIR bands came in 2021 with the detection of two specific interstellar PAHs, 1-cyanonaphthalene and 2-cyanonaphthalene, in the Taurus Molecular Cloud-1 (TMC-1), providing strong evidence supporting the long-standing hypothesis that PAHs are responsible for these ubiquitous emission features in space.

JWST and a young stellar object named T Chamaeleontis

The James Webb Space Telescope (JWST) has

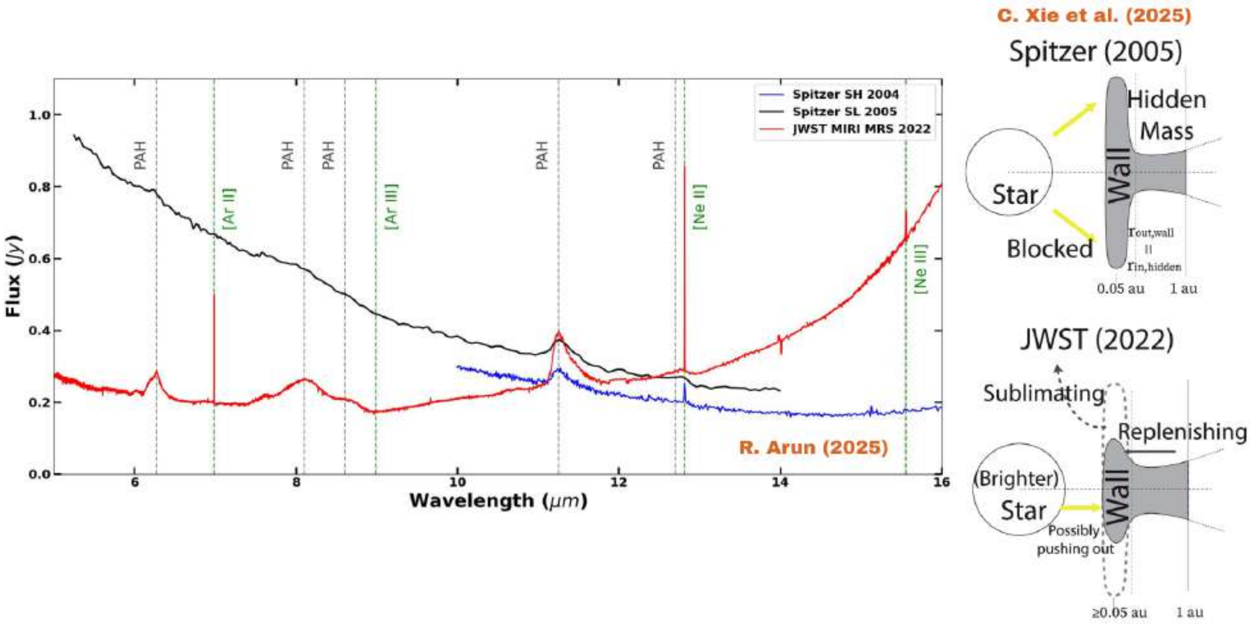


Figure 2: *T Cha "Seesaw": Continuum variation over 18 years from Spitzer to JWST (Arun 2025) and wall schematic (Xie et al. 2025)*

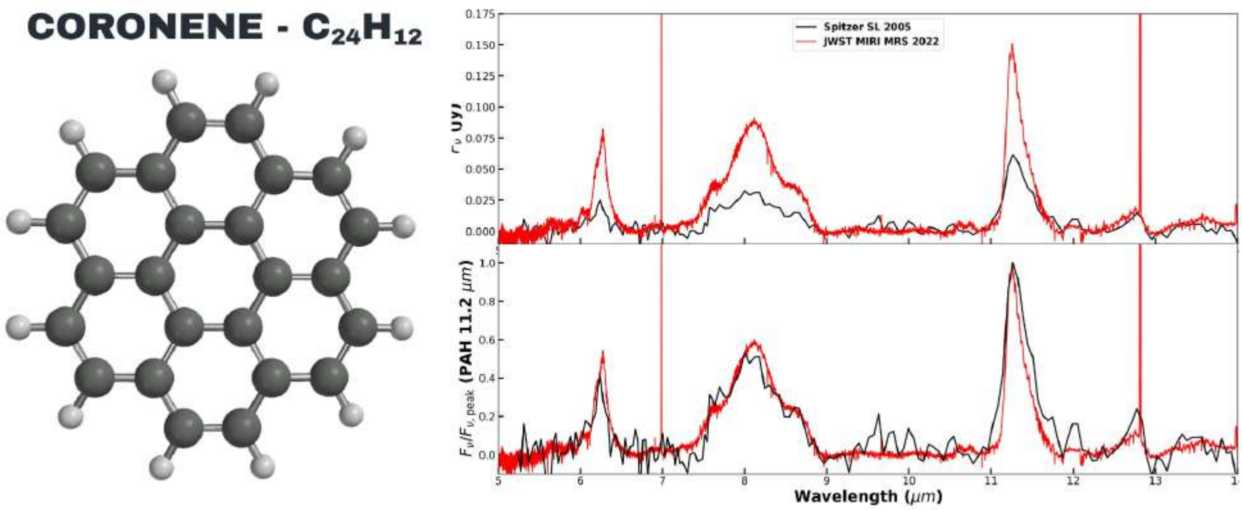


Figure 3: *(Left) The structure of coronene ($C_{24}H_{12}$). (Right) continuum-subtracted PAH spectra of T Chamaeleontis over time, showing brighter flux in 2022 (JWST) compared to 2005 (Spitzer) (top), while band ratios (bottom) remain similar.*

turbocharged PAH science. Its exquisite sensitivity and spectral resolution in the MIR enable us to disentangle overlapping features and map them across disks and nebulae. One particularly intriguing case is the young star T Chamaeleontis (T Cha), a relatively low-mass, Sun-like system with a "transitional" protoplanetary disk. Its inner disk regions show signs of clearing and re-sculpting, possibly by forming planets. PAH emission is most famously bright around more massive Herbig Ae/Be stars, but T Cha showed weak PAH signatures in its disk in Spitzer observations from 2004 and with increased intensity in JWST observations from 2022. That makes it an excellent laboratory to study how far-UV light threads its way through disk gaps and walls to excite these molecules.

When a disk's inner wall changes (or falls)

In my recent study [11], I compared archival

Spitzer data from 2005 with JWST observations from 2022. Over roughly two decades, T Cha's mid-IR continuum and PAH fluxes changed in tandem. The seesaw effect in T Cha was identified by comparing its 2004 Spitzer spectrum with the 2022 JWST spectrum. Xie et al. (2025) [10] showed that when the inner disk wall diminished, the short-wavelength continuum decreased while the longer-wavelength emission brightened, revealing structural variability in the disk. This wall destruction allowed more UV light from the star to reach the outer disk (Figure 2). That extra UV doesn't change what PAHs are made of, but it can light up more of them, or excite them more often, so their bands brighten. We first modelled and subtracted the dust continuum in the spectra, allowing the PAH bands to stand out cleanly. Then we decomposed the features to measure their fluxes and compare epochs. Across these checks, the picture held: T Cha's PAH features became brighter between 2005 and 2022, but their relative ratios were steady within reasonable errors. That stability points to similar PAH sizes and charge states across the two epochs, even as more UV light reaches the disk. In other words, glowing PAHs are of similar size and shape, and not from a fundamentally different population (Figure 3). A modelling of the PAH population reveals that PAHs in the circumstellar disk of T Cha are small, with less than 30 carbons, like well-known PAHs we see on Earth, named coronene ($C_{24}H_{12}$) (Figure 3). The work was possible because of the destruction of the wall, thus the title "When the Wall Fell: Study of Polycyclic Aromatic Hydrocarbons in T Chamaeleontis using JWST".

Why it matters for planet formation

Transitional disks, like T Cha, are snapshots of an active world-building. Their inner regions are being cleared by winds, magnetic fields, or newborn planets. PAHs sit at a sweet spot in this drama: they are small enough to respond immediately to UV changes, but widespread enough to trace conditions over large swaths of a disk. Seeing their flux vary while their character stays the same tells us that illumination—not chemistry—was the key player in T Cha's MIR makeover. That, in turn, supports pictures in which geometry (gaps, walls, shadows) strongly modulates how energy flows through a forming planetary system.

What's Next?

With JWST still in its prime, we can now go beyond two snapshots. By time-domain astrochemistry, revisiting the same disks, measuring how their PAH and dust spectra evolve, will let us watch geometry and illumination change in real time. Ground-based instruments like Very Large Telescope (VLT)/Enhanced Resolution Imager and Spectrograph (ERIS) can add high-resolution infrared imaging to map where PAH emission brightens or dims. Combined with millimeter-wave views from Atacama Large Millimeter/ submillimeter Array (ALMA), which trace the bulk of dust and gas, we can piece together a three-dimensional, time-varying portrait of how a young solar system breathes. T Cha has shown that even a relatively low-mass star can run a dynamic light show in PAHs. The next act is to find out how common this behavior is and how it connects to the making of planets.

Fifty years ago, the unidentified infrared bands were a tantalizing puzzle. Today, they are a Rosetta Stone for decoding the hidden physics of star and planet formation. And thanks to JWST, we are no longer limited to static snapshots; we can watch the cosmic soot shimmer and change. Sometimes, the smallest molecules tell the biggest stories.

Author's Bio:
Arun Roy was a Postdoctoral Fellow at the Indian Institute of Astrophysics, Bengaluru. His research focuses on Young Stellar Objects,

Triggered Star Formation, and Astrochemistry. He is now an Assistant Professor at CHRIST (Deemed to be University), Bengaluru.

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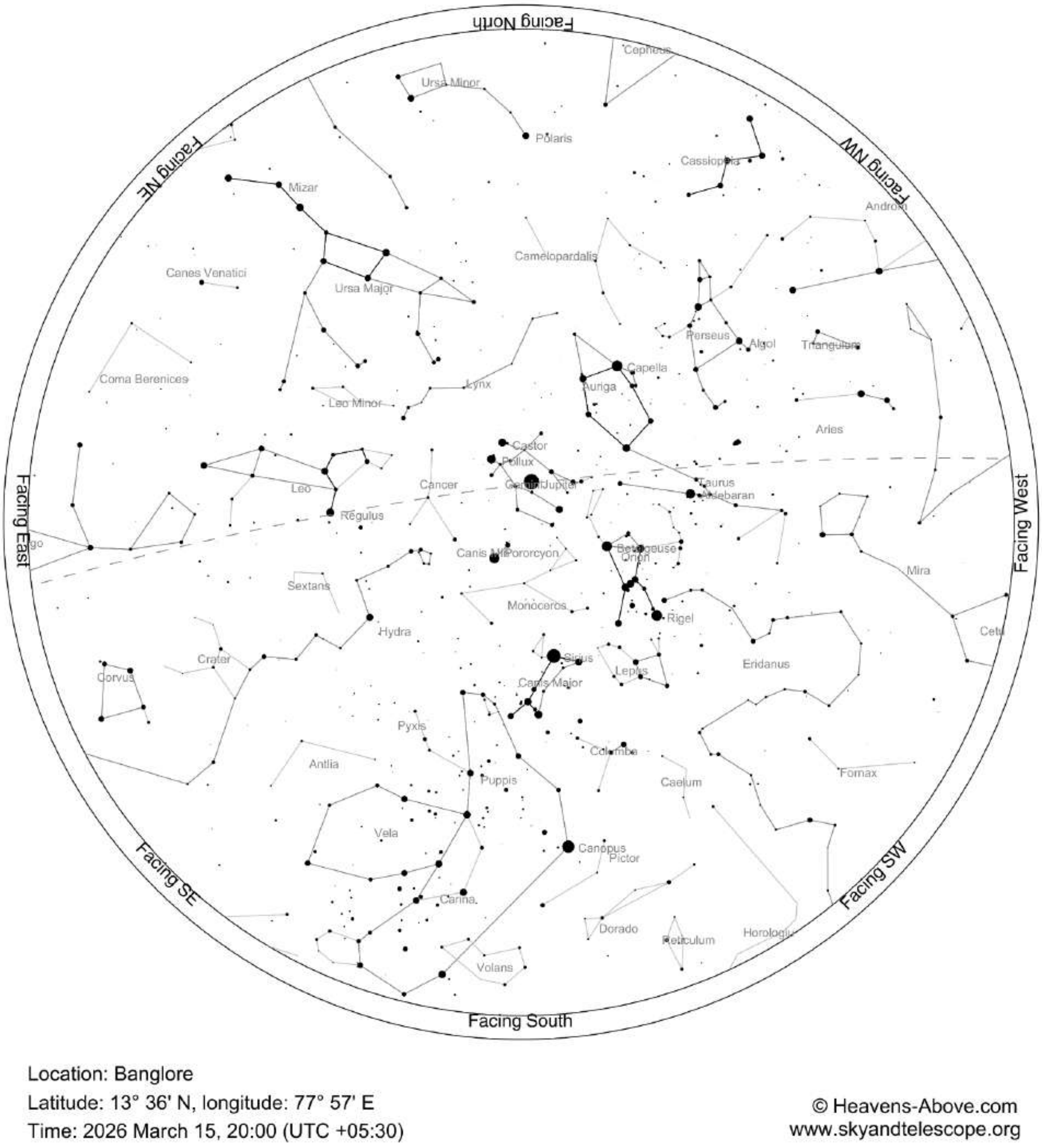


Skychart March 2026

March 3 – Total Lunar Eclipse: During a total lunar eclipse, the Moon passes entirely through Earth's shadow and takes on a coppery red color due to sunlight scattered through Earth's atmosphere.This eclipse will be visible from India, with the main phases occurring during the evening and night hours. No special equipment is required—this event is safe to view with the naked eye, though binoculars or a small telescope enhance the color and surface detail.

Interview with Prof. V. Krishnamurthy

Prof. V. Krishnamurthy was a renowned mathematician, educator, and author whose remarkable contributions to the field of mathematics span over half a century. He was the former Director of the KK Birla Academy, New Delhi, and former Deputy Director and Professor of Mathematics at BITS Pilani. His research contributions are in the areas of functional analysis, topology, combinatorics, and mathematics education. During his tenure at BITS Pilani, he was one of the top-ranking academic administrators responsible for the multifarious academic reforms for which BITS is now well-known. His contributions to the field extend beyond research, having served as the President of the Indian Mathematical Society, President of the Mathematics Section of the Indian Science Congress Association, and Executive Chairman of the Association of Mathematics Teachers of India. He was also a prolific author with notable works including *The Challenge and Thrill of Pre-College Mathematics, Combinatorics Theory and Application, Introduction to Linear Algebra, The Culture, Excitement, and Relevance of Mathematics*, and *The Clock of the Night Sky*, to name a few. His autobiography, *Looking Back*, offers a deeply personal and insightful reflection on his extraordinary journey in academia and other areas of life.Prof. V. Krishnamurthy sadly passed away on the 23rd of June 2025. His legacy continues to inspire in both intellectual and spiritual domains, making him a truly exceptional figure in the world of mathematics and beyond.

Arav: Your most recent book, *The Night Sky Tells the Time*, describes Sanskrit formulae that use the position of celestial bodies and the zodiac signs to tell the time at night. You were introduced to these formulae by your father on a morning walk at the age of 11, as you recall in your book. What inspired you to explore and document these 27 formulae in your first monograph, *The Clock of the Night Sky*, published in 1998, several decades after your first introduction?

Prof. Krishnamurthy: Thank you for the question. The inspiration grew from a blend of personal memory and cultural responsibility. I retired from BITS Pilani in 1988, in my 60th year, though they wanted me to continue, and I settled in Madras. In October 1994, I was appointed by Shri KK Birla as the director of Birla Academy in Delhi, and I worked there till February 1997. The academy was just a museum of books and nothing more at the time. Dr. Anantharaman was the previous director at the Academy before me. He wrote a book on the Iron Pillar of Delhi while working as the director of the academy. This made me think, and I remembered my father's teaching about the stars of the night sky, so I decided to write my book on the clock of the night sky. In fact, the Indian public's knowledge of the ancient way of understanding the night sky was very minimal. The Indian media did not at all refer to the stars with the ancient Indian names and borrowed all of their knowledge of the mythology of the stars from the West. So, I decided to bring them back to Indian terminology, which is older. I would like people to learn and not forget the ancient traditions of

Indian astronomy.

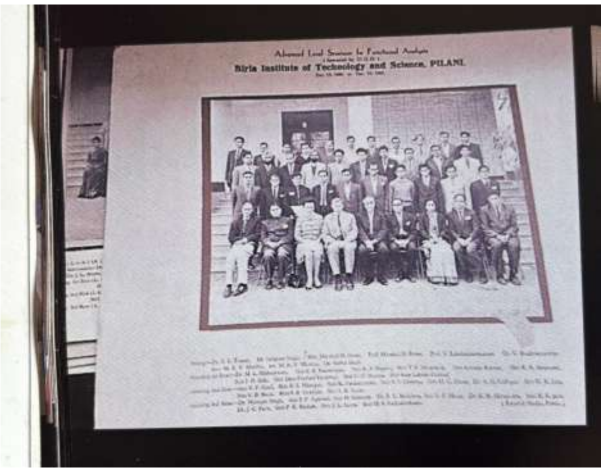
Amrutha: Can you also briefly share insights about your research during your PhD and your subsequent academic positions?

Prof. Krishnamurthy: Even while studying mathematics in high school, I was obsessed with the idea that after college, it would be a mathematics honors degree for me. I was not fully aware that engineering colleges existed and that I could go into engineering. I thought there was only mathematics. A friend of mine came to me and said he would be joining Guindy Engineering College. Guindy Engineering College was going to start a new session then. Stupidly, I asked him what engineering was. However, my aim and dream were mathematics, so I joined the Maths Honours course at St. Joseph's, Trichy, after my Intermediate (Pre-university course) in Govt College, Kumbakonam. Later, I joined Annamalai University as a research scholar in mathematics and did reasonably good work under Prof. Ganapathy Iyer, who was an internationally known expert in the subject. His research papers dealt with the subject of entire functions in complex analysis. You might not know what entire functions are, but they are very special in complex analysis. I worked on the universe of all entire functions in complex analysis and discovered that they had many properties in the universe of linear topological spaces.

Amrutha: Your career spans several decades, contributing to mathematics and academic administration. What initially drew you to mathematics?

Prof. Krishnamurthy: Around April 1956, I saw an advertisement in the paper that the Government of India was offering research scholarships to teachers to obtain a PhD, particularly to those in affiliated colleges, which would allow an individual to move away on leave or lien to university departments and do full-time research for three years. I was a lecturer at Thiagarajar College in Madurai during that time. I applied for a scholarship at Annamalai University to work under Dr. V. Ganapathy Iyer (Dr. V.G.), and I got it. I joined on September 1, 1956. On my first visit to Dr. V.G., he suggested two books to me – Titchmarsh's "Theory of Functions" and Hardy and Wright's "Theory of Numbers." I used to spend my whole day at the department or library reading almost everything on mathematics. My supervisor was always very thorough in clearing my doubts whenever I met him. I also began reading books in French and German, such as Bourbaki's books and "Uniformisierung" by Nevanlinna. I faced quite a big challenge during that time as Annamalai University did not recognise my Madras University M.A. as equivalent to an M.Sc. degree, so I had to submit an M.Sc. thesis in one year. I submitted my first paper for my thesis on the area of entire functions. By chance, as Dr. V.G. could not attend the Indian Science Congress, he recommended that I give a lecture on the Uniformisation of Riemann Surfaces since the only book available on the topic was in German. During my PhD years, the subject of "Linear Topological Surfaces" by Bourbaki later enabled me to publish three papers on Spaces of Entire Functions and generalise some results of Taylor and Halberg on state diagrams of linear operators on normed linear spaces to Linear Topological Spaces. I also secured the National Institute of Sciences of India (NISI) Fellowship, submitted my PhD thesis in July 1960, and then continued teaching at Thiagarajar College in Madurai.

Around August 1962, I got the opportunity to go to the University of Illinois at Urbana-Champaign for a three-year assignment as a faculty member (as a Fulbright Grantee). I first stayed with my host family in Davenport, Iowa, for a week and then joined my job at the University after moving to a residence in Urbana. My experience of teaching there was tremendously satisfying. The library, the resources at my disposal, and the infrastructure were beyond my imagination. In the first year, I was an instructor in the Department of Mathematics, and in the second semester of the first year, I taught a graduate course in topological vector spaces. A student named Joachim Loustanau registered for a PhD with me, and we published a joint long research paper on locally convex spaces.



Picture 1: *A photograph from the Advanced All-India-level Seminar in Functional Analysis conducted at BITS Pilani by Prof Krishnamurthy in Dec 1968.*

After one year, I called my family to experience a life beyond India. I was promoted to Assistant Professor by the end of my three years at the University. However, I was very eager to return to India and contribute the many good things I had seen and learned in the US to the Indian educational system. I was inspired by the breadth and depth of the US university curriculum of mathematics and the administration in terms of courses, examinations, research, and studies.

At that time, BITS Pilani had partnered with the Ford Foundation and had the Massachusetts Institute of Technology (MIT) as its educational advisor and consultant. They were recruiting professors from American universities, and I was also recruited. I joined BITS Pilani as a Professor of Mathematics in 1965. In 1968, I was made the Head of the Department of Mathematics. I also directed advanced-level seminars on Functional Analysis at Pilani in the same year. In 1969, I conducted an all-India summer institute for college teachers under the sponsorship of the UGC. For a few years, I was also appointed as the Academic Secretary of the Indian Mathematical Society. Around 1979, I accepted a one-year visiting professorship at the University of Delaware in Newark, Delaware, US, to teach combinatorics.

Arav: After having experienced the curriculum and the administration of universities in the US, you returned to India. What was your vision while joining BITS? What role did collaboration with other academic leaders, such as Dr. C.R. Mitra, play in realising this vision?

Prof. Krishnamurthy: Even as I was working as a mathematics lecturer at the University of Illinois from 1962-65, I was jealous of the progress that had been made by the West in abstract fields like mathematics, and I wanted to go back to India to introduce and teach these methods to my students. My ambition was to make Indian Universities come up to the level of American universities. After I was appointed as the Head of the Department of Mathematics at BITS in 1968, very soon, Dr. C.R. Mitra joined as the new director of BITS Pilani in 1969. He had tremendous ideas of how to make BITS Pilani an eastern MIT. So, I was in good company.

I was voted as the representative for BITS at the meetings of the American Committee to discuss the issues of the college. Dr. Mitra's vision for BITS was to raise it to the level of international universities like MIT, and they appointed Prof. TSKV Iyer and me as deputy directors.

Dr. Mitra and about 15 of us spent several days developing various reforms for BITS, some of which were major innovations for Indian universities and are the norm today. We introduced a system where professors conducted their own exams, and there was no external interference. The exam scripts were graded by the professors and returned to students for review, ensuring fairness and further discussions with the teachers. We introduced the concept of the "Practice School," where students could carry out a semester-long internship in an institute or company. This idea of an internship is now such a crucial part of many university curricula. For large classes, we adopted team teaching, where there would be one lead faculty member under whose leadership other teachers would take the class. Prof. Iyer and I also conducted intensive teacher training workshops to refine teaching skills, focusing on articulation, engagement, and effective blackboard usage. All of this happened over ten years, from 1970 to 1980, and these were crucial changes to the way a university normally operated back then. BITS grew leaps and bounds during this period, with several excellent faculty members joining the university.

Picture 2: *Prof. Krishnamurthy with the interviewers, Arav and Amrutha.*

Amrutha: You authored your first mathematics textbook, *Plane Trigonometry for the Intermediate*, at the age of 28. What inspired you to write this book, and how was it received at the time?

Prof. Krishnamurthy: At the age of 28, I was bubbling with enthusiasm for mathematics, its teaching, and its development in the colleges and universities in India. The subject of trigonometry was introduced in the intermediate classes, but at the time, there was no Indian book for it. Loney's "Plane Trigonometry" was the only book, and thus, I decided to write the book Trigonometry for the Intermediate classes. It was quite successful, and in one year, it went to all the colleges. By this time, I had become a successful teacher, having personally taught several students for extra tuition, and this made me love writing this book. However, my misfortune was that within the next two years, intermediate classes were abolished by Madras University, so I had to upgrade my book for the three-year degree classes. Despite the many hardships I have faced in my life, my love for teaching never faded, and the experience that I had already gathered both in the classes and in my personal tuition classes helped me write good books on the subject of mathematics.

Amrutha: You have authored numerous books, like *Challenge & Thrill of Pre-College Mathematics*, and *The Culture Excitement, and Relevance of Mathematics*. How do you approach writing for students to make the subject more approachable and engaging? How do you think educators can bring this excitement into the classroom?

Prof. Krishnamurthy: I believe that it's not my place to suggest how teachers should teach their students and write their books. A teacher himself should be a learner of how to teach and how to write. A teacher should not start with the idea that they know everything. They should keep learning as they proceed in their teaching. The learning is both of the subject as well as of how to teach and how to communicate.

Arav: As someone who has worn many hats – teacher, researcher, administrator, and author – how did you balance these roles, and which role did you cherish the most?

Prof. Krishnamurthy: There is no question of balancing these roles. Each role had to be done perfectly. That was my father's training. In fact, the training given by my father always allowed me to switch from one role to the other and still do well in each. When I used to do my college mathematics, my father would be in his easy chair reading Vedanta, and if I weren't doing anything, he would call me to learn Vedanta. In that way, he would change me from one field to another, and I had to do well in each field. To answer your question about which role I loved the most, teaching and writing were the roles that attracted me and fit me the most, and I cherished them as my best roles.

Amrutha: Do you believe mathematics is a tool to describe reality, or is it more like a lens that shapes how we perceive reality?

Prof. Krishnamurthy: The purpose of mathematics is not to describe reality, though all mathematics is rooted in the real world with its methods of counting and classifications. But mathematics certainly provides a number of tools for the other sciences, like biological sciences, physics, and chemistry, for their work. In that way, it is not a tool to describe reality, but it serves as a tool for other subjects.

Arav: Having grown up deeply rooted in Vedic traditions while pursuing a pioneering career in mathematics, how did your upbringing influence your approach to life, work, and, in general, your life philosophy?

Prof. Krishnamurthy: My upbringing goes back to my educated father, who worked under the British Government-established courts as a Sheristadar in Sub-courts. He was also a Vedantic scholar who trained me even as a young boy of six or seven in familiar Sanskrit shlokas. One of the shlokas he taught me states that "laziness is the greatest enemy residing in the human body. There is no friend equal to hard work – one who embraces it will never face sorrow."

I'm sure you will agree – laziness is the worst enemy, and hard work is the greatest friend. My father taught this to me when I was 6 years old, and this teaching stayed with me throughout my life, even up to the age of 90, as you can see. One who works hard will never be truly unhappy.

My father had also trained me to look at the world as it is and understand it. He used to give lectures on scriptures, so he talked about the Ramayana and the Mahabharata, and I used to listen to those lectures. In his lectures, he would say, "Who is the most scriptural character in Hindu philosophy who suffered the most?" – the answer is Rama. Kaikeyi, for her own satisfaction, asked for boons from Rama, and he was never angry with her. He suffered for 14 years. My father used to quote a sloka on this situation that even after all the suffering, Rama returns, bows to Kaikeyi, and expresses gratitude for all he learned through the experience – love, loyalty, strength, friendship, and devotion. Rama saw his hardships as opportunities for growth and gratitude. My father often emphasised this as a model for how to respond to or treat life's difficulties as lessons, not burdens. So he used to say, whatever happens, and whoever does bad things to you, remember this. So I always remember this. All my life, I have followed this. Both in my training for Vedanta by my father and also in my training in Mathematics by my college teachers, I have followed this maxim of continuous hard work, the importance of hard work,

Picture 3: *Prof. Krishnamurthy with the DOOT Team.*

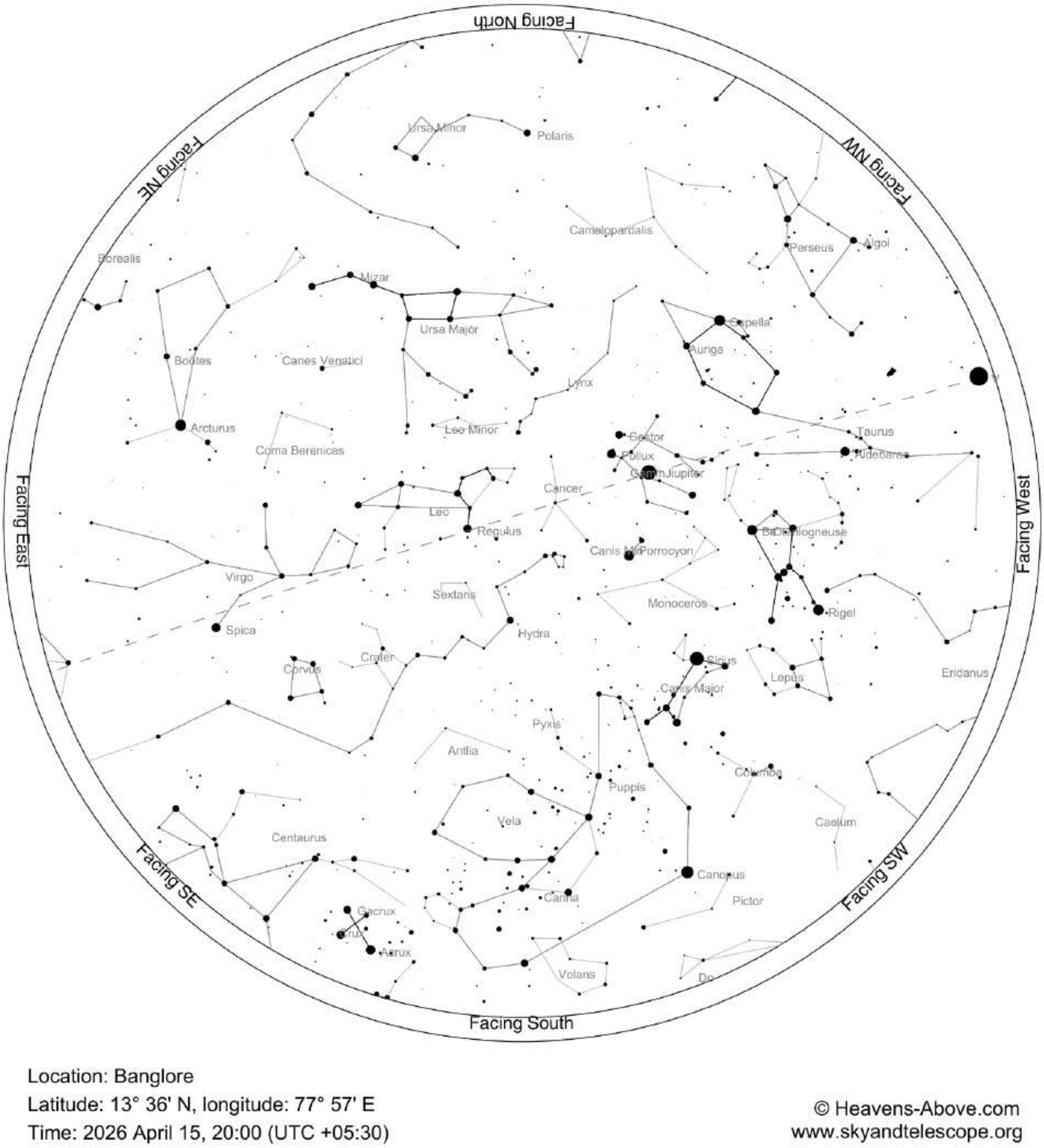
and never taking anybody to heart.

Amrutha: Looking back on nearly a century of life, what drives your motivation to work, write, and publish, and what is the most important lesson you've learned that you would like to pass on to others?

Prof. Krishnamurthy: In my opinion, it is continuous hard work that pays. Very often, the human experience is to get bored with the same work. So what I do is keep several works in my hand. I switch from this to that. Like I said earlier, my father trained me to easily switch from field to field, which helped me a lot. That is why my habit is to keep several things going on at the same time. I write mathematics books, I write Vedanta books, I listen to the radio, I speak on YouTube, and people come and visit to ask questions or do plain chit-chat. So, I switch from one thing to the other with purposeful ease.

Arav & Amrutha: Thank you, Professor Krishnamurthy, for sharing your remarkable journey and profound insights with us. It has been truly inspiring.

Prof. Krishnamurthy: Thank you. It was my pleasure to speak with you both.



Skychart April 2026

April 22 to 23 – Lyrids Meteor Shower: The Lyrids originate from debris left by Comet C/1861 G1 (Thatcher) and typically produce around 15–20 meteors per hour at peak. The shower runs from April 16–25 and peaks on the night of April 22 into the morning of April 23. In India, the first-quarter Moon sets shortly after midnight, leaving darker skies for observations after midnight. Best viewing is from a dark location, with meteors radiating from Lyra but visible across the entire sky.

Conservation laws in physics

Devang Agnihotri

We have studied in our textbooks about the conservation of quantities such as momentum, electric charge, and energy, among others. While in classical mechanics, the conserved quantities are transferred through direct "contact"; for example, a moving ball transfers its momentum to another ball during a collision. However, for forces that act at a distance (such as electromagnetic and gravitational forces), the concept of "fields" is introduced, and the conserved quantities are expressed as fields. In this article, we will explore how the conservation of a physical quantity, when expressed as fields (like energy carried by an electromagnetic wave), leads to the general mathematical expression known as the continuity equation.

1.1 Conservation of mass of a fluid

Let's start the discussion with the most intuitive case of water flowing in and out of a container. It is intuitively clear from Figure 1 that if the mass of water that flows out of the container is less than the mass coming in, then the mass of water inside the container must increase, and vice versa. So there is a conservation of water mass, i.e., water cannot be created nor destroyed (assuming no evaporation and condensation). Let's try to put it in the language of mathematics. Let dmobe the mass that flows out while dmi be the mass that flows in within a time dt. The mass that has flowed within the time dt could be determined by multiplying the tiny volume of the water that has flowed by its density (say). Thus, we can write for the outflowing mass:

$$dm_o = \rho A_o dx_o \tag{1}$$

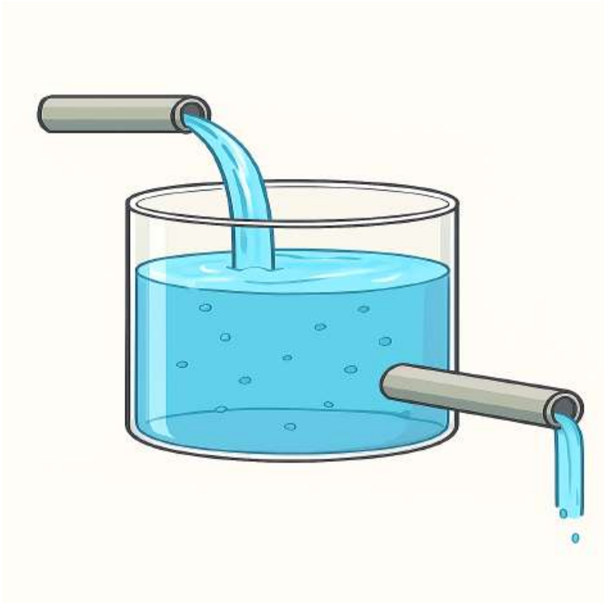


Figure 1: Water flows in and out of the container (Credit: Devang Agnihotri).

For the inflowing mass:

$$dm_i = \rho A_i dx_i \tag{2}$$

Here, A_o and A_i are the cross-sectional areas of the inlet pipe and the outlet pipe. The net outward flow of water is dm_o-dm_i, which is:

$$dm_{net} = \rho(A_o dx_o - A_i dx_i) \tag{3}$$

Mass flowing per second will be:

$$\frac{dm_{net}}{dt} = \rho A_o \frac{dx_o}{dt} - \rho A_i \frac{dx_i}{dt} \tag{4}$$

It is quite clear that the greater the cross-sectional area (**A**) of the pipe, the greater will be the mass of flowing water through the pipe. This leads us to define the quantity $\rho\frac{dx}{dt}$ as water current density (J). Mathematically, current density is defined as:

$$J = \rho v \tag{5}$$

where $v = \frac{dx}{dt}$ is the velocity of the fluid. Now, for flux denoted by ϕ, we can write:

$$\phi_{net} = J_o A_o - J_i A_i \tag{6}$$

This captures the net flow of water out of the container.

$$\frac{dm_{net}}{dt} = J_o A_o - J_i A_i \tag{7}$$

Hence, the rate of change of mass of water inside the container ($\frac{dm_c}{dt}$) should be equal to the outward mass flow rate, but with the negative sign. Thus, we can finally write:

$$\frac{dm_c}{dt} = -\frac{dm_{net}}{dt} \tag{8}$$

$$\frac{dm_c}{dt} = -(J_o A_o - J_i A_i) \tag{9}$$

In terms of net flux, we can write:

$$-\frac{dm_c}{dt} = \phi_{net} \tag{10}$$

This equation here is identified as the continuity equation in one dimension. The characteristic here is that the term on the left describes a negative rate of change of "conserved quantity" compensating for the net outward flux of the current density on the right-hand side.

1.2 Conservation of charge

In the electrical world, charges can flow for sure, but they have to be conserved, similar to the case for the mass of water. Thus, we should have a continuity equation for it too. Consider now that in 3D space, we have a charge distribution (scalar field) with charge density $(\mathbf{r}, t)$ (which featured as water mass density in Section 1.1). The electric charge per unit volume depends on the position vector in space, i.e., $\mathbf{r}$, and time t. Now, consider a hypothetical box as shown in Figure 2.

As can be seen in this image, charges are flowing in and out of the box, and the charge inside the box changes depending on the net flux of charges through the box. If there is a net outward flux of charge, then the charge stored inside the box must decrease.

To define flux in this case, we cannot simply multiply the current density by the area as we did in the simple case of one-dimensional flow of a fluid, as here the orientation of the current density vector with respect to the surface matters.

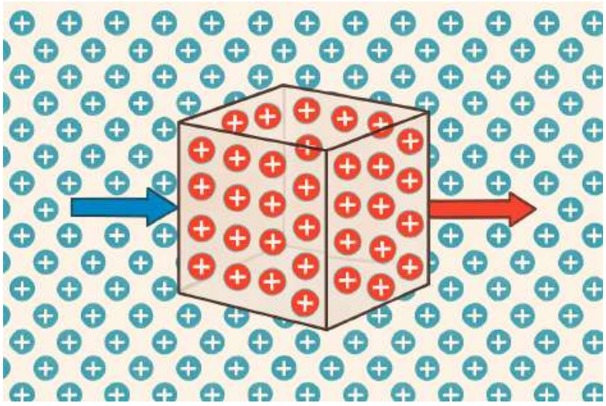


Figure 2: *Charges flowing in and out of the box (Credit: Devang Agnihotri).*

Consider two cases here, as indicated in Figure 3. Let's assume the grey surface represents one of the faces of the box. In Figure 3 (left), we can see that the current density vector **J** is perpendicular to the area vector (defined as a vector perpendicular to the surface of interest); hence, the flux of charge through this surface is zero. But, in Figure 3 (right), it cuts through the surface with maximum flux as **J** is parallel to the area vector. As it might be intuitively clear by now, the flux should depend on the angle between **J** and the orientation of the surface, which we denote by the area vector **A**. So if we define flux as the dot product of the two vectors, $\phi = \mathbf{J}.\mathbf{A}$, our problem is solved. Why the vector dot product solves the problem is an exercise for the reader. We take such a small area vector denoted by $d\mathbf{A}$ such that over this area, **J** doesn't vary, and hence we can define an infinitesimal flux corresponding to the infinitesimal area as (this is necessary as **J** is not constant throughout the area):

$$d\phi = \mathbf{J}.d\mathbf{A} \tag{11}$$

Thus, the net charge flux out of the box can be calculated by integrating over all these small areas over the box, and can be written as:

$$\phi = \oiint_s \mathbf{J}.d\mathbf{A} \tag{12}$$

We can write for the total charge q inside the container as:

$$\frac{dq}{dt} = -\phi \tag{13}$$

Replacing the general definition of ϕ we can write:

$$\frac{dq}{dt} = -\oiint_s \mathbf{J}.d\mathbf{A} \tag{14}$$

We can go one step further and write q as the volume integral of $\rho(\mathbf{r}, t)$ over the box as:

$$q = \iiint_V \rho dV \tag{15}$$

$$\iiint_V \frac{\partial \rho}{\partial t} dV = -\oiint_s \mathbf{J}.d\mathbf{A} \tag{16}$$

Further, using the Gauss divergence theorem, we can prove that:

$$-\frac{\partial \rho}{\partial t} = \nabla.\mathbf{J} \tag{17}$$

This equation is known as the equation of continuity in differential form, as it holds for every point $(\mathbf{r}, t)$ in space. The LHS $\frac{d\rho}{dt}$, is the rate of change of the volume density of the same physical quantity. So the equation tells us that if at any point in space we measure a net outward flow of the quantity (non-zero $\nabla.J$), then the amount of the quantity (its volume density ρ) has to compensate for the flow, and that is (-$\frac{d\rho}{dt}$).

1.3 Conservation of energy in an electromagnetic field

The electromagnetic field carries energy and can transfer it to the charged particles. We believe in electromagnetic fields and the fact that they carry energy. Now, if we set out to measure the net outward flow of energy at a point, and we find it to be non-zero, then the energy density (energy per unit volume) at that point must be decreasing, which is the idea we have been following so far. We denote the energy density by u and the energy current density vector (energy per unit time per unit area) as **S**, then we can use the differential form of the continuity equation to write:

$$-\frac{\partial u}{\partial t} = \nabla.\mathbf{S} \tag{18}$$

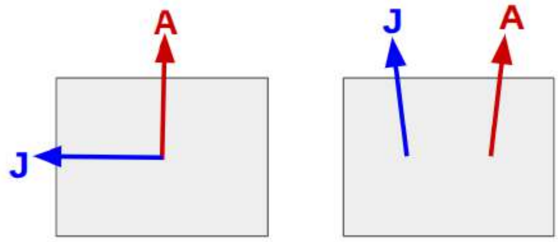


Figure 3: *Current density flowing perpendicular (left) and parallel (right) to the area vector (Credit: Devang Agnihotri).*

1.4 Conservation of probability in quantum mechanics

The probability of finding a particle can also flow in space and change in time. So you know the drill: if you have a net outward flow of probability current density at a point in space, then it should be compensated by the decreasing probability density in time at that point. So, if we denote the probability current density vector as **J** and the probability density by ρ, we can again write:

$$-\frac{\partial \rho}{\partial t} = \nabla.\mathbf{J} \tag{19}$$

This equation can be derived using Schrodinger's equation by defining the probability density $\rho = \Psi\Psi^*$, where Ψ is the wave function. The reader is encouraged to derive the expression for the probability current density vector **J** using Schrödinger's equation.

Conclusion

In a physical system, when a quantity is a field and it is conserved, it must follow the continuity equation. The equation retains its form; rather, it is the quantity of interest that keeps on changing with the regime of physics. For example, it was the mass of fluid in fluid mechanics, while it is the charge density in electrodynamics. In quantum mechanics, it is the probability density which is conserved.

Author's Bio:
Devang is a senior research fellow at the Indian Institute of Astrophysics (IIA), Bengaluru, working with Dr Anusha L. S. His research focuses on the area of radiative transfer, which deals with the interaction of radiation with matter in solar plasma.

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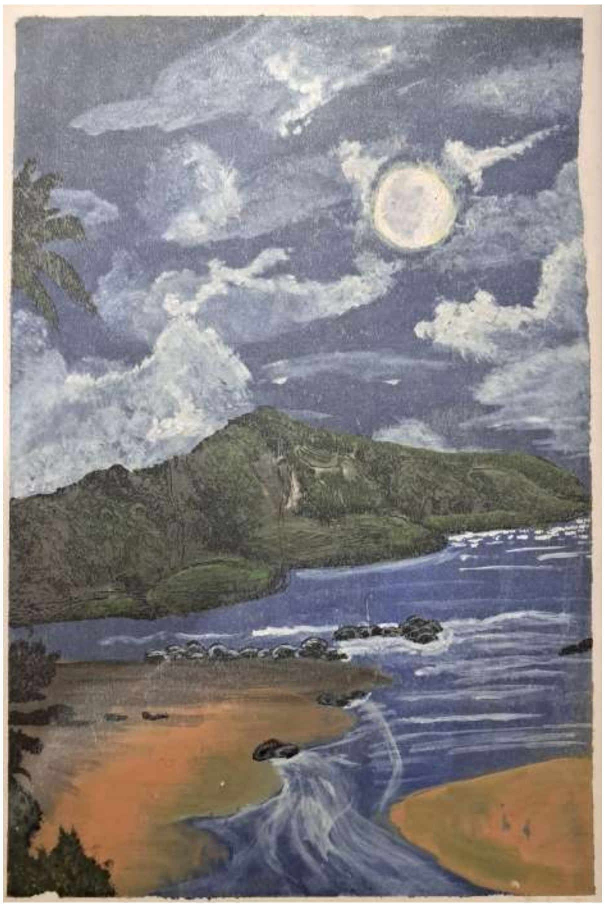
"**U**nexpected monsoon showers paused observations at Kavalur, but opened a window to nature's quiet beauty—lush blooms, vibrant greens, and moments worth capturing."
Photography by Shivani Gupta, a Senior Research Fellow (SRF) at IIA.

The Indian Gaur (Bos gaurus), locally called the bison in Kodaikanal, is the world's largest wild cattle with a strong build and white-marked legs. [Location: KSO Campus]

Photography by Chrisphin Karthick M (Scientist ' C ' & Deputy Head of Science Communication Public Outreach and Education (SCOPE))

The moon sang, I listened



Art by Gitika Rameshan,
a Junior Research Fellow at IIA.

The Terrace

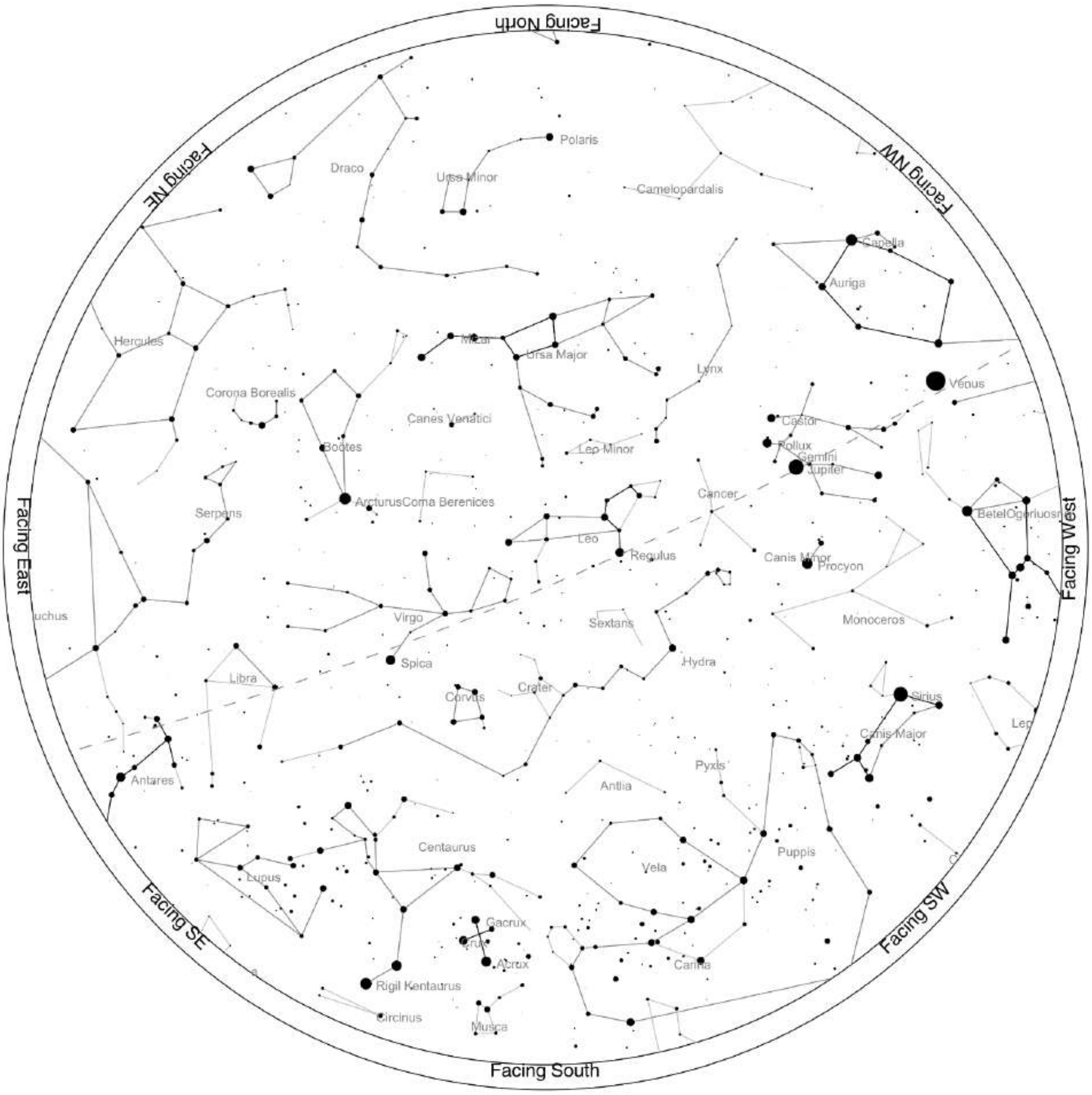
Anjali K A

Running to the rooftop in the evening
has almost become a habit these days.
I've fallen in love with how the warmth
of the breeze slowly turns into a chill.
With the sight of birds heading home—
how parrots disappear,
and bats quietly take their place in the sky.
With the way the sky shifts
from golden to deep blue.
I've fallen in love with how the city
slowly glows after the sun goes down.

I've fallen in love with the thoughts
that splash through my mind
as the city lights up in full.
I've fallen in love with how the wind
rushes through my hair.
After all, I've fallen in love
with how this place is not taken.
Although many live under this roof,
I love how this little place is not taken.

Anjali K A is a Junior Research Fellow at IIA

Astrophotography by Ayushi Chippa, a Senior Research Fellow (SRF) at IIA



Location: Banglore
Latitude: 13° 36′ N, longitude: 77° 57′ E
Time: 2026 May 15, 20:00 (UTC +05:30)

Skychart May 2026

May 31 – Full Moon (Blue Moon): Since this is the second full Moon in the same calendar month, it is commonly referred to as a “Blue Moon.” The Moon will appear bright and prominent throughout the night. While the moon will not appear blue in color, this is a relatively rare calendar event, giving rise to the phrase “once in a blue moon.”

Basics of Modern Cosmology

Kanan Vijay Virkar

We all must have thought about questions of our origin at some point. Where did we come from? How was our universe formed? When and how did the spectacularly beautiful objects such as galaxies, stars, and even Earth form? What is the future of our species and of the universe as a whole? With physics, we can finally attempt to answer such questions with scientific rigor. The goal of modern cosmology is to understand the universe we live in – its origin and evolution through the passage of time.

To embark on this journey, we must treat the universe as a whole and apply the laws of physics. The fundamental physics we need are Einstein's general relativity and statistical mechanics. I will briefly overview these theoretical pillars to help readers understand our universe.

General Relativity

In General Relativity, spatial coordinates and time coordinates are treated on equal footing, which together are called spacetime. Now, Einstein's equation of general relativity is given by:

$$G_{\mu\nu} = 8\pi G T_{\mu\nu} \tag{20}$$

This equation relates how the content of the universe, such as matter, radiation, or dark energy, can be described by the stress-energy tensor $T_{\mu\nu}$, which in turn is associated with the curvature of spacetime described by $G_{\mu\nu}$. To understand why spacetime curves, we can take a very simple example of a ball rolling on a rubber sheet. A flat rubber sheet bends when a heavy ball is placed on it—likewise, mass curves spacetime, with heavier objects producing deeper curvature.

Once we have the metric tensor ($g_{\mu\nu}$) of the spacetime we live in, we can describe how a particle moves through curved spacetime using the geodesic equation:

$$\frac{d^2x^\mu}{d\lambda^2} + \Gamma^\mu_{\alpha\beta}\frac{dx^\alpha}{d\lambda}\frac{dx^\beta}{d\lambda} = 0 \tag{21}$$

where λ is a parameter that monotonically increases along the particle's path.

For a homogeneous and isotropic universe, we can prove that the Friedmann–Lemaître–Robertson–Walker metric (FLRW metric) describes spacetime. We can then represent a line element in spherical coordinates as follows:

$$ds^2 = c^2dt^2 - a^2\left[\frac{dr^2}{1-kr^2} + r^2d\theta^2 + r^2sin^2\theta d\phi^2\right] \tag{22}$$

For a flat universe, k = 0 seems to be observationally true for our universe. So the metric can be written as:

$$g_{\mu\nu} = diag[1, -a^2, -a^2r^2, -a^2r^2sin^2\theta] \tag{23}$$

$$ds^2 = c^2dt^2 - a^2(dr^2 + r^2d\theta^2 + r^2sin^2\theta d\phi^2) \tag{24}$$

Or, in Cartesian coordinates, $g_{\mu\nu}$ becomes:

$$g = diag[1, -a^2, -a^2, -a^2] \tag{25}$$

$$ds^2 = c^2dt^2 - a^2(dx^2 + dy^2 + dz^2) \tag{26}$$

The above equations represent a flat expanding/contracting universe, where the expansion or contraction is determined by 'a'. The universe we live in is expanding at an ever-increasing speed (accelerated expansion). Observations from Type Ia supernovae show that distant supernovae appear fainter than expected for a uniformly expanding universe, meaning they are farther away than expected.

This directly shows that the universe's expansion has been accelerating.

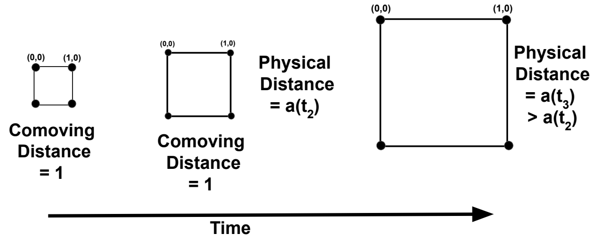


Figure 1: *Expansion of the universe (Credits: Modern Cosmology by Scott Dodelson and Fabian Schmidt*

Let's consider a grid encompassing the universe that expands along with it, as shown in Figure 1. The coordinates associated with this grid are called comoving coordinates, which are simply the x, y, z coordinates in Equation 26. By definition, the comoving distance (the distance between points on the hypothetical grid) remains constant as the universe expands, while the physical distance (the actual distance observed between the points) is proportional to the comoving distance times the scale factor (see the spatial part of Equation (7)), which increases as time evolves, as seen in Figure 1.

The evolution of $a(t)$, the scale factor, describes how fast the universe is expanding/contracting with time, which can be found from the Friedmann equation described below.

$$H^2 = \frac{(\dot{a})^2}{a^2} = \frac{8\pi G\rho}{3} - \frac{k}{a^2} + \frac{\Lambda}{3} \tag{27}$$

If the constituents of the universe follow the ideal isotropic fluid (which has the same properties in all directions) equations, then the stress-energy tensor becomes

$$T_{\mu\nu} = diag[\rho, -P, -P, -P] \tag{28}$$

We can substitute Equations (23) and (28) in Equation (20) to get the Friedmann equations (see Equation (27)) that describe the evolution of the scale factor a.

Boltzmann Equation

We are interested in the statistical behaviour of matter and radiation because the universe contains an enormous number of particles, making it impossible to track each one individually. Therefore, we study their behaviour through statistical averages. Moreover, the large-scale evolution of the cosmos – such as the CMB temperature, density fluctuations, and galaxy distributions – is inherently statistical, arising from the collective behaviour of particle distributions rather than individual motions.

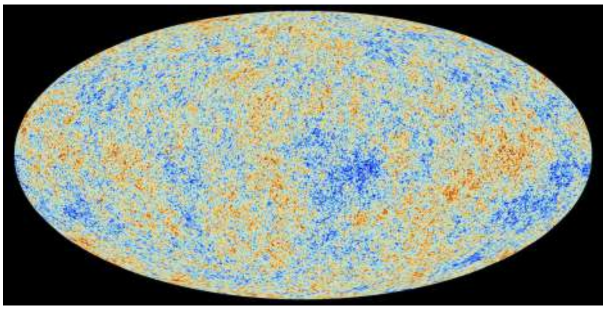


Figure 2: *Cosmic Microwave Background Radiation (Credits:ESA/Planck Collaboration).*

To carry out this task, we can define a distribution function $f(\vec{x}, \vec{p}, t)$ on phase space, which determines how the particles are distributed in terms of position and momentum $(\vec{x}, \vec{p})$, and how this distribution varies with time.
The number of particles of a particular species at the position $(\vec{x}, \vec{p})$ can be written as:

$$N(\vec{x}, \vec{p}, t) = f(\vec{x}, \vec{p}, t)\frac{(\Delta x)^3(\Delta p)^3}{(2\pi)^3} \tag{29}$$

In the limit of a large particle number, $f(\vec{x}, \vec{p}, t)$ approaches a continuous function that can be used to describe the state of the collection of particles. We want to know how this distribution function $f(\vec{x}, \vec{p}, t)$ changes with time.

Let's take the derivative of f and use the chain rule of differentiation:

$$\frac{df}{dt} = \frac{\partial f}{\partial t} + \frac{\partial f}{\partial x_i}\frac{dx_i}{dt} + \frac{\partial f}{\partial p_i}\frac{dp_i}{dt} = C[f] \tag{30}$$

The LHS is the rate of change of 'f' with time, which is equal to the term $C[f]$ in the RHS. The source term determines the total rate of change of particles in the phase space element due to particle-particle interactions, which can include chemical reactions, ionization, recombination, scattering, particle-antiparticle production, or annihilation.

To solve this Boltzmann equation, we use equations of general relativity, particularly the geodesic equation, to get terms $\frac{dp_i}{dt}$, which requires us to use the metric $g_{\mu\nu}$ of our universe. The geodesic equation describes how a particle moves in curved spacetime. In general relativity, particles do not feel a "force" from gravity; instead, they simply follow the straightest possible path allowed by the curvature of spacetime. This path is called a geodesic, or the straightest possible path in curved spacetime.

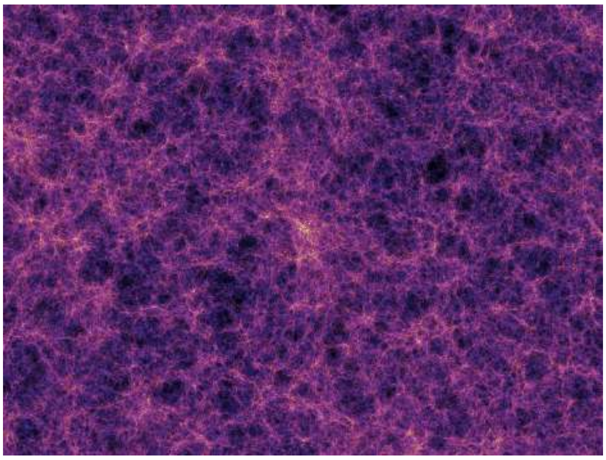


Figure 3: *Cosmic Web (Credits: Volker Springel & Max Planck Institute for Astrophysics et al.).*

The simplest case will be the FLRW metric considered previously, which assumes a perfectly uniform, homogeneous, and isotropic universe. We can solve Equation (30) for this case. However, it will give us a solution valid only on large scales, where the universe is indeed homogeneous and isotropic. We cannot use this solution on smaller scales because these assumptions break down in our local universe.

We have highly concentrated structures of galaxies and stars, which are ultimately made of baryonic matter. Between these structures, we have vast near-vacuum spaces. This distribution is not homogeneous at all. Similarly, the assumption of isotropy is invalid. To deal with the real universe at all scales, we have to go beyond the simple case of the FLRW universe. We do this by considering perturbations to the ideal conditions that evolve with time to give us the universe we see today.

In an ideal universe which is homogeneous and isotropic, the temperature would be constant at every position. In reality, however, we observe temperature fluctuations of the order of $10^{-5}K$, which are shown in blue and red spots in the CMB radiation map in Figure 2. Tiny CMB temperature fluctuations ($\Delta T/T \approx 10^{-5}$) directly reflect the density perturbations in the early universe. The hotter regions correspond to overdensities (slightly higher photon energies and deeper gravitational potentials), while the colder regions correspond to underdensities. As the universe evolves, the overdense region becomes more overdense, and the underdense region becomes more underdense. These over-dense regions later evolve into large-scale structures, such as galaxy clusters within dark matter halos, filaments within the cosmic web, and so on, which we observe today (see Figures 2 and 3).

Author's Bio:
Kanan Vijay Virkar is a PhD student at the Indian Institute of Astrophysics, Bengaluru, working with Prof. Pravabati Chingangbam in the field of cosmology.

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Beginning my Scientific Career at Kodaikanal and Bangalore

Prof. Tushar Prabhu

After spending two years as a Research Scholar at the Kodaikanal Observatory, I obtained a regular position as a Research Associate in August 1975 (half a century ago!). My teenage dream was to work as a scientist with optical telescopes. Earning a Ph.D. was a step towards that goal, but I had now skipped the first step! My scholarship did not adequately cover my expenses at Kodaikanal and Kavalur, and getting a job with a higher salary was a relief.

Dr. Bappu was now my employer, Reporting Officer, and Director, not just my Ph.D. supervisor. I had once addressed him as Prof. Bappu in a paper submission, and he made me replace it with Dr.; "That is the only thing I have earned," he said. He did not have the designation of Professor at IIA! I could interact with Dr. Bappu with greater confidence than before. The first assignment after joining as a Research Associate was a research project on Nova Cygni (V1500 Cygni) 1975.

The Nova was discovered on August 29, 1975, and peaked at a visual magnitude of 1.8 the following day. Bappu read in the newspapers and asked me to rush to Kavalur and monitor it. There were no methods yet to disseminate such information to astronomers worldwide. It was a naked eye nova, but we could not see it from Kodaikanal as the monsoon had set in.

Kavalur was cloudy too, and it had faded when the skies cleared. Without knowing its exact position, it was difficult to identify it in the rich and large field of Cygnus. Dr. S. Mohin and I photographed the field with an astrograph (named M-camera since Dr.Mohin had traveled to Bombay to get it cleared through Customs) and found it near the edge of the plate after Dr. Bappu sent me a telegram with exact coordinates. I monitored spectra till December intermittently.

During a break from observations, back at Kodaikanal, I received my transfer order to Bangalore. I asked Dr. Bappu if I could stay on at Kodaikanal, which I liked a lot. He said he plans to move the library to Bangalore, and what would I read in Kodaikanal?

I was invited to a winter school in High-Energy Astrophysics at TIFR (Tata Institute of Fundamental Research) during Christmas of 1975. I thought it would be convenient to travel from Kodaikanal to Bombay (now Mumbai), and then report to Bangalore after school. Prof. P. Venkatakrishnan, who had joined as a Research Associate with me, was attending the same school, and also transferred to Bangalore. We travelled together to Mumbai and Bangalore, and took rooms near the Shivaji Nagar bus station, from where we could get a bus to Madiwala. We had to share rooms with different roommates, so after a few months, we left and shared a room in Jayanagar. While it appeared closer (I once walked the distance in 45 min, the same as to Shivajinagar), we had to change buses at Wilson Garden, and it took 90 min to reach IIA. Later, Venkatakrishnan went to stay with his relatives and showed me a room in Wilson Garden where an employee of Canara Bank, Madiwala, was looking for a roommate.

The entire institute was housed in the current administrative building, which was designed by Dr. Bappu and constructed by the Kavalur and Kodaikanal workshop staff. The director's office was in the current Personnel Section, with the library adjacent to it. The administration was limited to the space now occupied by the Billing section. The academic staff shared the remaining rooms with 2-3 people per room. The Workshop & Stores building was ready, but there was no accommodation on its top yet. The Optics Laboratory Building was still in progress. The Main Building (housing the library) was completed in 1978-79, and the academic-technical staff moved there. The older building was given to the administration, except for the erstwhile Director's office, which was converted to a Lecture Hall until the Auditorium in the main building was ready.

There were no eateries in Koramangala - can you imagine? The two restaurants near the Jamia Masjid of Madiwala were unappealing. Some senior faculty arranged our entry into the St. John's Medical College hostel mess and later in the staff canteen, but we were pushed out when legitimate users could not find a table. My lunch would then be a cold sandwich with butter and jam I prepared in my room, or a banana, buns, and tea at a 'Kaka' shack on the roadside in front of the main gate, until Venkatakrishnan's mother moved to Bangalore, and he started bringing lunch from home for both of us.

I bought a motorcycle with partial support from an advance by the Institute. I asked my office roommate, Mr. Rahim, to drive me from the showroom to the Institute and explain its operation. I took a round of the campus, felt confident, and rode to Prof. Ramesh Kapoor's house in Koramangala 7th block at lunch time and to my Wilson Garden room in the evening. The next day, I visited colleagues in Jayanagar and was struck by a flooded engine on my way back. Seeing me push the bike, someone stopped his car, asked me for a plug spanner, which I had left in my room, and then helped me push-start it. I learnt a lot from that incident and could look after my bike on my own.

Figure 1: Indian Institute of Astrophysics around 1980, when a new floor was added to the Workshop building (extreme left, top). Notice the absence of Kendriya Sadana at its back.

Bangalore, the Science City, had its academic advantages: Some staff who were working temporarily from the premises of the Raman Research Institute had also moved to Koramangala, along with those of us who were transferred from Kodaikanal. IIA joined the Astronomy groups of the Raman Research Institute and the Radio Astronomy Center of TIFR, Bombay (then located on the Indian Institute of Science (IISc) campus), to hold summer schools in Astronomy and Astrophysics in 1976, aiming to attract research students. The Joint Astronomy Programme was initiated at IISc. I was happy to get involved with these activities and make more friends in the astronomy community. We all attended talks in different institutions.

I was happy with my work on Nova Cygni 1975 (Figure 2). The data were as good as I could get with a photographic plate. I converted it to a density plot using the Zeiss microdensitometer in Kavalur. A calibration spectrograph recorded spectra with known intensity steps. I used the calibration to convert density to relative intensity; the density graph was read with a millimeter scale. Calculations were made using logarithm tables, and plots were made on a graph sheet. It took me a year to reduce the data, but I enjoyed the analysis and wrote my first scientific paper - Early Nebular Stage of Nova Cygni, 1975, Kodaikanal Obs. Bull. Ser. A, 1977, 2, 75.

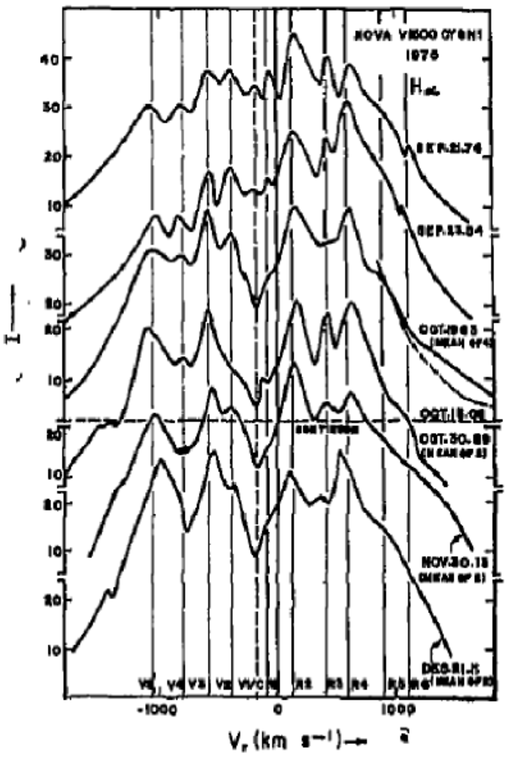


Figure 2: *Evolution of Hα profile from early (top) to late (bottom) period. Vertical lines indicate positions of peaks. The structure was proposed to arise from the superposition of rings parallel to the equator and polar caps, each providing a double-peaked profile. Final figure traced by the draftsman, Mr. Muthukrishnan.*

Dr. Bappu read through the draft paper as soon as I showed it to him, and was not convinced about one point in my conclusion: I wrote "The blue emission peaks of Hα were initially faint compared to the red ones, and brightened steadily to become equal. The envelope was optically thick to Balmer radiation, and was thinning out rapidly during the period of observations" (quoting from the abstract submitted to the third annual meeting of ASI at Nainital). Dr. Bappu said I can keep the paragraph if my seniors agree. Seniors were not convinced, but they helped me to improve the paper. One of them advised me to agree to the Editor's comment and remove the paragraph. In those days, Kodaikanal Observatory Bulletins edited by Dr. Bappu were the default mode of publication at IIA.

After I published the paper, Gary Ferland published a letter in Nature (1977, 267, 597) titled "Nova Shells: matter-bound or radiation-bound?" He referred to the Ph.D. thesis paper of Stuart Pottasch (1959, Ann. Astroph. 22, 394) which argued that a nova shell may initially be optically thick in Hα. This was followed by Peter Strittmatter et al. (1977, ApJ 216, 23) who estimated the optical depth of Hα using OI emission lines resulting from Lymanβ fluorescence. I was happy that my hunch was correct, but I learnt that good science needs convincing proof, and a good paper follows a thorough literature survey.

I missed presenting the abstract of the Nova Cygni paper in person at the ASI meeting since another nova had exploded, and I rushed to Kavalur to observe it. Bappu mentioned my work on Novae in his keynote address! He had not seen my abstract, which appeared in print in the Bulletin ASI later and noted the optical thickness of Hα.

While I was busy observing more novae, Dr. Bappu, who was planning to visit Kavalur, asked me to join him so we could discuss my thesis. We chatted for an hour before he asked me if I had come up with some idea for my thesis in extragalactic astronomy. I was happy working on novae, but changing the topic would be a hassle with the university. He gave me a copy of "A List of Galaxies with Peculiar Nuclei" by J. L. Sérsic (1973, PASP, 85, 103), told me to start with a literature survey, and dropped me off at Jolarpet station so I could get back to Bangalore and start my work.

Sérsic's list was expanded from a smaller list published earlier by him and his student M. Pastoriza (1965, PASP, 77, 287). I termed them Sersic-Pastoriza galaxies and began a literature survey. Dr. Bappu built a 'Nebular Spectrograph' with a fast camera, which increased sensitivity to extended objects. I found that the brightest emission lines from galactic nuclei fell on the low-efficiency wavelength regions of the photographic plates. Dr. Bappu imported an image intensifier and fitted it to the spectrograph, and I was in business, but only with the brightest emission lines. I recorded slit spectra of the central regions of 22 galaxies and detected emission lines in several of them, mostly already reported in the literature.

I decided to image the nuclei in the blue and red bands using the intensifier at the F/16 focus of the 40-inch to study the morphology of nuclear structure, qualitatively described by Sérsic and Pastoriza as amorphous, hot-spot, or dumbbell nuclei. The filters I used were not standardized. The transmission of the fiber optic interface of the image intensifier, coupled with a blue glass filter, limited the blue band to 400 - 460 nm. The red filter and the sensitivity of the photocathode allowed both R and I bands to pass through. This became my primary data set. Dr. Bappu suggested I could widen the slit and record emission line images of nuclei to study the spatial distribution of emission line ratios. I was worried that the large, unknown velocity field would distort the line images in the dispersion direction. The nucleus of NGC 5236 (M83) was so bright that I was tempted to record wide slit spectra and hoped to estimate the rotation velocity field of the circumnuclear structure.

There was a period when Dr. Bappu and I did not speak to each other. I did not know why Dr. Bappu was ignoring me, but I decided to ignore him too. The grapevine helped me to learn what happened behind my back (It was related to my explanation of the nebular spectrograph to another user). When we had made up, I began to share my information with Dr. Bappu before anyone else had an opportunity to twist it.

Dr. Bappu suffered severe angina in 1978 and was hospitalized. All my colleagues met him while he was recuperating at home, and someone persuaded me to visit. Dr. Bappu asked about my thesis (thus restarting our communication), and I said I require a 6-month extension beyond the deadline of Madurai University (now called Madurai Kamaraj University). He refused and told me to complete it in the 9 months available to me.

Dr. Bappu arranged to digitize my data at the Space Application Center, Ahmedabad, and I made an exploratory visit. IIA was permitted to use the central computer at IISc, but the time provided was limited, and there was no lab space. We had to make a trip to submit the program, another trip to collect the output, spot errors, debug, correct, and resubmit. Digitizing all my data in Ahmedabad, developing software, and analyzing on the IISc computer would have taken a lot of time. Any facility available at the workplace would be better.

The traditional method of surface photometry employed isophotes (equal-intensity contours). Making one contour required overlaying positive and negative copies, exposing through the overlay. I began the laborious work. Once, when I visited the Stores to procure more film, I noticed that there were boxes labelled Agfacontour. I could obtain a contour with a single exposure, reducing the time spent on the first two copies. I got the films issued and began to assemble the contours of my galaxies. When I had opened the last box, Prof. K.R. Sivaraman came to me and asked if I had any film left that he could try out. I gave him the box and wound up my work. I did not know that the films were procured for Prof. Sivaraman's project. I was grateful that he was not offended when I used most of them without his consent.

Morphology, intensity, and colour distribution

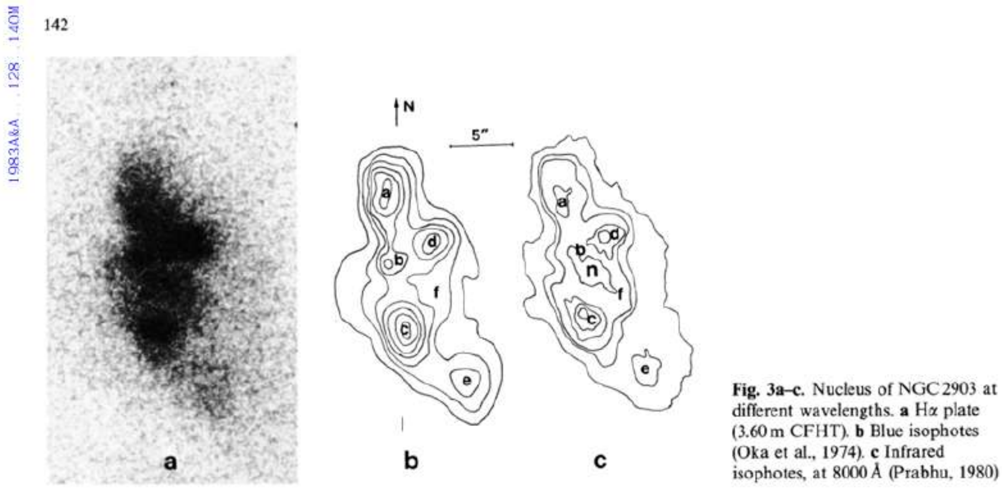


Figure 3: *Circumnuclear region of NGC 2903 with the nucleus marked n was identified from VBO, Kavalur. Figure and Caption from Marcelin et al. (1983, A&A 128, 140).*

provided me with enough data for the bulk of my thesis. I described the presence or absence of emission lines based on my spectroscopic data. I would often think of determining the central rotation velocity of M83, assuming that the emission is from a differentially rotating tilted disk. I tried to derive the distortion of contours in the wide-slit spectroscopic image due to rotation velocity using analytical geometry, and failed. One morning, I woke up dreaming that I had solved it by using a different method. I visited the mathematics section in the library and found a book titled Geometric Transformations (P.S. Modenov & A.S. Parkhomonko 1965, Academic Press). The chapter on Affine Geometric Transformations gave me an idea: The component of radial velocity along the direction of dispersion would distort the isophotes and change the area enclosed. As proof of the concept, I computed the radial velocity curve of the circumnuclear region of NGC 5236 by comparing the isophotes of direct image without filter with dispersed images in the emission line of Hα. I wrote a chapter over the next 24 hours, gave it to Bappu to read, and went to catch some sleep. In the evening, I found Dr. Bappu did not share my excitement, but did not mind if I included it in my thesis. I did, and in return, I compromised by not publishing it anywhere else. There are moments of joy in science which may not necessarily leave a great impact on the field.

Since the term galactic nucleus was vague at that time, and the size of the region under study extended several hundreds of parsecs, I termed the structures as 'peri-nuclear formations' in my thesis. One of the referees commented that mixing Greek and Latin in a single word is not permitted. He did not suggest the alternative 'circum-nuclear', which was not yet used widely. I dropped the word from my publications.

One of the galaxies I had observed was NGC 2903, whose real nucleus was faint, and the brightest star-forming region "c" was assumed to be the nucleus (Figure 3). The I-band sensitivity of the image intensifier showed the dust-obscured nucleus "n" lying symmetrically between the circumnuclear star-forming regions (a,e), (c,d), (b,f). I wanted to publish a paper on this in a widely circulated journal. Dr. Bappu suggested that the glossy paper used by Astrophysics and Space Science would show my images better. Bappu served on the Editorial Board of the Journal. The paper was published early in 1980 (AP& SS, 68, 519), and I was elated to see it cited in Nature by the end of the year (Laques, P. 1980, Nature, 288, 145). Discussion on whether “n” is really the nucleus continued for some time in the literature. Marcelin et al. (1983) found that the dynamical centre is closer to “c”, whereas Wynn-Williams and Becklin (1985, ApJ, 290, 108) found that Near-Infrared emission peaks near “n”.

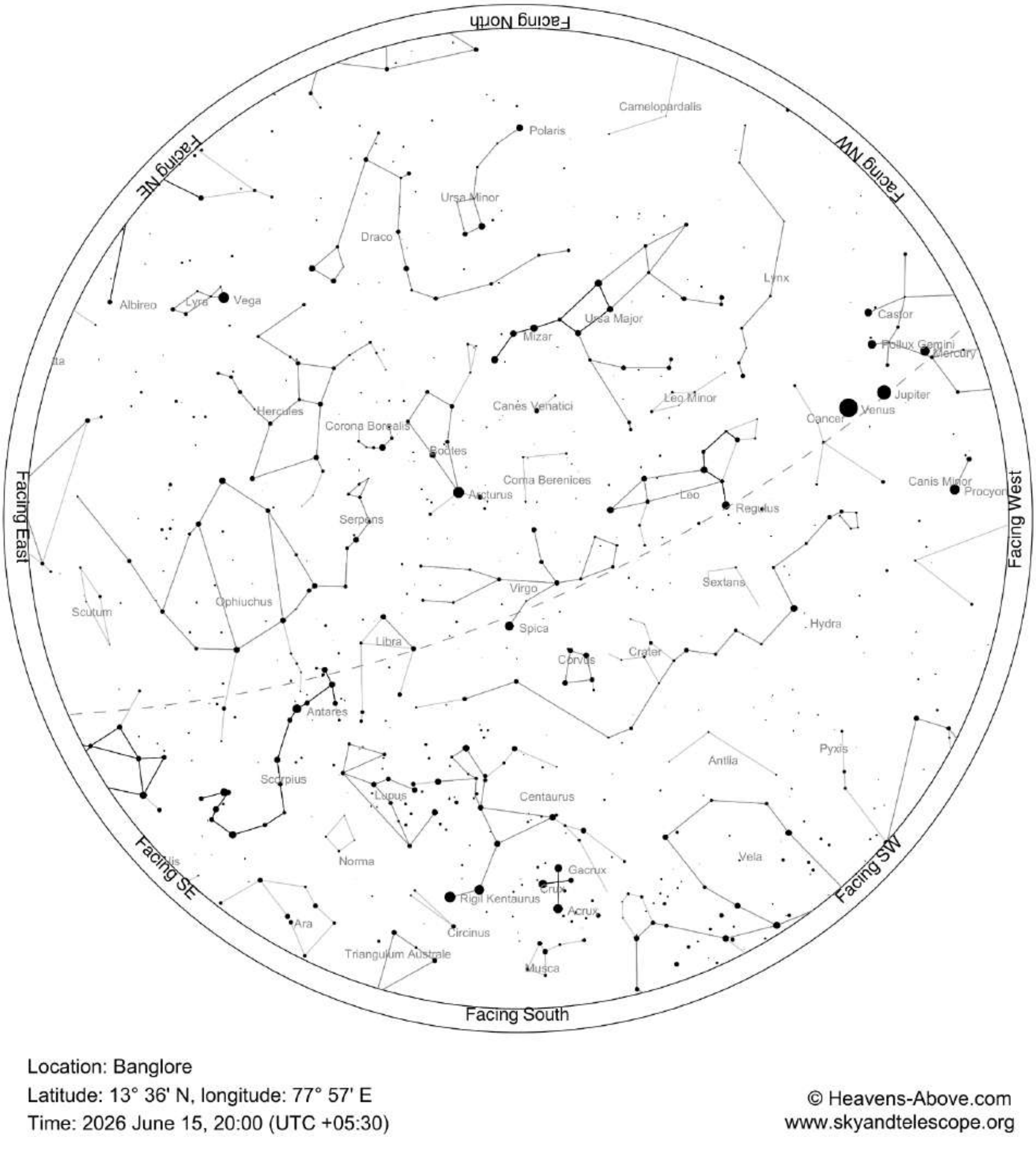
I published the main body of the thesis in the second issue of the Journal of Astrophysics and Astronomy (1980, 1, 129), a new Journal published by the Indian Academy of Sciences with Dr. Bappu as the Chief Editor. A colleague had stopped me on the way to the Editor and advised me strongly to include the supervisor’s name as a co-author. I retyped the first page, but Dr. Bappu struck it with a red pen. I said the work was done under his supervision, and he replied that there is a section named Acknowledgments for it.

I submitted my Ph.D. thesis to Madurai University in January 1979, but the University needed to recognize my M.Sc. degree from IIT (Powai), Bombay, which was probably not on their list of recognized universities. They asked for a “Migration Certificate” which IIT informed that they do not provide. Eventually, the evaluation of the thesis and defence took place in 1980, and by the end of the year, I received a communication that I had qualified “for the degree of Doctor of Philosophy” and I “may take the degree at a convocation”. I missed the next convocation and applied for the diploma by post (in absentia). I did not receive it. I was beyond care. I had an academic position. I could guide students at Bangalore University and the Indian Institute of Science without a degree certificate.

Dr. Bappu involved me in diverse activities after submitting my Ph.D. thesis: a solar eclipse, attendance of an IAU Symposium, and editorial aspects of the Journal of Astrophysics and Astronomy. That story befits a separate article.

Author’s Bio:

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



Skychart June 2026

June 15 – Mercury at Greatest Eastern Elongation: Mercury reaches its greatest eastern elongation of about 24.5° from the Sun, making this the best evening opportunity to observe the planet from India. Look for Mercury low in the western sky shortly after sunset, where it will appear as a bright, star-like point before quickly setting.

The Only Goodbye

Akanksha Kapathia

I remember that juncture,
the one where all would move on
to their journeys
as time fades, often several hands
waving goodbye and pictures clicked
outside the gates...

Of the many hands I had held there once,
most had slipped away,
yet there was one that stayed,
that steadied me amidst fear,
driving me towards the beauty
I had lost off late...

The beauty of mornings warming into sun,
of mountains, of rivers, of villages
and of streets, of drives to temples
and churches,of meals that we shared,
of similar t-shirts, perfumes
and boat rides on cascades...

With color and words, she shaped her world,
of adventures, of journeys through mountains
and countries, under seas, of creatures,
of lovers, of friends she liked to keep...

She carried the stories of her Mother
and Father, of losses, of longings,
of dishes, of dreams —
like a book with lessons to move ashore,
she painted her art yet again,
more beautiful than ever before...

And when I stood at the same juncture,
I am glad there were not many hands to wave,
but a blank canvas ahead to re-paint,
starting from her warmest hug —
as when it was time to leave,
she was but my only goodbye.

In loving memory of my friend Maya Prabhakar.

Author's Bio:
Akanksha Kapathia is a Postdoctoral Fellow at the
Max Planck Institute for Astronomy, Heidelberg.

Maya's Paintings

Sojourn in Kolkata

Shubham Ghatul

"Welcome to Netaji Subhas Chandra Bose International Airport, Kolkata," announced the flight attendant over the radio speakers as I landed after a two-hour-long journey through the clouds early in the morning of August 18th, 2019. This was the second city in the last two months that I had migrated to after leaving my beloved Pune. After the short one-month stay at the Indian Institute of Astrophysics (IIA), Bengaluru, was over, we four batchmates had to report to Calcutta University's Salt Lake Campus as our M.Tech first-semester classes were about to begin. I could immediately feel the much-talked-about climate of Kolkata from our seniors back in Bengaluru as I stepped outside the airport - hot and humid. I took a cab and after a 25-minute ride, it dropped me at IA-204, Salt Lake City, which was going to be my abode for the next one year.

"Please don't expect the accommodation to be very good; it's just okay-ish," Sujay (name not changed!), one of my batchmates and a fellow Marathi speaker, had informed me on the phone while I was still in the cab. I scanned the apartment from top to bottom and end to end as I entered through the main gate. It was a ground-floor 2-BHK, equipped with basic amenities, with all kitchenware set up by our immediate seniors who had just left before we moved in, and a bicycle left behind by another super-senior. One of the bedrooms was already occupied by Manjunath and Sayuf, both natives of Andhra Pradesh. I dropped off my luggage in the house, and we all started walking towards the Department of Applied Optics and Photonics, where we had to report that day.

Days slipped by as we became immersed in lectures, lab sessions, and practicals. Yet, in the middle of all the academic bustle, I was still on a quest for decent vegetarian food. The struggle finally eased when we managed to hire a cook for our dinners, after each of us had tried and failed miserably to prepare anything remotely edible. Kolkata, with its hot and humid climate, unfamiliar food, and different lifestyle, did test my patience at times. But at the same time, it welcomed us warmly through its people. The professors, staff, and students at the Department of Applied Optics and Photonics, in particular, were remarkably kind and supportive, knowing that we had just moved here from IIA. The professors were so down to earth that they would be available to solve any small problem at any time of the day. In fact, in our very first week, Prof. K. Bhattacharya, fondly known as KB, took us on a two-day trip to Bolpur Shantiniketan, a place deeply connected with the great Indian poet and Nobel laureate Rabindranath Thakur. Yes, it is Thakur and not Tagore, as we non-Bengalis have always heard and read in our books. By the time Durga Puja was around the corner, I had begun to take genuine pleasure in understanding, if not fully learning, the Bengali language, which has to be the sweetest one could ever hear when spoken.

When the grand festive season of Durga Puja came to an end, Kolkata woke up once again to return to its daily rhythm. It was already November, and the climate had completely transformed. The heavy humidity had given way to cool breezes, and the harsh summer sun was now replaced by gentle, warm light. Having moved here from Pune, which is about an hour behind Kolkata in time, I could clearly feel the difference. The sun would set as early as 4:45 pm, and on some days it would already be dark by the time we stepped out of the department after our last lecture. This was

Picture 1: *A group picture with the professors taken outside KB's villa in Shantiniketan, where he hosted us twice during our sojourn in Kolkata. From left to right: Sujay, Sreekant, Sayuf, Manjunath, Sireesha, RC (Prof. Rajib Chakraborty, the then HoD), KB (Prof. Kallol Bhattacharya), and myself.*

when the explorer in me truly came alive. I began wandering through the city, its markets, historic landmarks, parks, and lakes, soaking in its charm. On one such evening, I wrote the following lines to capture the essence of a typical Kolkata evening:

An evening in Kolkata

When the bright daylight dims, and somewhat cooler winds blow, Kolkata welcomes an evening. Birds and people start rushing back to their homes. Streets bustling with shoppers, fishes getting ready to be picked by the foodies, Phuchka vendors (Gol-Gappe or Paanipuri) preparing the Potato Fillings with bare hands, Chai-wallas serving hot smoky Chai in an earthen pot called Kullhad, and the sound of a conch shell that hits your ears, which marks a Kali-Mata Prayer getting over, is a typical Kolkata Evening. I love taking a stroll through such a lively market in the evenings and sipping a hot Kullhad-Chai while tradition-ridden but uniquely beautiful Bengali Women pass by. I'm deeply falling in love with this part of India

During our time at Calcutta University, all of us batchmates actively participated in outreach activities. We visited not only schools and colleges in Kolkata but also travelled to faraway rural areas outside the city, demonstrating various "experiments of light." After one such outreach program, we returned to Kolkata on 17th March 2020, only to receive a circular from the University stating that all academic institutions would remain closed for 30 days due to the COVID-19 outbreak. This was the first time in my life that I felt sad about getting such a long holiday. My heart and feet were unwilling to leave, but alas, the situation was worsening. I finally left Kolkata on 18th March 2020, never to return so far, with a ton of memories I would cherish for life. In my time there, I met not just students and professors, but also discovered the rich yet often hidden talents within them: vocalists, instrumentalists, singers, chefs, poets, and, most importantly, truly remarkable human beings. To sum up my thoughts, I would say, “If memories were a lane, it would be in Kolkata..!"

Author's Bio:
Shubham Ghatul is a Senior Research Fellow at IIA working with Prof. Jayant Murthy and Dr. Rekhesh Mohan on instrumentation for UV astronomy. He was in Kolkata for the first year of IIA's Integrated M.Tech-PhD program with Calcutta University.

"Schrodinger's cat is alive... Hurray!! "

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