DOOT

Quarterly Magazine of the Indian Institute of Astrophysics

Issue 2
November 2020

Thirty Meter Telescope
WFOS: The First Light Instrument

Govind Swarup
Pioneer of Radio Astronomy

Science is for EVERYBODY
Interview with Prof. Prajval Shastri

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Invitation For The Next Issue

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

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

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

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

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

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

Note: Attach a brief bio of the author along with the article .

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

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

Featuring

From the Editor

Since the release of the DOOT e-magazine's first issue, we have received a lot of feedback from the readers. In this November issue of the magazine, we have improvised on the magazine structure as per constructive feedback. As we have adjusted to the new normal with all the physical colloquiums/meetings/conferences shifting to online ones which have both pros and cons of its own, the question persists, "When will we be back to previous normal ?" In these times, there are several good news in the Indian astrophysics community, from the cutting edge discoveries like the Lyman continuum emitter at z=1.6 by ASTROSAT, digital mapping of the sun's magnetic field over five decades to the first measurement of HI masses galaxies at z~1 from upgraded GMRT. At the same time, we have a giant loss in the Indian astronomy community, Prof. Govind Swarup, whose ideas will always be with us and continue to inspire us. In this issue, we have a tribute article about his contributions. Continuing the streak, this year's Nobel prize in physics has been awarded to Astronomy and Astrophysics, which brings much excitement to the field. One half of the prize is given to Prof. Roger Penrose for the discovery that black hole formation is a robust prediction of the general theory of relativity and another half is given jointly to Prof. Reinhard Genzel & Prof. Andrea M. Ghez for the discovery of supermassive compact object (black hole) in the center of the Milky Way galaxy. We would be having articles about these discoveries in the coming issues of the magazine.

We have received several contributions to the magazine since the last issue was published. We are really thankful to all the contributors to this issue of the magazine. We hope that you will enjoy the articles in the magazine and provide us with your valuable feedback.

Dr. Sandeep Kataria

Chief Editor, DOOT

(Sandeep is a Postdoctoral Researcher at the Indian Institute of Astrophysics, Bangalore. His area of research lies in Galactic Dynamics and Large Scale Structure of the Universe.)

The Cover Picture

High-altitude balloon (HAB) experiments in near space are becoming very popular as they can be used for scientific research at fractions of the cost of space projects. Because of the low cost, they are perfect for both academic and educational institutions. Besides that, at high altitudes we escape most of the atmosphere, enabling observations at a wider wavelength range compared to the ground.

Near space is the region of Earth's atmosphere that lies between 20 km and 100 km above sea level; the area above 99% of the atmosphere, ozone layer and most of the turbulence. The ozone layer prevents ultraviolet (UV) light from reaching the ground, and atmospheric turbulence distorts the optical images of the astronomical sources. Telescopic platforms at high altitudes have significant advantages over operations from the ground, enabling observations at forbidden wavelengths with diffraction-limited imaging without the use of adaptive optics. Also, the lower cost and flexibility in launch timings and flight duration make HAB experiments a wonderful test-bed for space technologies.

The HAB program of the UV team at IIA aims at developing and flying low-cost scientific payloads on balloon-borne platforms, and also at developing instruments that can operate on a range of space platforms, including CubeSats, mini-satellites, or space missions. Our balloon experience since 2012 has been invaluable in the training and verification of our current space activities. We now have several payloads that are either ready for space flight or are planned for future flights. Our program is one of the few experimental space programs in the country and we are training students for the growth of space astronomy.

UV Team at IIA, Bangalore:

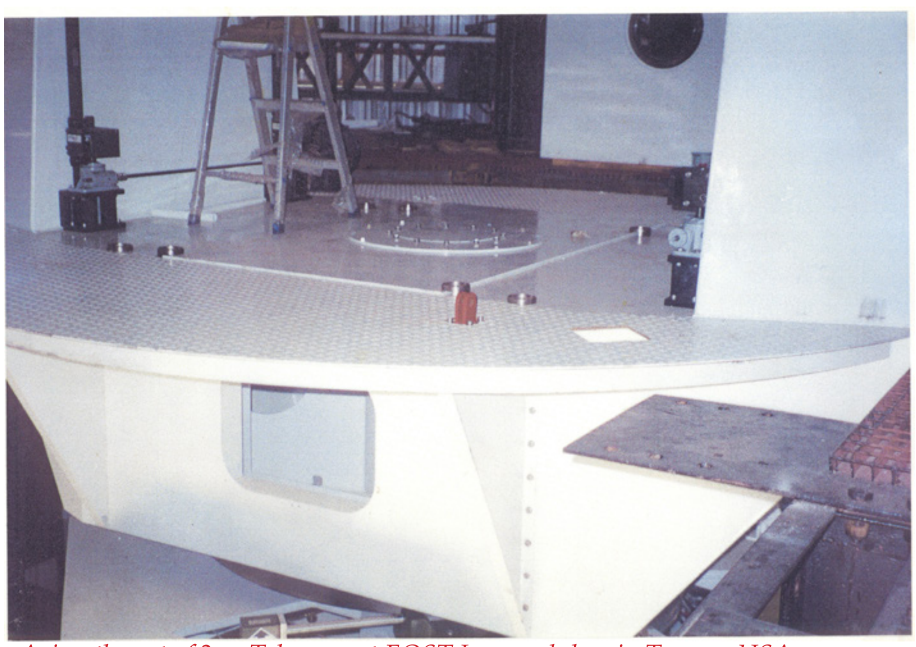
Prof. Jayant Murthy, Margarita Safonova, Rekhesh Mohan, Binukumar G. Nair, Richa Rai, Shanti Prabha, Bharat Chandra

Glimpses of memories at IAO-Hanle

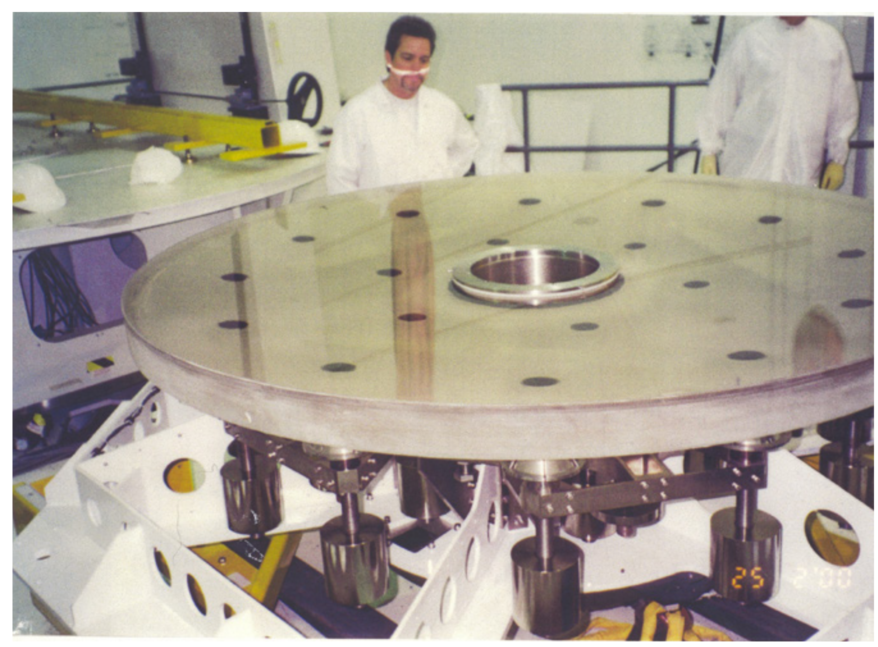
Indian Astronomical Observatory: 25 Years

Part 2

B C Bhatt, Dorje Angchuk & Man Singh



Azimuth part of 2-m Telescope at EOST Inc. workshop in Tucson, USA



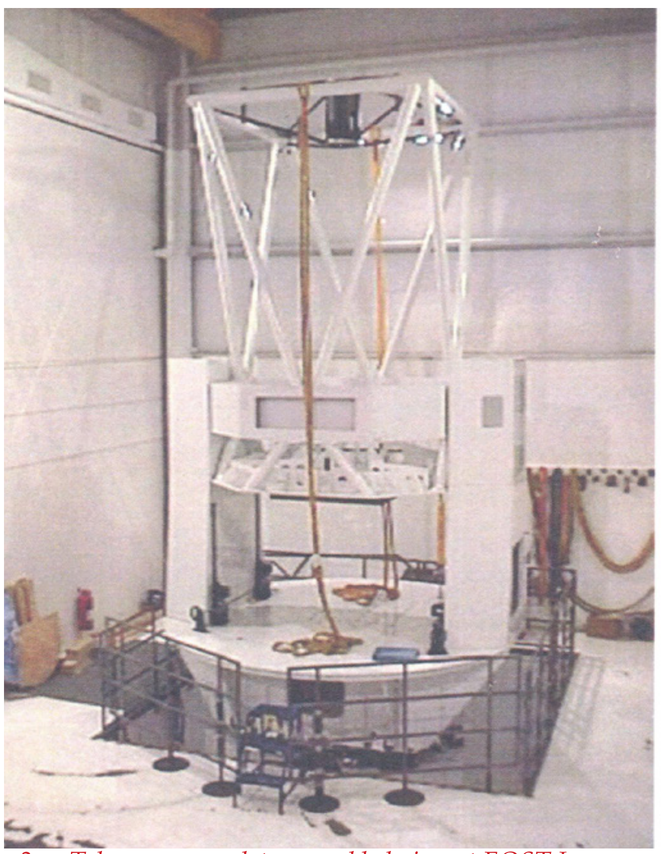
2-m mirror with support assembly at EOST Inc. workshop in Tucson, USA

In Ladakh, there are only two seasons. One is winter (October to April), and the other is Summer (May to September). That's why business activities start as soon as the surface transport opens in May, and all resources reach Ladakh in the first two months. By July, all activities in construction, tourism, business, and others come to a peak. Hence in my previous story in July, I shared my memories at IAO-Hanle from 1995 to 1999. In the present part, I shall share the significant works at IAO during the year 2000 for the shipment of the 2m telescope consignment.

The contract for fabricating the 2m optical telescope for IAO-Hanle was awarded to EOS Technologies, Australia, as per the configurations/specifications of IIA. EOS Technologies took the fabrication work to its facility at Tucson, Arizona, USA. In March 2000, the telescope management committee members, Prof. Yashpal and Prof. B. V. Sreekantan, with other IIA scientists, visited Tucson for the pre-shipment acceptance test.

Back home, it was discussed and planned that the complete consignment of the telescope would be shipped to an Indian Port, and then it would be transported to Chandigarh by surface. Indian Air Force transport plane IL76 would be used between Chandigarh and Leh. That's why with Air Force Station-Leh's permission, our team at Leh visited the airport area personally to discuss this shipment and assess the cargo area inside the IL76 plane and other; and unloading facilities available in Leh with the Air Force and the Army. Further help from the Indian Army was planned to transport the consignment to Hanle.

Telescope acceptance by the team at EOST Inc. workshop in Tucson, USA



2-m Telescope: complete assembled view at EOST Inc.

I was also a part of the pre-shipment group from IIA and visited the Tucson facility at the end of March. I had training on telescope working and operations/maintenance, etc. I took part in the final aluminizing of the 2m mirror at Arizona University. Shipment details were also discussed as per our experience back home with the Air Force IL76 Transport plane. Accordingly, the size and weight of packing boxes could be accommodated and handled inside IL76 and other vehicles at Leh for Hanle.

The 2m telescope consignment was dispatched from the USA to India by Cargo Ship and further by road to Air Force Chandigarh. Prof. R. C. Kapoor organized this part of transportation. From Chandigarh, the telescope consignment was airlifted to Leh by IL76 on two trips during the first week of August 2000.

The Air Force 21 Wing at Leh and the Indian Army 14 Corp. helped IIA to handle and download the big bulky and over-sized boxes of telescope and accessories. All took proper care of the mirror boxes and stored in a safe area of the airfield for some time.

The transportation of this load to Hanle was planned by the Indian Army and Border Road Organization (BRO, BRTF-GREF wing) with their high altitude rugged lorries. When we had requested the agency, Army Supply Core (ASC) did not even give a second thought and immediately chopped their lorries' upper bodies and made the flatbed for easy loading and unloading of the material boxes. For mirror transportation, BRTF-GREF gave a perfect high-performance vehicle with an excellent suspension to move on jerks and bumps in the sandy path along the Leh-Hanle route.

IIA worked on the feasibility of road width and bridge capacity along the Leh-Hanle route to move lorries with over-sized boxes since the beginning of the project. We surveyed this 260 km road between Leh and Hanle many times and conveyed it to the road agency, BRO HQ Project HIMANK, in Leh. BRO helped us a lot and improved many bottle-necks and other points along this road and strengthened the bridges coming on the way.

At Leh airfield, once we got the complete consignment on August 1-2, we loaded these on the lorries, specially re-fabricated by Army ASC Core for our purpose. The mirror boxes were loaded onto the BRTF special vehicle and tied the loads with MS fixtures for safety. When we had received the 2m consignment at Leh, we were unable to move due to intermittent rain and road closure. We were allowed to park all loaded vehicles inside the air-field in the Air Force area.

After the road opened, we did a complete recce of the road carefully between Leh and Hanle, keeping in mind the present load we intended to transport now. We requested the Army and BRTF to provide recovery and workforce at points of concern along the road, and they did it successfully. The convoy of vehicles (approximately 9-10 Army trucks + BRFT Vehicle with the mirror boxes + other transport team) started

from Leh on 17th August, with an IIA pilot vehicle. At the end of the first day, all vehicles continued up to a place named Kiary (140 KM from Leh). At Kiary, we parked all vehicles in Brigade HQ of the Indian Army. The Army provided lodging/boarding and other logistics for that night to all crew members of this transport team.

On 18th August, this transport team's convoy started in the morning from Kiary to Hanle with care and safety. The last 60 KM patch of the route from Rongo to Hanle top was very rough and deserted without any population. This part had no real road formation, an untarred pathway with sands and stones, making it difficult to drive. The Army

had deputed many recovery vehicles and other logistics at many points along this part of the road, which helped safe and secure transportation of the trucks loaded with telescope consignment boxes. By the evening, all loaded lorries reached the Hanle top successfully. IIA officials accompanied the vehicles for safety purposes. Once it arrived at IAO in the late evening, a jubilant atmosphere and happiness filled everywhere.

(To be continued)

B C Bhatt joined IIA in 1994 and was part of the first team of IIA that did the site-testing and characterization of Hanle, Ladakh in November 1994. He was the Project Officer for setting up the 2 meter HCT at Leh/Hanle. Currently he is a professor at IIA and Scientist-in-Charge CREST campus, Hoskotte.

Dorje Angchuk was the first person from Ladakh to join IAO as a Trainee Engineer during its initial phase. He contributed to the installation and commissioning of the 2 meter HCT, later getting a permanent position there. Presently he is Engineer-in-Charge, IAO.

Man Singh joined as Cook/Caretaker at IIA's transit guest house, and was later posted as Caretaker, IAO, Leh. During this time, he supported the guest houses at Leh and Hanle including office related work. He is currently a UDC at Raman Science Centre, IAO, Leh.

BRO Road Inspection

* Authorship and photo credits : Prof. B. C. Bhatt, IIA, Bangalore, Mr Dorje Angchuk and Mr. Man Singh, IAO, Leh.

Science Is For Everybody

Prajval Shastri is an astrophysicist of over thirty-five years. She got her PhD from the Tata Institute of Fundamental Research, Mumbai and was a faculty at Indian Institute of Astrophysics, Bangalore for 23 years. She specialises in the empirical investigation of giant black holes that are found in the centres of distant galaxies. She is extremely passionate about science outreach, believes that the cultivation of scientific thinking is for everyone and uses astrophysics as a vehicle to engage lay audiences of all ages with these questions. She is also deeply concerned about the gender disparity in the sciences.

Professor Prajval Shastri speaks on her life journey, memories at IIA, research career, her thoughts on gender disparities in science, science popularization etc

Raveena Khan, Fazlu Rahman, Manika Singla & Sandeep Kataria

S: ***IIA is celebrating its 50th anniversary this year, and it is nice to be a part of such a reputed institute with a great legacy. The situation of working from home, in this pandemic crisis, made us all realise how badly we miss IIA. Spending a large portion of your life in this campus, can you please share your memories about IIA?***

I was a PhD student at TIFR, and they had a campus inside IISc Bangalore. I spent several years of my PhD life there. We were a part of the "Bengaluru Astronomy Neighbourhood". My memories of IIA go back to those days. Those days, at TIFR, we had a very small library. So, we used to go to the Raman Research Institute, but I used to often come to the IIA library. Sometimes I would come with the TIFR vehicle for the colloquium. But I would also like to spend more of my time in the IIA library because it would be the first in Bengaluru to get the Monthly Notices. And, you know there were no digital libraries those days. So I would often come in the morning and spend the whole day in the IIA library, which holds very nice memories. I also slimed into the Joint Astronomy Programme courses, in particular, J. C. Bhattacharya's astronomy techniques course, and I got the chance to go to Kavalur for the lab of the course. We did some spectroscopy with the 40-inch telescope, and rode up and down the 90-inch platform - it was being built. That was a superb experience.

Many years later, I joined as a faculty in IIA. My best memories are of Kavalur. I had observed at McDonald Observatory, which is one of the best observatories for optical observation. It is the darkest observatory in the US. That was a fantastic experience. But Kavalur was pretty good too, primarily because of the very committed staff there. They were respectful and not gender-biased. For me, this was a very positive experience, quite a contrast to TIFR. I think it speaks to the kind of training they got from Vainu Bappu and the culture that Vainu Bappu had built. Also in Kavalur, the staff would give their everything for our observations. That was one very strong memory.

The other enjoyable memories are with my students and their friends. In my early years, several of us would gather weekly in the coffee lounge irrespective of our specialisation, and we would have free-flowing astrophysics discussions. That was very nice. We interacted in a lot of other ways too - like we played volleyball together quite regularly, went for a picnic or two etc.

There was a formal journal club also, every week. I did make a lot of friends, some of them are retired now, some of them are still there. I had 3 PhD students who graduated from IIA, and they are doing extremely well as faculty in TIFR and PRL. I also had intern students who came for short term projects, and I had a lot of fun with them. Most of them are doing PhDs in astrophysics, which is a very good feeling. They are still in touch and bring back a lot of positive memories.

I must mention the International Year of Astronomy 2009. I was in the core-team which was excellent, and worked extremely well together. We planned early, built partnerships with amateur astronomers, science activists, theatre people and teachers, a lot of people from IIA contributed, and what we achieved in terms of number and reach of the activities was unprecedented and went far beyond our expectations - that was a fabulous experience and a strong memory.

I also initiated the idea of the IIA-PennState International Astrostatistics Schools. I invited Jogesh Babu from PennState University to visit IIA and give a lecture series, and then with my IIA colleague Sabyasachi Chatterjee, we together planned this series of schools, modelled after the similar PennState series - there were a total of four. Participants ranged from PhD students to faculty and the resource persons were drawn mostly from the Indian statistical community. The series was extremely successful, received positive feedback from both the student and faculty participants, with, in fact, demands for more schools. The statisticians enjoyed the interdisciplinary work and the stay in beautiful Kavalur. This was an extremely rewarding experience, both the process itself and the lasting impact it had.

F: ***You have done very interesting research on supermassive black holes and AGN systems. Can you tell us about your major findings and how the field is currently progressing, given the developments in observational astronomy?***

Research in physics on giant black holes in distant galaxies is a fascinating field. And happily, for me, it has continuously been an exciting one. It had been about 15 years since people had connected the unexplainably powerful radiation from some distant suspected galaxies with black holes. Meanwhile, my supervisor Vijay Kapahi and his collaborators had just published empirical evidence supporting the predictions of the idea of Martin Rees, Roger Blandford and others that all the powerful jets of plasma launched from accreting black

"With Govind Swarup, who was my de jure supervisor, and de facto supervisor's supervisor, on the lawns of TIFR-NCRA in 2018, celebrating Govind's 90th birthday. He had begun to enjoy showing me how using my Wikipedia page, I could trace my lineage, via him, back to Isaac Newton. Seen here with all my current and former PhD students. L to R : Dharam Vir Lal, M N Sundar, Govind Swarup, PS, Preeti Kharb, Veeresh Singh, i.e., four more people further down in that same lineage" - PS

holes had bulk relativistic speeds. This was an exciting topic, and my thesis landed up being that. Relativistic beaming in Active Galactic Nuclei was the title of my thesis. I found more evidence consistent with the jets being relativistic, especially for the predicted subclass of giant black holes. And then, going further the work I did with my students was about showing that inclination of the accreting giant black hole to the line of sight was a dominant predictor of what we see in these systems, including the structures of the parsec-scale plasma jets, the evidence for coherent magnetic fields, the spectra of the x-ray emission etc.

In the early days, we were like pathologists, doing research on some special galaxies which did weird things. Over the past 15 years, however, accreting supermassive black holes have come to the centre-stage of galaxy evolution. This means that the galaxy evolution physicists and the giant black hole physicists go to the same conferences too, which never happened in the earlier time. That is really fabulous. My recent work has also been in this area of feedback between the accreting giant black hole system, its near environment and star formation in the galaxy.

"I think science is for everyone. Scientific thinking should be a way of life for everyone, whether they are doing science or theatre or art or whatever. I think if they understand the scientific method, they will be better artists. The scientific method is the best method if we have to understand nature."

It is exhilarating that the 2020 Nobel Prize is awarded for black hole physics. Two of the winners, Reinhard Genzel and Andrea Ghez, did a fantastic job looking at the motion of the stars in the centre of the Milky Way and using Keplerian physics, they obtained the mass of the central dark object. From the closest orbits, they could get an upper limit on its size and therefore, infer that it is a supermassive black hole. Unlike the circumstantial evidence from active galaxies and relativistic jets etc., this is direct evidence for a massive black hole in the centre of a galaxy.

R: ***Based in Bangalore, you are very active in outreach and science popularization activities. It would be nice if you can tell us some of your outreach experiences.***

I started my outreach activities as a young faculty, and it was very mundane in the beginning - mostly giving lectures to college students. As a TIFR student, I used to do a little bit of outreach. In the Ooty observatory, we used to get a lot of visitors on Saturday, and it was our responsibility to take them around and show them the telescope and answer questions, both adults and children. We had no training for that. Then as a post-doc in Austin, I saw a rich outreach program both at the university and at the observatory. It was when I got involved with the People Science Movement that things changed for me, and it played out in IYA2009.

Firstly, it was about acknowledging that outreach is not about us smart people describing this "very very difficult" thing called astrophysics to the so-called "ordinary" people. Outreach is a two-way street. When fielding questions from children and adults about not just what we know, but how we know what we know, what is the process of discovery, and how did we come to this conclusion etc., the process deepens our own understanding even though we consider ourselves as experts. That was a big shift for me, and that has driven my outreach work.

I do outreach because I think science is for everyone. Scientific thinking should be a way of life for everyone, whether they are doing science or theatre or art or whatever. I think if they understand the scientific method, they will be better artists. The scientific method is the best method if we have to understand nature. It is not perfect, but it is self-correcting, and as scientists, we have a responsibility to ensure that it indeed corrects itself. As citizens, we all need to understand the scientific method. It may be that a few scientists actually do specialized research in the laboratory. But in terms of understanding what science is and what the scientific methods are, science should be for everybody. This is written in the constitution too!

"All of us are raised to find sexist actions as acceptable. We need to get trained to overcome that. The primary thing we need to do is to get away from this thing of 'fixing the women'. There is nothing wrong with the women. We need to address the barriers within the institutions."

M: ***Apart from science, you have been actively involved in various social platforms like that of gender discourses and women issues. What inspired/ motivated you to become a socially-committed scientist?***

It wasn't exactly an inspiration as such. I think it's really because of my parents. My father was a medical doctor, and my mother studied economics. But both of them were science buffs. They were active communists too, and they brought that political understanding of the world to everything that they did, including parenting. They bought a lot of fantastic children's books on science and maths for me. I was really floored when I read about the gold-foil experiment when I was 8 or 9 years old, and I wanted to be a scientist right then. We used to regularly lie on a mat in our garden, watching the stars and the Milky Way. They also situated all of that for me in a larger context. For example, the atomic bomb, the cold war and the peace movement - all of these were everyday topics for me and my parents, and also some of their friends who hung out with us. This really helped me to have a broader understanding of various topics. The idea that science is for everyone is something I was brought up with! That is what makes me believe that even if you are a dancer, you need to understand science because it will make you a better dancer just like I, as a scientist, need to understand dance, and it will make me a better scientist.

It is true that this sort of bringing up is opposite to what institutions do where they discourage you from thinking about anything beyond your narrow work. Also, there is this concept that institutions make you believe - that you are here doing physics because you are brilliant. I think both these things are problematic.

S: ***In many societies, the intellectual vigour of women is always questioned. This is well reflected in the counts of women scholars in subjects like physics and mathematics. Awareness against this wrong notion is the first step in all gender gap discourses. You are a living example for women to have intellectual pursuits of higher order. According to you, how can we get rid of this misconception in society?***

That is a very big question. One aspect is what you said - that I am an example. That is because of my privileged bringing up. There were, of course, my parents. I was born the year after Sputnik was launched. It was an era when there was a lot of excitement about science in the air, in the public discourse. There was an optimism that science would lead humanity to abundance and prosperity. I should say that even in my school, which was an ordinary Kannada medium school in my town, all teachers stressed on understanding the concept, with less emphasis on rote learning. We really played around experimenting in the labs, and my college teachers were also motivating. But most important, in college, there was no hierarchy between "theory" and "experiment", and I am very grateful to my college for that. I actually appreciated it when I found the opposite climate in IIT and TIFR, where I did my higher studies. I am saying all this because I think there is a connection with the gender inequity question.

Participating in 'India March for Science Bengaluru' in 2017. Sadiq Rangwala is also seen.

The question about why there is such a skewed distribution of men and women in science was there somewhere at the back of my mind when I was growing up. When I was 11 years old, my mother had given me Marie Curie's biography, written by her daughter Ève Curie, to read. I read a lot of science fiction, and one book called Andromeda by Ivan Yefremov, which is about space exploration , had a lot of women scientists as well as men scientists in it. The story has an ambience of very open and healthy relationships between men and women. That influenced me hugely. I somehow naively expected that in science and higher education, it would be like that. I went to a girls' college in my town. But the teachers in physics and maths were of mixed gender with no disparity. One physics professor and one maths professor were Roman Catholic nuns. Hence, it was not in my mind that gender inequity was such a problem in science. But when I went to IIT, it really hit me, and more so in TIFR. I think I survived because of the cultural capital that I came with. Many of the experiences were not nice. People saw us first as women, and then they saw us as short, tall, fat, what we wore, etc., but they mostly did not see us as physicists. Patriarchy and misogyny were very deep, but we didn't know these words even. Some of us didn't survive; some of us survived because of our privileged background.

"Then there was the book "Lilavati's daughters'' commissioned by the Indian Academy of Sciences where they got around 100 women scientists to write their autobiographical stories. It was quite an achievement due to the fact that a science academy commissioned it because a major challenge to mitigate gender inequity is that within the scientific community, there is little acknowledgement that there is a problem."

When it comes to what we should do about it, fundamentally, the barriers are within the institutions. Scientific institutions claim to be meritocracies. But in reality, that is not the case. This has to be addressed. People often talk about attracting girls to science. However, the statistics don't at all suggest that girls are not interested in science. You can look at the papers we published as part of the International Union of Pure and Applied Physics conferences. There are more girls who actually get fellowships like INSPIRE, IAS etc. On the other hand, it was very common for people to tell us that you got a good grade because we looked good or wore such-and-such clothes. These things happen even today. Girls are also being told, "you will get married after PhD - how you will balance work with family". Those things are not said to a man. All of us are raised to find sexist actions as acceptable. We need to get trained to overcome that. The primary thing we need to do is to get away from this thing of 'fixing the women'. There is nothing wrong with the women. We need to address the barriers within the institutions.

R: ***Discrimination at work is a significant problem faced by women who came out fighting the patriarchal notions of any society. We are very eager to know your experiences at the workplace in the early days of your career. Did you feel discouraged at times?***

Yes, there were a lot of discouraging experiences, both personally for myself and friends around me. We were often seen as women first, rather than as individuals who are excited about physics. People would say stuff like, "Oh! How can she go to the observatory? How can she stay up all night? What does she do when she gets her periods? She got a good grade because she is a girl". So it was not a level playing field at all. There is evidence that this is a global phenomenon, and everywhere young women leave the field because of their negative experiences. But some of us survived. I think we stayed primarily because of the privilege and the cultural capital we came with, which enabled us to somehow plough through.

In the student newsletter of IISER Pune called KALPA, there was a particular issue with an article called "Misogyny Inc." It speaks of students' experiences in the hostel and so on. The experiences were really terrible. However, it is really heartening to see that there were younger male students who actually questioned the toxic behaviour and also the unthinking behaviour that arises in group settings. That was actually quite positive and hopeful. So it is essential to look at how people react to women. For example, in faculty meetings, it is very unconscious, subtle and very common that a man saying something animated is considered very dynamic, but a woman saying something animated will be asked to calm down or be considered as difficult to get along with.

All these things are tiny, taken just by themselves, but they can become big things. So they need to be curtailed. I think the good thing is that at least there is some dialogue now. When I was a student, these things never came up. If we had a negative experience, the whole ambience was that it is your personal problem. You may share it with some of your friends outside, but not at the workplace. That trend has changed, which is good. But the important thing is, unless there is deliberate and concrete action, things will not change. And the way forward is not to fix the women, saying women need skill-development, confidence-building or even karate classes.

F: ***What are the kind of activities going on in India to address gender issues? How has the response of Indian science communities, mainly the physics community, evolved over the***

past three decades towards these movements?

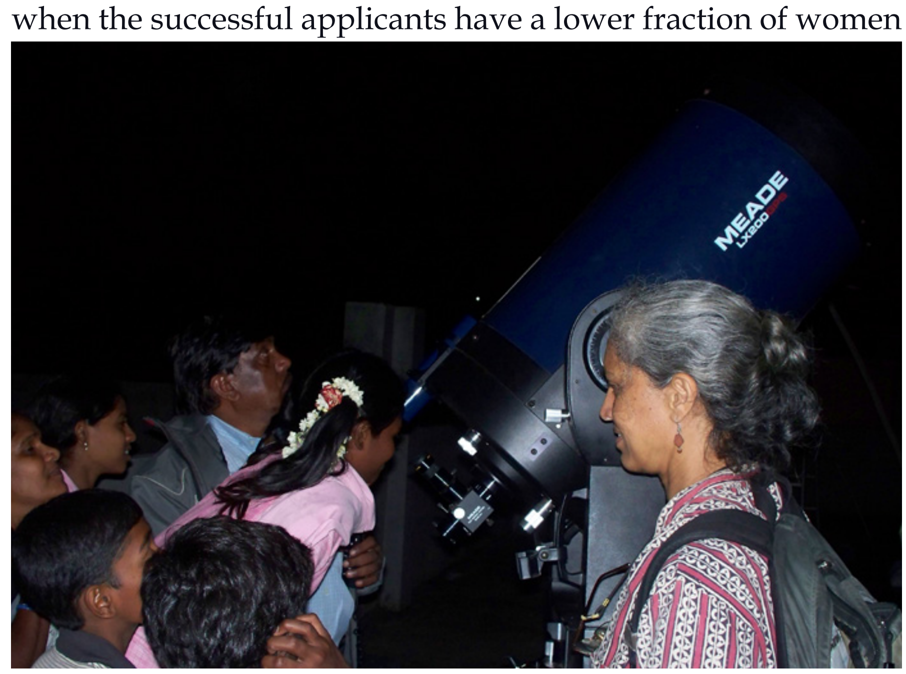
To start with, I would say the efforts have all come from outside the science community. There have been work by e.g., sociologists, on "gender inequity in sciences" as part of their scholarship. But the problem is that within the community, especially in India, we are so insulated that we stop studying sociology, history etc. right at the college level and therefore, as scientists, we have no clue about these studies. For example, there was a sociologist Neelam Kumar who published a study in 2001 of four different Indian science institutes. She compared the productivity of men and women scientists and found that there was no productivity deficit between men and women. But women were lower in the hierarchy. The age of the women was

Talking at The ICSU Gender Gap in Science Project Regional Workshop at National Taiwan Normal University, Taipei, Taiwan in November 2017

also higher at a given level which implies that women have to wait longer to reach a certain position/level. This was in 2001, but I, for example, had no idea about this study until many years later. Scientists have been completely oblivious to such studies.

Also, some efforts have been there from the government, who did recognise that there is a serious gender inequity problem in the field of science. So the government did put in play certain measures, for example, DST instituted the so-called "Career-break Fellowship". Many people have benefitted from it. But they have made it open only to women, which is again patriarchy because you are assuming that it is only women who will take a career break. It may be true that the majority of people who take career breaks for the family are women, but that doesn't mean there are no men who are doing that. Similarly, the policy of child-care leave for government employees is open only to women; men cannot take it. So again, it is a patriarchal approach reinforcing that women have to take the responsibility of child care. In short, the government has recognised the problem, but the measures that they put in are all reinforcing the root cause of patriarchy.

In 2004, the Indian National Academy of Sciences commissioned a report, which clearly says that patriarchy is the source of the problem. But when it comes to actual implementation again, be it DST/UGC programme or gender sensitisation schemes, all are for women, not for men. However, studies indicate that it is not because women are less competent or less productive that they are not advancing, but that there are other barriers within institutions. For example, the Pasadena Charter of the American Astronomical Society says that one very clear signature of bias is when the successful applicants have a lower fraction of women



Moon-watch with children through IIA's telescope taken on-site to the informal school for school-drop outs. Sam from IIA is seen in the background. The children were completely immersed in watching the moon, and the girl with her eyes to the eye-piece declared that she wanted to become a scientist!

than the applicants' pool. For example, in the case of PhD selection, suppose we take the gender ratio of the applicants' pool at face value, then selected candidates should show the same gender ratio. If it doesn't, then that means the selection process is gender-biased. If the fraction matches, that doesn't mean everything is fine, but at least it means necessary conditions are met, even if not the sufficient ones. These are the kind of tools that need to be used by institutions to monitor institutional bias.

Then there was the book "Lilavati's daughters'' commissioned by the Indian Academy of Sciences where they got around 100 women scientists to write their autobiographical stories. It was quite an achievement due to the fact that a science academy commissioned it because a major challenge to mitigate gender inequity is that within the scientific community, there is little acknowledgement that there is a problem. Now for physics, under the Indian Physics Association (IPA), there is a 'gender in physics' working group, and under the Astronomical Society of India (ASI), there is a Working Group for Gender Equity. The ASI group, now headed by Preeti Kharb, one of my PhD students and graduate from IIA, has had sessions at ASI conferences with discussions on gender inequity since around 2013. A lot of good work is done by this team, and they started the "Anna Mani Gender Equity Lecture Series". The main objective here is to bring gender scholars into our fora to talk about gender inequity. So there have been sociologists, philosophers and historians of science, who have spoken on these topics. This is actually a big step to get to know about the kind of work happening in their field related to gender inequity, which scientists tend to be clueless about.

With Prof. Palahalli Vishwanath during an eclipse outreach session at IIA

I proposed the gender equity working group under the IPA, and in the process, we also brought out three science publications which had all women authors. One of them was Physics News, the IPA's bulletin of invited articles, and earlier, the gender ratio of the authors was pathetic. Hence, we decided to bring out an issue with all women authors, not to showcase women or their work, but to convey that women are regular physicists who can competently write physics articles for a range of audiences. I guest-edited that issue of Physics News and also Resonance, which is the Indian Academy of Sciences' publication. And, I didn't find any difficulty whatsoever to find competent women to write these articles. It means that the editorial boards were utterly biased and simply not asking women to write. So there again we emphasised that what we need is not fixing of the women, but we need to remove the bias.

Finally, I want to mention the conference that I organised last year under the IPA called "Pressing for Progress 2019" towards gender equity in physics. It was quite a landmark event as it was a first of its kind in terms of bringing physicists and experts in other disciplines like sociologists, educationists and even theatre artists, onto the same platform. So there were physics presentations, and there were also presentations on gender inequity in physics. 30% of the participants were men, there were several men speakers as well on the issue of inequity, and there were several workshops which were designed as interactive sensitisation workshops. So, the way forward is to admit that it is not just a women's problem, but it is everybody's problem, so everybody needs to take steps to eliminate it.

R: ***We are excited to know about your hobbies and interests.***

I was a voracious reader until I started my PhD. I used to read science fiction, non-fiction, thrillers, romance etc. but all that tapered off once I started my PhD. Now, it takes me forever to finish a book due to lack of time, but I do consider reading as one of my hobbies. I always loved music. I seriously learnt Western Classical piano, Carnatic vocal music for many years and also other styles like Dhrupad. I also love food; I belong to the "Live to Eat" category. But now the distinction between work and hobby has kind of gone and everything, whether it is astrophysics or music, seems like a hobby.

S: ***From your rich experience as an astrophysics researcher, what advice would you like to give to the young researchers in the field?***

I think all of you will agree that astrophysics addresses absolutely fascinating questions, it will always remain exciting, and just the idea that laws of physics that we infer here on Earth seem to apply everywhere right out into the beginning of the Universe is really fascinating! But one danger I would think that PhD students should watch out for is getting too narrow, losing sight of the physics they are studying. There is a tendency in institutions to tag people by the tools that they are using rather than the physics they are investigating. It really annoys me sometimes when people say so-and-so-person is a "radio astronomer" or "theorist". Now the thing is a radio telescope or the theoretical approach or computational simulations, are tools which are being used to study some physics - they are not the subject of study. So it is important to not lose sight of that physics. Of course, it is essential to become a deep expert in your narrow area. However, it is equally important to have an understanding of the broader sub-discipline that you are working in, at least to the extent that you should be able to teach it at the end of your PhD.

All photographs used are provided by PS

With Arvind Paranjpye, during the Transit of Venus preparatory workshop organised at IIA in November 2011

Also, it is a special quality of astrophysics that everything is connected to everything. In fact, one of my former colleagues at IIA, Bhanu Das, would never tire of quoting the physicist, D. ter Haar (supervisor of Prof. Siraj Hasan). D. ter Haar apparently used to say, “Astrophysics is the last bastion of the generalist”. That’s a privilege of astrophysics, and it is something to enjoy. So, for example, in addition to the research seminars which happen, there should be colloquia in astrophysics which are delivered in a manner to make them accessible to all the astrophysicists. When I was a student, if there was a colloquium in the institute, regardless of which area it was in, every person of that institute would be there. So that is something which needs to come back so that students stay wider in their understanding.

Thirdly, I would say that astrophysics is truly an international enterprise. Now more than ever, regardless of what the astrophysical problem is, partnerships and collaborations are key, whether it is because of the need for big complicated experimental facilities or for collaboratively using smaller facilities at different institutes. This also builds a great international community, but to really get the best out of it, I think it needs an open and non-hierarchical way of functioning between scientists, with a collaborative mindset rather than a competitive mindset. So I would say young people will benefit from being mentored in such a positive ambience, and they will also benefit from building it themselves in a non-competitive environment for the future.

\Prajval Shastri

(Raveena Khan is a Junior Research Fellow at IIA. She works in the field of solar spectropolarimetry.
Fazlu Rahman is a Senior Research Fellow at IIA. He works in observational cosmology.
Manika Singla is a Senior Research Fellow at IIA working in the field of exoplanets.
Sandeep Kataria is a Post Doctoral Researcher at IIA working in galactic dynamics)

November 2020

Location: Bangalore , 12.9791°N, 77.5913°E
Date: 15th November 2020
Time: 20:00 IST

Watch out for

November 10 - Mercury at Greatest Western

Elongation. The planet Mercury reaches greatest western elongation of 19.1 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the morning sky. Look for the planet low in the eastern sky just before sunrise.

November 16, 17 - Leonids Meteor Shower.

The Leonids is an average shower, producing up to 15 meteors per hour at its peak. Leonids is produced by dust grains left behind by comet Tempel-Tuttle, which was discovered in 1865. The shower runs annually from November 6-30. It peaks this year on the night of the 16th and morning of the 17th. The crescent moon will set early in the evening leaving dark skies for what should be an excellent show. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Leo, but can appear anywhere in the sky.

November 30 - Penumbral Lunar Eclipse

A penumbral lunar eclipse occurs when the Moon passes through the Earth's partial shadow, or penumbra. During this type of eclipse the Moon will darken slightly but not completely. The eclipse will be visible throughout most of North America, the Pacific Ocean, and northeastern Asia. From India this eclipse is visible from Eastern and northeastern India.

* Everyday, stars will rise 4 minutes earlier than previous day.

Comets Tales From India

R C Kapoor

Observing comets from India

Although the subject of comets has received space in a few old Indian texts, the description remains confined only to their morphology and the ominous implications. Nowhere is there an allusion as to a specific comet or even a hint that some real-time observations were made.

Since 2009, I have explored records of cometary sightings made from the Indian region, since antiquity until 1960; where available data, however minimal, permits identification of the comet. A few comets that have been dealt with in this series and published are, sequentially, the Great Comet of 1831 (C/1831 A1), Comet Bappu–Bok–Newkirk 1949 IV, the bright comet of 1941 (C/1941 B2), the bright comet of 1825 IV (C/1825 N1), Donati's Comet (C/1858 L1), the Great Comet of 1807 (C/1807 R1), the Great Comet of 1811 (C/1811 F1), and the Great September Comet of 1882 (C/1882 R1).

A few discoveries too

The first thing that I discovered in this journey was the fact that Comet Bappu–Bok–Newkirk 1949 IV remains the only one with an Indian's name to it. Then a research student at Harvard, M K Vainu Bappu (1927–82) was destined to set modern astronomy in India on an ambitious path to progress. Is that all? That was my question, but I found the scene less disappointing than it seemed at first. The quest, at best a preliminary, has enabled me to bring forth a number of interesting but hitherto lesser-known or unknown observations of comets from India. These include a handful of discoveries too.

Mughal memoirs mention several astronomical phenomena, namely, fireballs and comets, and the occurrence of a number of solar and lunar eclipses. Abū'l Faḍl and Ārif Qandahārī have narrated their observations of a comet seen in the 22nd year of the reign of the Mughal Emperor Akbar, in 1577. Abū'l Faḍl recorded his observations of the comet in the *Akbarnāmā*, made during an expedition of Akbar from Rajasthan to Punjab. Ārif Qandahārī, in his account in *Tārikh-i Akbar Shāhī,* describes the comet as a bright star in the west. Both the accounts are about the celebrated comet of 1577 (C/1577 V1), that was first sighted in Peru on 2 November at dusk as a very bright object that 'shone through clouds like the Moon (–7 mag)' and which Abū'l Faḍl and Qandahārī are among the first very few to have independently witnessed on 5 November and 6 November 1577 (Julian) respectively, and entered their impressions in their records.

Tycho Brahe's observations of this comet were a milestone in the history of astronomy when he placed it in a supra-lunar position. This challenged the Aristotelian perception that comets were atmospheric phenomena. We find Emperor Jehangir as an independent discoverer of two bright comets in succession: the comet 1618 III (C/1618 V1) on the morning of 10 November and the comet 1618 II (C/1618 W1) on the morning of 26 November, going by the corresponding chronological entries in his memoirs *Tūzuk-i-Jahangīri*.

Scattered among the Madras Observatory correspondence and its publications of the 19th century are observations of some comets, brief but duly reported. Many of these did not receive attention up till now for reasons of lack of access or limited circulation. While sifting through a few scientific communications, I came across observations that can be termed as discoveries only. So, may the due credits be given to – Jeremiah Shakerley as among the earliest observers of and, more likely, being an independent discoverer of the comet C/1652 Y1 from Surat, to Jesuit Fr Jean Richaud as an independent discoverer of the comet C/1689 X1 from Pondicherry, to Ali al Husayani for the discovery of the comet C/1742 C1 probably from Burhanpur and to T G Taylor at Madras Observatory as an independent discoverer of the Great Comet of 1831 on Jan 7.0097 UT, credited to John Herapath alone who discovered it on 1831 Jan 7.25 UT. As I gathered from cometographies, there are also a few independent discoveries made from India – of the comet C/1695 U1 from Surat on 30 October by a French Jesuit Joachim Bouvet, of the comet C/1839 X1 discovered by J G Galle and independently by T G Taylor, and, the Comet 1872 I (X/1872 X1), discovered by Norman Pogson at Madras on 2 December, that was also called Klinkerfues–Pogson Comet by K C Bruhns, who reasoned not to identify it with the lost Biela's Comet.

John Warren's unpublished work

This note is about how John Warren's work on the Great Comets of 1807 and 1811, published only recently, saw the light of the day.

Captain John Warren (Figure 1; 1769–1830) was the acting astronomer at Madras Observatory during the years 1805–1811 when Astronomer John Goldingham went to England on leave. For details of the history of Madras Observatory and development of modern astronomy in India, see Kochhar and Orchiston (2017). Warren had observed the Great Comet that rose in September of 1807 (C/1807 R1) and computed its orbit. He summed up his observations in a paper titled —*An account of the comet, which appeared in the months of September, October and November 1807* and sent it to England. The addressee is not known. The paper was a hand-written manuscript with four drawings, dated 1 January 1808. It is now in the Royal Astronomical Society Archives, London (RAS MSS Madras 6). The paper (Warren 1808) remained unpublished.

Figure 1. J Warren, Acting Astronomer, Madras Observatory 1805-1811 (IIA Archives)

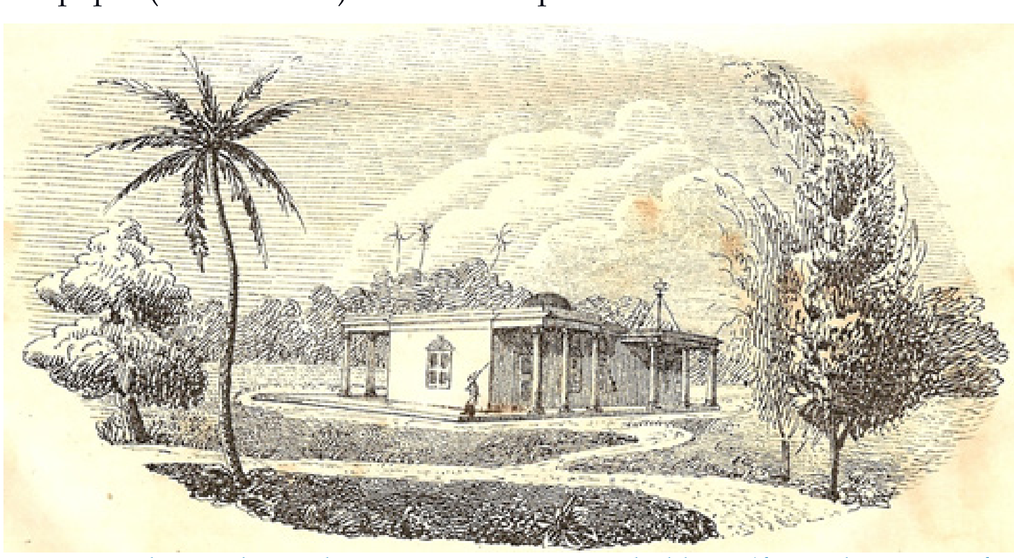


Figure 2. The Madras Observatory at Numgambakkam (from the cover of the volume IV of Taylor (1838; IIA Archives).

I came to know of it in 2009 from a paper on Madras Observatory by Ananthasubramaniam (1991), when I had begun to collect information on comet observations made from India. I followed up and traced the paper to the Royal Astronomical Society Archives. On request, the RAS kindly sent me the *jpeg* images of the original manuscript (Figure 3a). I initially wrote a paper on the Great Comet of 1807 with John Warren's manuscript as the prime source. I showed it to Prof R K Kochhar for his comments. He suggested that Warren's paper itself should be brought to light and that my own notes can follow it. I then approached the Royal Astronomical Society for permission to have it published in a suitable journal. The RAS readily agreed and gave me formal permission. Much help in this regard came from Dr Sian Prosser, librarian and archivist, RAS. I transcribed the text from the 21 *jpeg* images of the original manuscript. Dr

Prosser went through the transcription and provided some of the lines missed in the *jpeg* images. When approached, Prof Wayne Orchiston, Editor, *Journal of Astronomical History and Heritage* expressed keen interest to publish it. He too went through the transcribed text carefully. The paper has now been published under John Warren's authorship, with Madras Observatory, Madras as the affiliation (Figure 3b) in the *Journal of Astronomical History and Heritage*, vide Warren (1808/2019).

The first decade of the 19th century witnessed the most crucial development in the art of orbit computations, spurred on by the discovery of four minor planets between 1 January 1801 and 29 March 1807. The whole exercise of orbit determination used to be arduous. One would divide the orbit into degrees, and for each degree, the computations were performed. The task was daunting. Then in 1801, Carl Gauss (1777–1855) presented a simple and quicker method of computing an elliptical orbit by using observations derived from an arc in the sky (Gauss, 1809). This approach soon led to the recovery of a lost Ceres. As for the Great Comet of 1807, a number of astronomers, including Friedrich Bessel (1784–1846), worked out their methods and calculated parabolic orbits based on observations made in October 1807 and incorporating the effects of perturbations. These led to different dates for the perihelion passage. Notably, Warren (1808) had determined the orbit of the comet using spherical trigonometry and Kepler's laws. The orbital elements are quite close to Bessel's 1810 values, the latter determined from a much larger set of observations and including the effects of perturbations. Warren's values differed slightly in the time of the perihelion passage and in the eccentricity value (*e*) as he regarded the orbit as a parabola. His paper is worth a read by anyone interested in the history of the art of computing the orbits of celestial bodies.

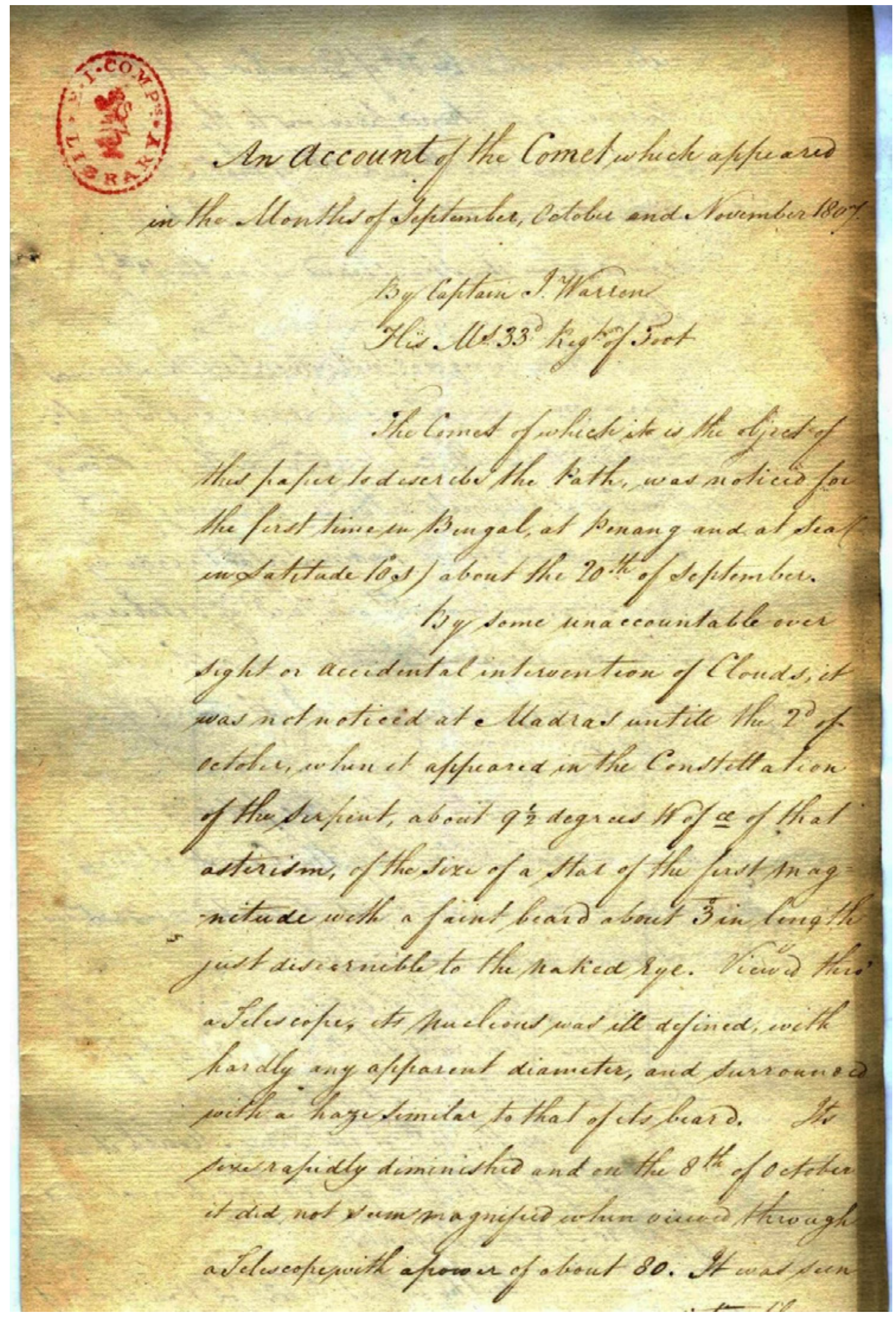


Figure 3a. The first page of John Warren's paper (RAS MSS Madras 6; Courtesy RAS Archives, London).

Journal of Astronomical History and Heritage, 22(1), 132–136 (2019).

AN ACCOUNT OF THE COMET, WHICH APPEARED IN THE MONTHS OF SEPTEMBER, OCTOBER AND NOVEMBER 1807*

Captain John Warren
Acting Astronomer, Madras Observatory, Madras, India.

The Comet of which it is the object of this paper to describe the path, was noticed for the first time in Bengal, at Penang and at Sea (in latitude 10°S) about the 20th of September.

By some unaccountable over sight or accidental intervention of clouds, it was not noticed at Madras untill the 2d of October, when it appeared in the constellation of the Serpent, about 9½ degrees W of α of that asterism, of the size

45": 17" P.M. 14°: 8': 15" of α Coronae Borealis and 7°: 50': 25" NE of α Serpentis.

On the 25th, at 6h: 42': 15" P.M., it was of ζ Herculis 9°: 26': 15" S, and 8°: 47' :45" SW of σ Herculis.

On the 18th of November the Comet was from α Lyrae 4°: 50': 7" SW and from Altair 35°: 1': 15" NW.

* Based on a MS dated 1 January 1808 now in the RAS Archives, London (RAS MSS Madras 6). We are grateful to the Royal Astronomical Society for permission to publish this manuscript and to Dr Sian Prosser (RAS Librarian and Archivist) for his help.

Figure 3b. The top and bottom of the first page of John Warren's published paper.

Subsequently, Warren observed the Great Comet of 1811 (C/1811 F1) and recorded his observations in the *Madras MS Records* for the year 1812. For anyone outside Europe, Warren's Head Assistant Sanevasa Chairy was the first to independently notice in the sky the Great Comet-to-be from Madras Observatory, after rightfully sensing that the faint nebulosity near a star in Monoceros was a comet. He was well versed with the night sky and celestial phenomena, and prescient enough to perceive the observed nebulous form as a comet. We can only guess how the observers responded to the language barrier, but what the assistant reported to his superior did earn him credit in the latter's report.

Prompted, perhaps, by the fate of his 1807 paper, Warren chose not to write a paper about Madras Observatory observations of the comet of 1811. My own notes on the comets of 1807 and 1811 appear in the same issue of the *Journal of Astronomical History and Heritage* (Kapoor 2019a, 2019b) and discuss Warren's observations of the Great Comets and also those made by others from the Indian Subcontinent. It has also turned out that the Comet C/1807 R1 was first sighted on 20 September in Bengal, making this an independent discovery from India. Notably, this one was the first comet observed at the Madras Observatory ever since its inception in 1786.

Acknowledgements

I am grateful to the Royal Astronomical Society (RAS) for making available from the RAS Archives scans of John Warren's unpublished manuscript *MSS Madras 6* and for permission for it to be published. RAS Librarian Dr Sian Prosser and Prof W Orchiston were very helpful in cross-checks with the original John Warren manuscript. I thank the Director, Indian Institute of Astrophysics (IIA) for permission to use John Warren's unpublished accounts of the Great Comets of 1807 and 1811 contained in the Madras MS Records held with the IIA Archives. In my quest for comet observations from India, much help has come from Dr A Vagiswari and Dr Christina Birdie in the search for reference material. Mr B S Mohan, Mr P Prabahar, and the Library Staff have continued to be very helpful.

R C Kapoor was with UPSO (now ARIES) during 1971-74 and with IIA through 1974-2010. He has worked on flare stars, the observational aspects of black holes, white holes and pulsars.

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How To Know If You Are Stuck In The “miRЯor universe”?

Priya Goyal (Part 2)

In the previous article, we figured out a way to know if we are in the real universe or stuck in the mirror universe. Wu’s experiment, which involved radioactive decay of Cobalt atoms (cooled) placed in a magnetic field, came to our rescue. This discovery of weak forces violating parity symmetry was shocking to many theoretical physicists. To get around this shocking revelation, physicists started to think that maybe parity is not real symmetry of the universe, and hence, it is okay for weak forces not to respect it. They envisaged that parity symmetry is a part of larger symmetry, i.e., Charge Parity (CP) symmetry, which means experiments remain identical under the combined charge and parity transformation. So, in the mirror universe version of the Wu’s experiment, if we flip the sign of charged particles, i.e., we swap particles with their antiparticles, the symmetry would be restored, and again, we will end up wondering where we are; in the real universe or the negative-mirror universe!

But fortunately, in 1964, Val Fitch, Jim Cronin, and collaborators observed the CP violation phenomenon for the first time in the study of the decay of neutral kaons, particles formed by a strange quark and a down antiquark. It was found that neutral kaons can transform into their antiparticles (in which each quark is replaced with the other’s antiquark) and vice versa, but such transformation does not occur with exactly the same probability in both directions; this is called *indirect* CP violation. The observed effect was small, one part in a thousand, but was extremely important because it proved that matter and antimatter are intrinsically different. For this discovery, Fitch and Cronin were awarded the Nobel Prize in 1980. Hence, this experiment can also differentiate between our real and the negative-mirror universe. But wait, are we missing something? Yes, there is one more component left in this symmetry package, i.e., the time (T) component. What about the combined CPT symmetry? Is it a real symmetry to be respected by all the fundamental laws of nature, or is there evidence of CPT violation? So far, no instance of CPT symmetry violation has been reported in any kind of experiment. This means a negative-mirror-tenet Universe would be exactly like ours and so far, we do not know any way of differentiating them. This restoration of combined CPT symmetry has an important implication.

In an experiment, if there is Charge-Parity symmetry violation, then the T -symmetry must also be broken in the same experiment; otherwise, there would be no way for the combined three-way symmetry to be maintained while two of the sub symmetries are broken. Breaking of time symmetry sounds very strange. But physicists have conducted experiments that confirm that certain particles break time symmetry. For example, when a pair of quarks are held together by the strong forces, there are sometimes two different possible configurations, as shown in Figure 1. These two possible configurations can

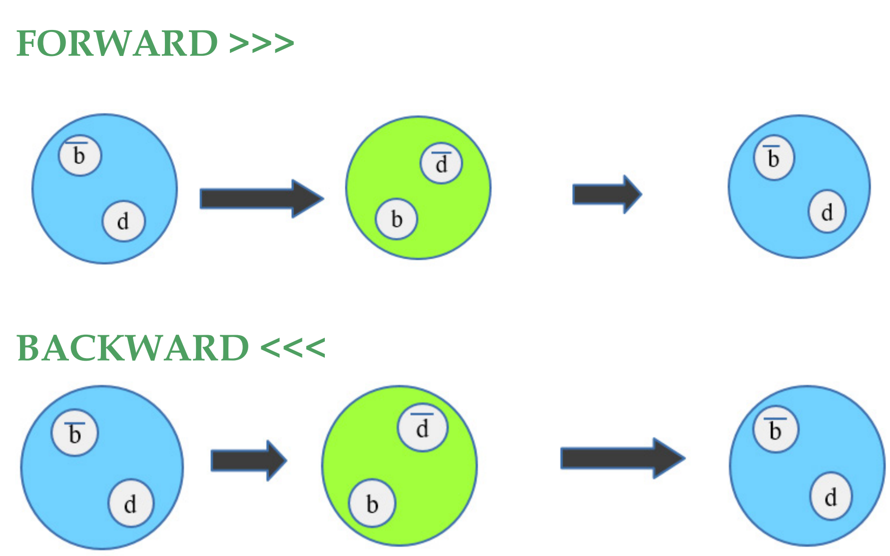


Figure 1: Pair of quarks switching from one configuration to another via weak forces. The idea of time symmetry violation here is demonstrated via this process when ran backward in time. The length of arrows here represents the time taken for going from one arrangement to another.

switch back and forth into one another via the weak forces. But switching in one direction takes a little longer than switching in another. So, if we could record this event and play it forward and backward, it would look different. This is exactly what it means to break the Time (T) symmetry. Therefore, certain fundamental particles can tell the difference between going forwards and backward in time. Symmetries that were thought to be fundamental in nature or laws of physics, each of them over time, were demonstrably violated. However, combined CPT symmetry remains to be preserved in all known experiments, by all known particles; hence it's impossible to differentiate a negative-mirror-tenet universe from ours, until nature offers us CPT violation.

For further discussions, please write to priya.goyal@iiap.res.in

(Priya Goyal is a Senior Research Fellow at IIA, and she works on large scale structures and effects of Gravitational lensing on CMBR)

The Flow . . .

Akanksha Kapahtia

The stone took pride in its immovable spite,
its strength could halt the river in fright;
The river flowed by in effortless delight,
Moulding the stone with its benevolent might!

The leaves would flaunt their solemn silence,
oblivious of the winds in majestic environs;
The winds blew by in tranquil persistence,
enthusing the leaves with a childlike exuberance!

The sky would adorn its unaltered expanse,
the sun it thought was a mite in trance;
The sun moved by in a graceful dance,
painting the sky like an artist in romance!

The naive found joy in ephemeral triumphs,
ignorant of time and its perpetual defiance;
The time passes by like an angel so pious,
Anchoring the naive to its eternal reliance!

(Akanksha Kapahtia is a Post-Doctoral Researcher at the Indian Institute Of Astrophysics)

Image is provided by the Author

Tidal Disruption Of Stars By Supermassive Black Holes & Its Implications

A Mangalam

Supermassive black holes found at the center of massive galaxies govern the dynamics of orbiting stars within the radius of dominance of its gravitational potential. The stars are disrupted when the black hole's tidal gravity exceeds the star's self-gravity, and this phenomenon is called a tidal disruption event (TDE). The stars in a galaxy are captured about a few times in a million years. This can be estimated from the stellar flux at the point of closest approach, $\dot{N} \simeq n r^2 v \pi \theta_{LC}$, where n is the stellar density and θ_{LC} is the loss cone angle in phase space; sophisticated treatments involve solving the Fokker plank equation. The disrupted debris follows a Keplerian orbit and returns with a mass fallback rate that decreases with time, as $\propto t^{-5/3}$. This can be argued as follows [4]

$$\dot{M}_{\bullet} = \frac{dM}{dT} = \frac{dM}{d\Delta\epsilon}\frac{d\Delta\epsilon}{dr_a}\frac{dr_a}{dT} = \frac{1}{3}(2\pi G M_h)^{\frac{2}{3}}\frac{dM}{d\Delta\epsilon}T^{-\frac{5}{3}} \propto t^{-5/3},$$

where, T is the Keplerian period of the star,
r_a is the apocenter and
$\epsilon = -GM_{\bullet}/r_T$ is the mechanical energy, where r_T is the tidal radius.

The infalling debris interacts with the outflowing debris resulting in the circularization and the formation of an accretion disk, which emits in various spectral bands from X-ray, optical to IR wavelengths (sometimes jets are seen in the radio). The transient nature of TDE luminosity makes it an ideal laboratory to study the physics of an evolving accretion disk that includes the gas dynamics of the inflow, outflow, and the radiation.

We have calculated the rate of disruption and its statistics previously (Mageshwaran & Mangalam 2015[1]). Here the focus is on the observational appearance of a given stellar disruption and inferring the black hole mass, star mass, and the point of closest approach of the star's orbit. The tidal disruption events are crucial and useful phenomena to detect and predict the mass of supermassive black holes in quiescent galaxies [2]. Our time-dependent models provide insights into disk evolution in a black hole potential with viscosity by gas or radiation. These models applied to observations result in expanding our understanding of the physics, besides building valuable statistics of the black hole mass and stellar mass. This model is applicable after the star is tidally disrupted and an accretion disk is formed.

We developed a detailed semi-analytic model of the dynamics of accretion and winds in TDEs; this work recently reported in New Astronomy (2020), discusses various theoretical aspects of both gas dynamical and photon mediated viscosity and pressure. The super-Eddington (when the radiative force exceeds gravity) disk results in an outflowing wind in a self-consistent model while balancing momentum and energy. The outflow rate decreases with time and the transient nature of TDEs implies the evolution of an accretion disk through multiple phases that include the sub-Eddington phase dominated by a viscosity based on gas or total (sum of gas and radiation) pressures (called the α viscosity where the coefficient of dynamical viscosity is given by $\eta_\alpha = \alpha \rho c_s^2/\Omega$ where c_s is the sound speed and Ω is the Keplerian frequency [4]), and a super-Eddington phase dominated by a radiative viscosity (where the dynamical viscosity can be shown to be

$\eta_\gamma = \frac{1}{3}\frac{\varepsilon_\gamma}{n_e \sigma_T}$, where ε_γ is the energy density of radiation, n_e is the electron density and σ_T is the Thomson cross-section; [4]). A super-Eddington disk with outflows and dominated by radiative viscosity evolves to a sub-Eddington disk with gas viscosity and total pressure. This disk then evolves to a sub-Eddington disk dominated by gas dominated pressure and viscosity [see Fig 1]. The various evolutionary phases are thermally stable and governed by a time-dependent and self-similar accretion model.

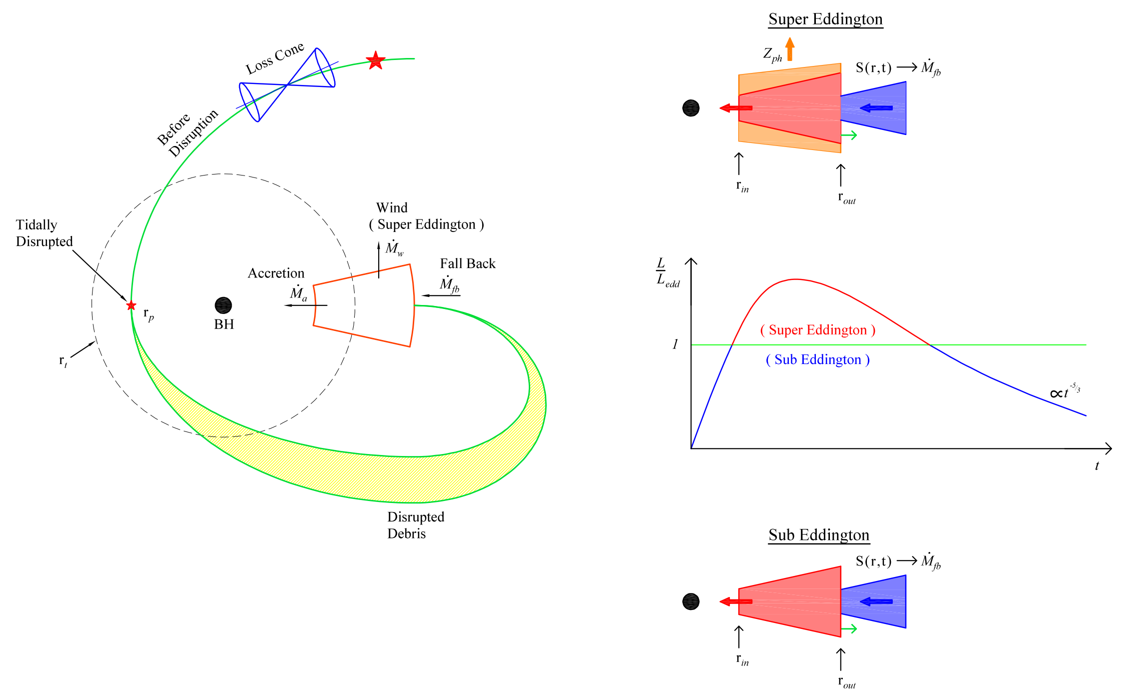


Figure 1: Left: The star with an orbit in the loss cone in phase space, which takes it inside the tidal sphere of radius, r_t, is tidally disrupted near the pericenter, r_p, and its debris forms a seed disk that evolves by accretion, wind, and mass fallback. A schematic structure of accretion disk showing the accretion rate, $\dot{M}_a$, mass fallback rate $\dot{M}_{fb}$, and mass outflow rate, $\dot{M}_w$. Right: The top figure represents the disk structure for the super-Eddington and at the bottom, the sub-Eddington phases.The blue, red, and orange shaded regions show the mass fallback of debris, the disk structure, and the wind structure respectively. The r_{in} and r_{out} are the inner and outer radii of the disk and z_{ph} is the photospheric height from where the wind is launched. The right arrow at r_{out} implies an evolving outer radius. In the middle plot, the light curve evolves through both sub and super Eddington phases.

The infalling debris forms a seed accretion disk that evolves due to mass loss by accretion onto the black hole and wind but gains mass by fallback of the debris. The mass added to the disk is transported inward due to viscous stresses, impacting the disk evolution and its luminosity that declines faster with fallback. The model is reasonably successful in producing fits to the multi-wavelength TDE observations, and physical parameters such as black hole mass and spin, and star mass are extracted [as shown in the Figure 2].

The highlight of the model is the inclusion of all the essential elements: accretion, fallback, and the wind, self-consistently, in a self-similar formulation that is numerically fast to execute and shows good fits to the observations compared to the earlier steady structure accretion models.

These accretion models help us understand the TDE accretion dynamics and provide an insight into TDE evolution through its various accretion phases with novel inclusion of photon viscosity. These semi-analytic accretion models will be useful to predict light curves quickly and plan multi- wavelength observations to catch them in the crucial early phase and also for comparing future

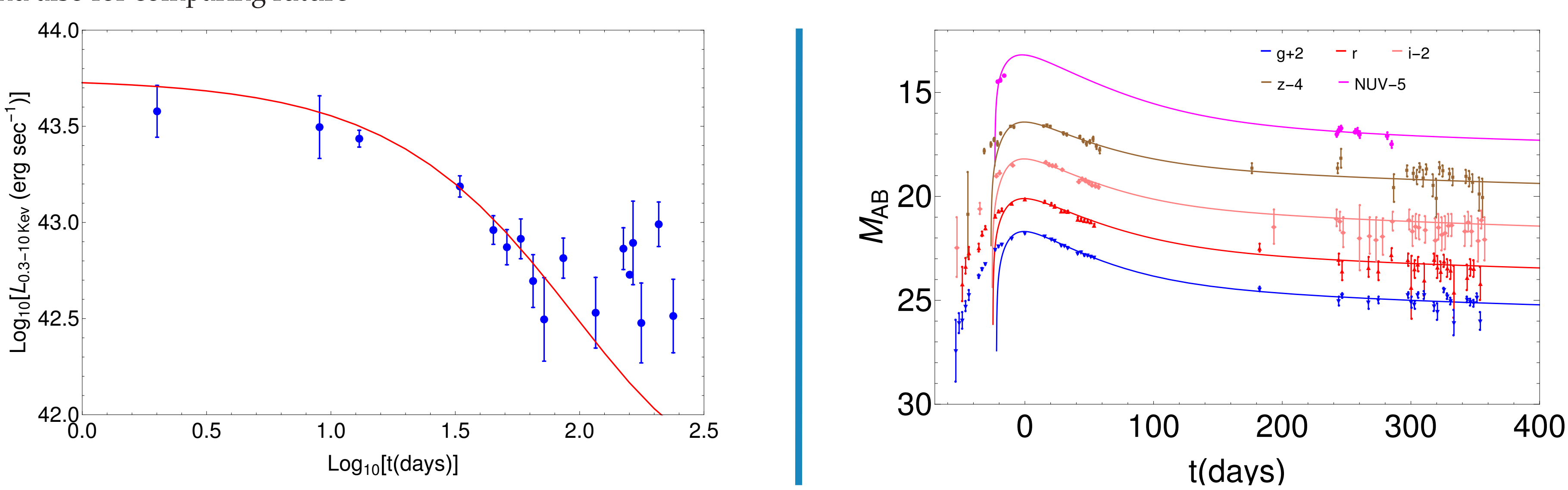


Figure 2: The super-Eddington model fit to the observations. (Left) The X-ray observation of XMMSL1J061927.1-655311 (Saxton et al. 2014) with obtained black hole mass is 8 × 10⁶ $M_\odot$ and star mass is 8.3 $M_\odot$. (Right) The PS1-10jh observation (Gezari et al. 2012) with obtained black hole mass is 6.8×10⁶ $M_\odot$ and star mass is 1.1 $M_\odot$, where $M_\odot$ is the solar mass.

detailed simulational studies. The fits to the observations yield parameters of the star and the black hole that are useful for the statistical studies and to build the demographics of black holes. The ongoing (ASAS-SN, iPTF, MAXI, the Indian mission ASTROSAT-SSM, OGLE, Pan-STARRS, eROSITA) and upcoming (LSST, ILMT) missions are crucial for detecting a large sample of TDEs, which will provide data for probing black hole distributions in mass and redshift space through the model fits and in general a precious resource for black hole studies.

The early phase of detection here signifies the disk evolution at initial times when the luminosity is in the rising phase, which then declines at later times. Black hole demographics is the population distribution of mass and spin of black holes in the Universe that is represented by the black hole mass function, which is the number of black holes per unit co-moving volume per unit log black hole mass. Black hole demographics is useful to study the cosmic evolution of black hole mass and spin (Bhattacharyya & Mangalam 2020[3]). Our time-dependent model simulates the luminosity, which along with the capture rate of stars for tidal disruption, black hole mass function, and the instrument details from the survey missions, can provide the detection rate of TDEs for the given missions. The TDE disk dynamics depends on the physical parameters such as black hole mass and spin, and stellar mass. The TDEs are observed in multi-wavelengths, and our model fit to the observations will provide estimates of the physical parameters. By comparing the expected detection rate with the detection rate from observations, we can extract the black hole mass function and thus the black hole demographics. Future directions include studying black hole demographics, predicting the rate of EMRIs, and building a theory for the disruption of compact stars. The calculations involving both symbolic and numeric operations were performed using the HPC facility of IIA. This work was supported by the SERB grant CRG/2018/003415.

(Arun Mangalam is currently a professor and the chair of the theory group at the Indian Institute of Astrophysics, Bangalore. Arun does research in theoretical astrophysics: gravitational dynamics, relativistic astrophysics, gas dynamics and magnetic fields. His interests include relativistic, high energy, stellar dynamical and hydromagnetic processes concerning black hole systems, galaxies, cosmology and solar plasma.)

Reference:

Dynamics of accretion and winds in tidal disruption events, 2021, New Astronomy, Volume 83, 101491

Useful resources:

1. Stellar capture rate of black holes

Stellar and gas dynamical model for TDEs in a quiescent galaxy, Mageshwaran & Mangalam, *2020, ApJ, 814, 141*

2. Popular articles on TDEs

- TDEs on Wiki
- Black holes caught in the act of Swallowing stars, Clery, D., 2020, Science Mag
- Supermassive Black Hole Belches X-Rays from Shredded Star, Choi, C. Q., 2016, Scientific American
- Scientists watch a black hole shredding a star, Ohio State University, 2019, Eureka Alert
- Black Hole Binges on Record-Setting Stellar Meal, Wall, M. 2017, Scientific American

3. Black hole evolution

- Cosmic Spin and Mass Evolution of Black Holes and Its Impact, Bhattacharyya & Mangalam, 2020, ApJ, 895, 130
- IIA scientists model to redraw co-evolution of the black hole and galaxy and stellar capture scenarios, 2020, DST news

4. Solve it as an exercise! You can check the solution with me.

December 2020

Location: Bangalore , 12.9791°N, 77.5913°E
Date: 15th December 2020
Time: 20:00 IST

Watch out for

December 13, 14 - Geminids Meteor Shower.

The Geminids is the king of the meteor showers. It is considered by many to be the best shower in the heavens, producing up to 120 multicolored meteors per hour at its peak. It is produced by debris left behind by an asteroid known as 3200 Phaethon, which was discovered in 1982. The shower runs annually from December 7-17. It peaks this year on the night of the 13th and morning of the 14th. The nearly new moon will ensure dark skies for what should be an excellent show. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Gemini, but can appear anywhere in the sky.

December 14 - Total Solar Eclipse.

A total solar eclipse occurs when the moon completely blocks the Sun, revealing the Sun's beautiful outer atmosphere known as the corona. The path of totality will only be visible in parts of southern Chile and southern Argentina. This eclipse is not visible from India.

December 21 - Rare Conjunction of Jupiter and Saturn.

A conjunction of Jupiter and Saturn will take place on December 21. This rare conjunction of these two planets is known as a great conjunction. The last great conjunction occurred in the year 2000. The two bright planets will appear only 7 arc minutes of each other in the night sky. They will be so close that they will appear to make a bright double planet. Look to the west just after sunset for this impressive and rare planetary pair.

* Everyday, stars will rise 4 minutes earlier than previous day.


Govind Swarup (Credit: Astronomical Society of India)

Govind Swarup – A Tribute

Kshitij Bane

An internationally renowned astronomer, a pioneer of radio Astronomy research and torch-bearer for building and nurturing scientific capacity in post-independent India, an innovator responsible for creating unique and world-class scientific facilities, a mentor, and an inspiration for generations of young astronomers – Professor Govind Swarup, who passed away on 7th September 2020 in Pune at the age of 91.

It is because of Govind Swarup's vision and achievements that India is one of the leading communities in the field of Radio Astronomy today. He indigenously designed and established powerful and unique observational facilities like the Ooty Radio Telescope (ORT) and the Giant Metrewave Radio Telescope (GMRT), which are among the best in the world.

Born on 23 March 1929, in the small village of Thakurdwara (now in the state of Uttar Pradesh), Prof Swarup completed his MSc degree from Allahabad University in 1950 and joined the newly formed National Physical Laboratory (NPL) in Delhi. There he worked under the eminent physicist K S Krishnan in the field of paramagnetic resonance. With the leftover parts from a radar used in World War II, Swarup set up a device to measure the spin resonance of electrons at microwave frequencies. Impressed by Swarup's work and intrigued by the progress of CSIRO's Division of Radio Physics in studying the Universe at radio wavelengths, Krishnan recommended Swarup to join the Australian group at Pott's Hill, near Sydney. Swarup spent two years there working with Prof Joseph Pawsey building a radio array to study the Sun. Swarup joined the Fort Davis Radio Astronomy station of Harvard observatory in 1956, where he built an apparatus to detect radio bursts from the Sun and discovered Type-U Solar bursts. Then he joined Stanford University, California, to work on his doctoral thesis with the renowned radio astronomer Prof Ron Bracewell. After finishing his thesis on the studies of the Sun using the cross-antenna interferometer, he worked as an Assistant Professor at the Stanford University on a three-year appointment. He was also offered positions at the University of Illinois and the National Radio Astronomy Observatory, USA. But he had a desire to contribute to the scientific endeavours in his home country and decided to return to India.

Swarup, along with three radio astronomers, Prof. Kundu, Krishnan, and Menon, wrote to various Indian institutions about setting up radio observation facilities in India and their importance in strengthening the science and technology infrastructure of the country. The visionary scientist and founding director of the Tata Institute of Fundamental Research (TIFR), Dr Homi Bhabha, understood the importance of this proposal and responded positively. In 1963, Swarup returned to India and became a part of the Radio Astronomy group at TIFR.

With the antennae dishes acquired from Pott's Hill telescope, the TIFR group under the leadership of Swarup established a radio telescope at Kalyan (near Mumbai) in 1965. Later, the group found a hill near Ooty in Tamil Nadu where the slope of the hill matched the local latitude exactly. This led to the birth of the Ooty Radio Telescope (ORT) – a smart design that uses the rotation of the Earth on a natural Equatorial mount to track celestial sources. With a parabolic cylinder antenna and an operational frequency of 327 MHz, which hadn't been well studied before, the Ooty Radio Telescope became operational in 1970. Its objective was to measure the structure of arc-second sized celestial weak radio sources by lunar occultation, which could be used to distinguish between the Steady-state and the Big-bang theories. In the following years, this unique and indigenously developed new radio telescope made numerous path-breaking discoveries and contributed to the studies of the Sun, pulsars, quasars, interplanetary scintillation, and gravitational lenses. The ORT is still operational today and continues to make valuable contributions to our understanding of the Universe.

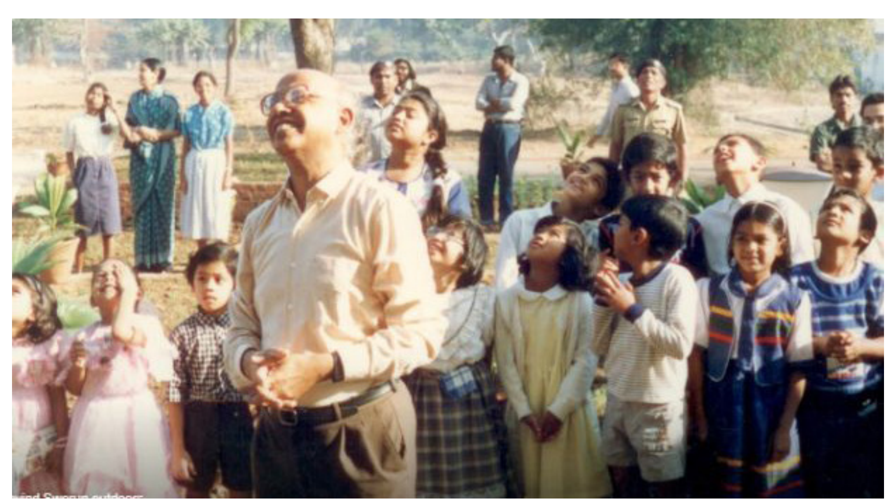
Govind Swarup was not someone to be satisfied with such an achievement. He was ready to take on a new challenge – to build the world's biggest radio telescope at that time! In 1984, Swarup proposed setting up the Giant Metrewave Radio Telescope (GMRT) – an interferometric array consisting of 30 huge parabolic dishes spread across a 25-km area near Pune. He designed a novel low-cost, low-weight, 45-m parabolic dish antenna operating in the frequency range of ~150 MHz – 1430 MHz for GMRT. From the antenna feed to the electronic system to the Servo system, almost everything was indigenously designed and built. GMRT became fully operational in 2000, and it is utilized by astronomers all around the world to study nearly all types of radio sources. The upgraded GMRT (uGMRT) was inaugurated in 2019 on Prof Swarup's 90th birthday and is currently the world's most sensitive radio telescope in this frequency range. For the past two decades, GMRT has been a top astronomical facility responsible for numerous discoveries and is now a pathfinder telescope for the upcoming Square Kilometre Array (SKA).

The ORT and GMRT are testaments to Swarup's vision, passion, and persistence. He was not afraid to take up new challenges and would strive to achieve them despite financial and technical difficulties. His philosophy was to "think big". He always came up with out-of-the-ordinary, novel ideas and found ways to turn

Govind Swarup at one of the GMRT antennas (Credit: TIFR)

them into realities. These massive projects also produced an ingenious and capable bunch of young engineers and scientists. Swarup trained and mentored them over the years and turned them into experts not afraid to think big. Swarup won many national and international awards in his life – the Padma Shri, the Shanti Swarup Bhatnagar award, and the Fellowship of the Royal Society, to name a few. But inspiring generations of young students seem to be his greatest reward.

Apart from his engineering expertise and in-depth knowledge of Astronomy, Swarup was also an advocate of science popularisation and scientific temperament. He put efforts to improve the quality of science education in India and believed in a more practical and research-based education. He started a bunch of summer schools to get science and engineering



Govind Swarup with school children (Credit: TIFR)

students excited about Astronomy. He played vital roles in the establishment of the Indian Institute of Science Education and Research (IISER) and the Joint Astronomy Program (JAP).

I was lucky enough to meet him in person once. This was during the URSI Asia Pacific Radio Science Conference 2019 in Delhi, a couple of days before his 90th birthday, where he gave a talk on the growth of Radio Astronomy in India. Even at that age, he was full of energy and enthusiastic about new ideas, meeting young astronomers, and talking with them. Even after his retirement in 1994, he continued working and doing research. He kept exchanging ideas with his peers and students till his last day.

Prof Govind Swarup may not be with us physically, but his legacy continues through his projects. He will continue to inspire young students and astronomers. He will be remembered for his role in shaping India's science and technology capacity, and for establishing India as one of the world's leading communities in Radio Astronomy. Govind Swarup steered us into the future and the future will always remember this legend.

Govind Swarup – the Father of Indian Radio Astronomy

(23rd March 1929 to 7th September 2020)

(Kshitij Bane is a Junior Research Fellow at the Indian Institute of Astrophysics and currently building a Radio Telescope at Gauribidanur Radio Observatory to study Pulsars)
Email: kshitij.sb@iiap.res.in

Abstract Art by Maya

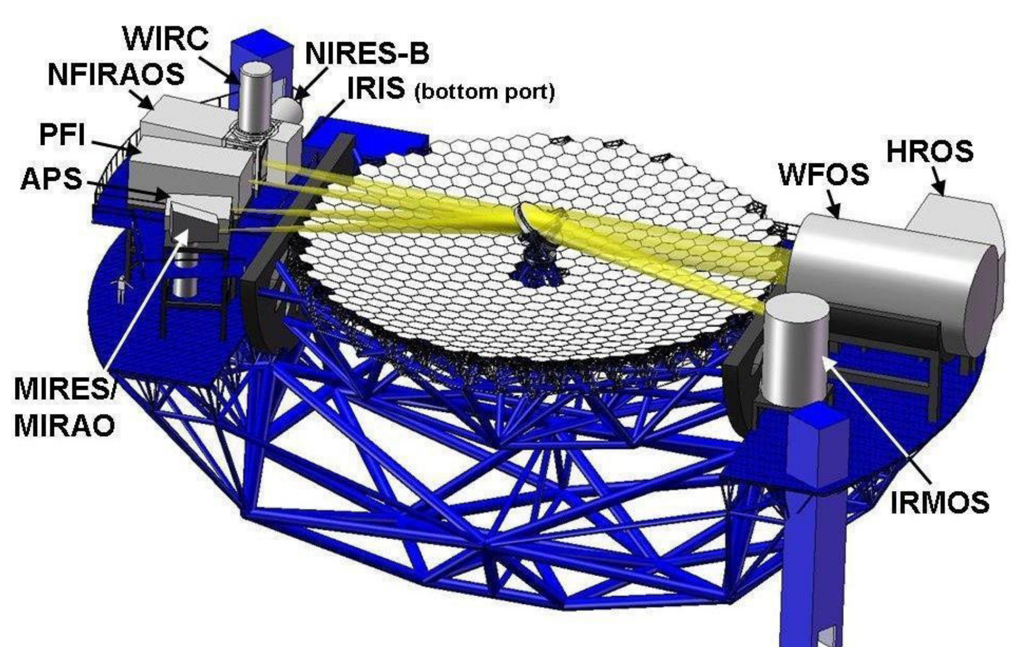
"Mary's room and the outside world"

The knowledge argument (also known as Mary's room or Mary the super-scientist) is a philosophical thought experiment proposed by Frank Jackson in his article "Epiphenomenal Qualia" (1982) and extended in "What Mary Didn't Know" (1986). The experiment is intended to argue against physicalism—the view that the universe, including all that is mental, is entirely physical.

Thirty Meter Telescope & Its First Light Instrument-WFOS

Ramya & Sivarani

The next decade of astronomy will be led by the discoveries from the upcoming large telescopes, such as the Thirty Meter Telescope (TMT). TMT will take images and spectra of the faintest and farthest objects in the Universe and will deliver an unprecedented view of the Universe to humankind. TMT is a Ritchey-Chrétien telescope with a 30 meter primary (M1), which consists of 492 hexagonal mirror segments of size 1.44m. These mirror segments are supported by a segment support assembly (SSA), which will tip, tilt and also warp the mirror segments to compensate for figuring errors and actively controlled during observations to compensate for varying environmental conditions and produce the sharpest images of the sky. The sensitivity of the telescope scales with the area of the primary mirror, for seeing limited observations. However, in the case of diffraction-limited performance of the telescope, the sensitivity scales as the square of the area of the primary mirror. TMT has one of the most advanced multi-conjugate adaptive optics systems (deformable mirrors conjugated at 0km and 11.8km height of the atmosphere) to achieve diffraction-limited performance over a large field of view. TMT is being built as a partnership between Canada, China, Caltech, University of California, Japan and India. The most attractive feature of TMT is the scalable segmented mirror and adaptive optics techniques. The partnership allows a larger in-kind contribution that will enhance training in science and technology beneficial for India. India is a 10% partner in this massive ~2 billion USD project and a significant portion (~70%) will be delivered through in-kind contributions.



Rendering of TMT Telescope Enclosure and suite of science instruments on the Nasmyth platform. NFIRAOS, IRIS, WFOS and MODHIS (not shown in picture) form the first light instruments of TMT.

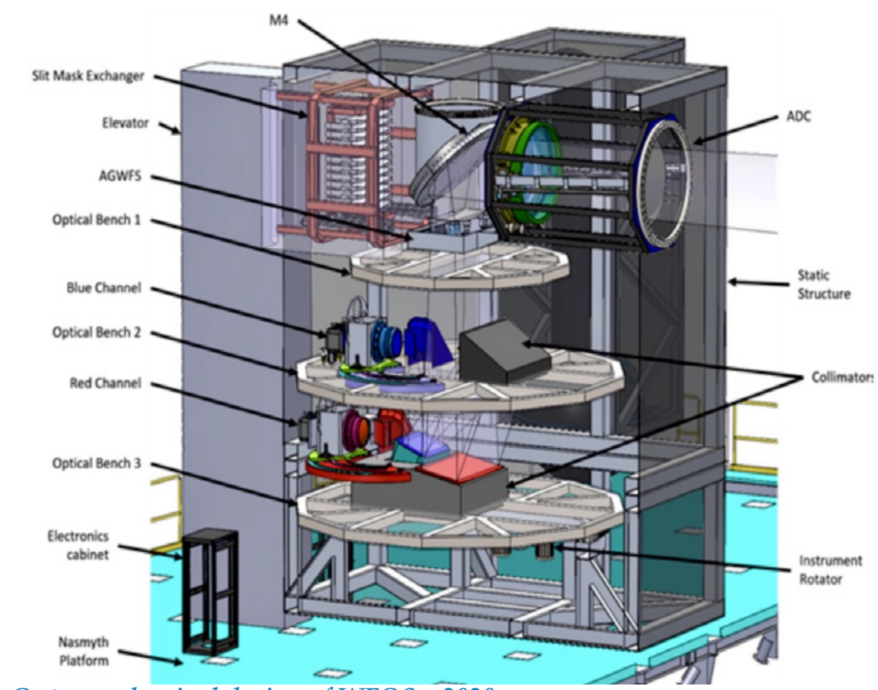
India's Contributions:

India will polish 86 of the primary mirror segments at ITOFF, CREST Campus, Hosakote. These mirrors have to be polished to an accuracy of (1-micron peak-to-valley) and will be cut into hexagonal segments. Rest of the 492 segments will be made across the partner countries. The final surface figure, each of these mirror segments should achieve after ion beam figuring, is ~2nm. The entire segmented mirror assembly will function as a monolithic 30-meter mirror using the actively controlled M1 control system. The M1 control system (M1CS) consists of individual SSA that provides stable support of M1 segments without causing distortion, and a large number of Actuators (1476) and Edge sensors (2772) will provide sensing and active control of the entire SSA assembly. Another major Indian contribution is in the development of Observatory Control Software and the Telescope Control Software of TMT. India is also making significant contributions to the design and development of one of the first-light instruments, the wide-field optical spectrometer (WFOS) and will lead the development of one of the 2nd generation instruments – the high-resolution optical spectrograph (HROS). Details about each of the contributions will be presented in subsequent issues of DOOT.

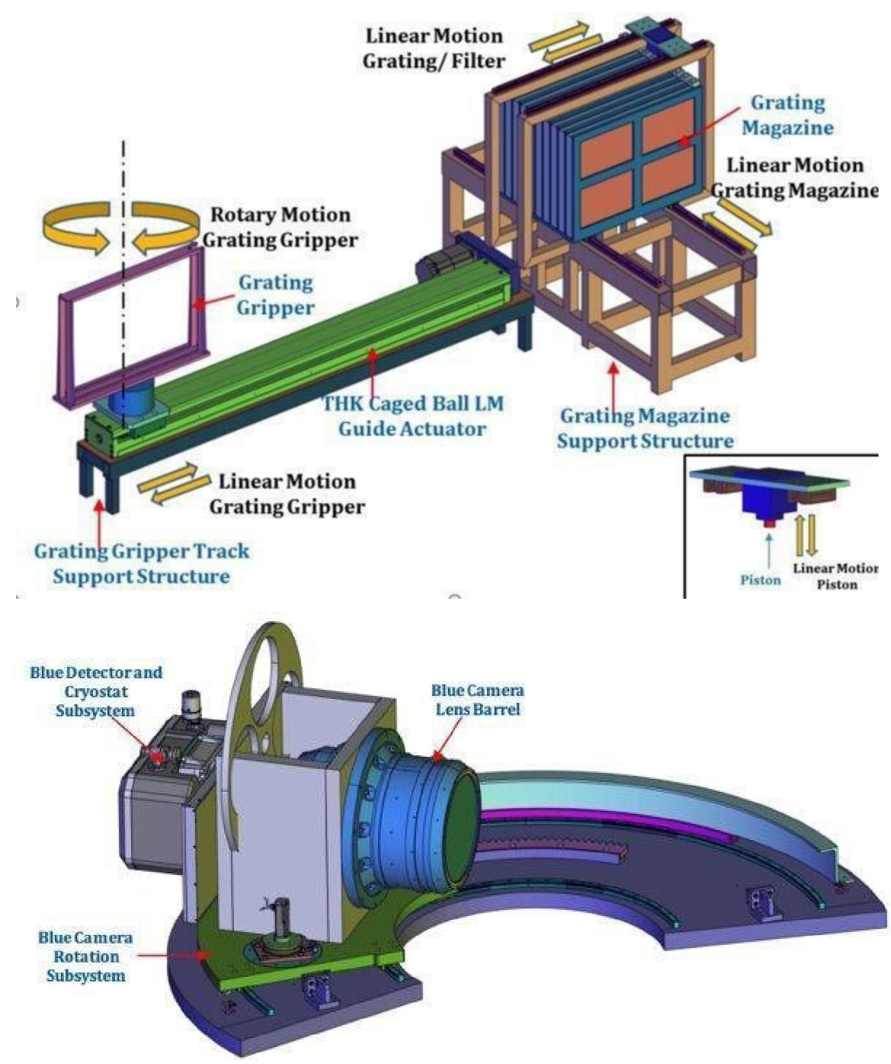
In addition to WFOS, other first light instruments are NFIRAOS, the adaptive optics facility of TMT which will feed the light to IRIS – InfraRed Imaging Spectrometer and MODHIS, a high-resolution IR spectrograph.

WFOS – First light instrument: Design Phase

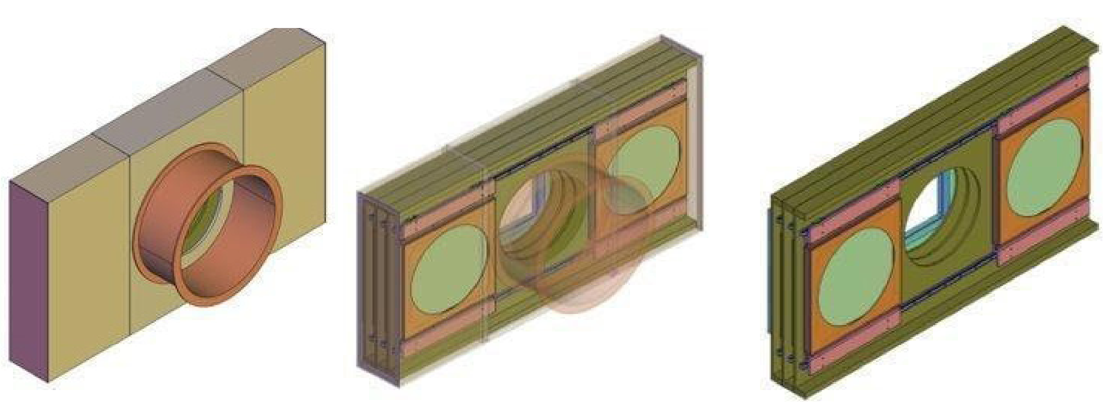
In this issue of DOOT, details about WFOS are presented. WFOS is a versatile work-horse instrument of TMT capable of direct imaging, long single-slit spectroscopy and multi-slit spectroscopy of the entire optical wavelengths. These can be performed at different spectral resolution modes, R~1500, 3500 and 5000, through various gratings and slit widths. The field of view of WFOS is 8.3x3 arcminutes. The corresponding physical size is about (~1x0.4) m. Hence the instrument is huge, similar to the size of a 2m telescope. The light from the telescope's Nasmyth focus is corrected for atmospheric dispersion, as the atmosphere of earth itself disperses the light like a prism. The dispersion could be of the order of several millimetres. WFOS corrects the atmospheric dispersion using a pair of prisms of 1.3 m size that moves linearly to correct the dispersion caused by the atmosphere. WFOS uses novel aspheric

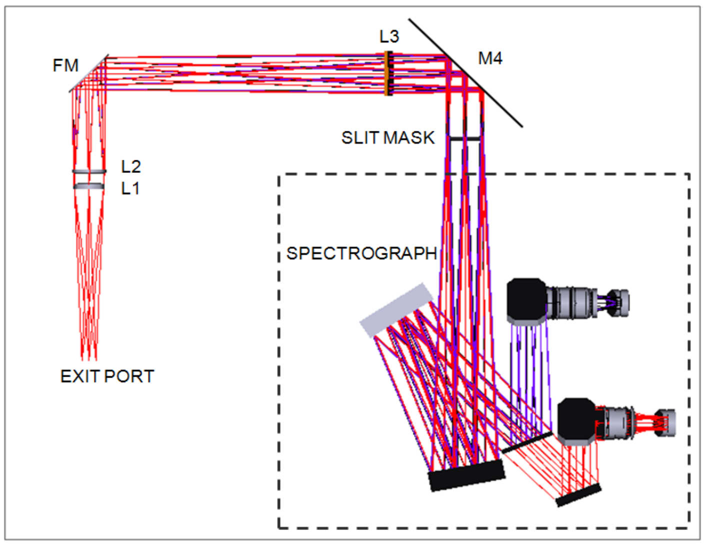


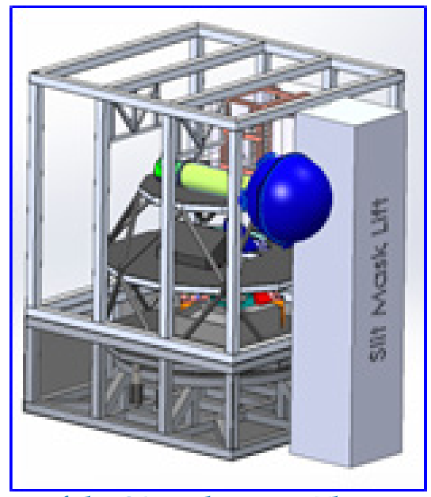
Opto-mechanical design of WFOS – 2020

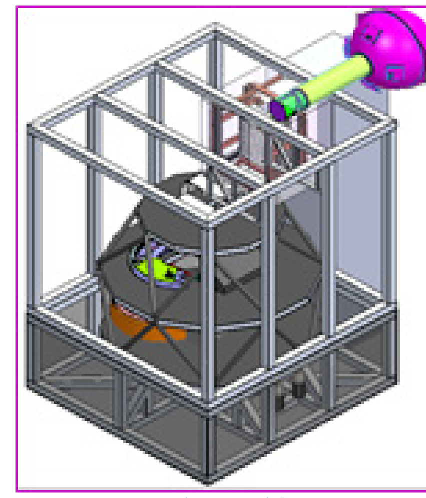


Mechanical design of GRX and CRS subsystems by the Indian team


Mechanical design of filter subsystem







Optical layout of the CAL subsystem. The team is looking at various mechanical layouts to place the 2m Integrating Sphere

dual collimators, and a dichroic mirror separates the light into blue and red channels with the split around 550 nm, that feeds the blue and red spectrographs. Each of the spectrographs has a number of filters/gratings to optimise the performance and facilitate the broad science goals of TMT. The camera, cryostat and detector assemblies are also optimised for the wavelength range of the spectrograph to maximise the efficiency. WFOS also has a guiding and wavefront sensing system to facilitate guiding and active wavefront sensing during observations.

Some of the key science goals of WFOS will be to study the intergalactic medium, galaxy formation and evolution, dark matter, chemical evolution of the local group and exoplanets. It is hard to speculate about the exciting science cases of the next decade. Hence, WFOS has several observing modes with maximum flexibility to enhance the discovery of space for future astronomy.

The WFOS team successfully passed the interim conceptual design review in May 2020, which was attended by over 30 scientists and engineers from across partner countries. WFOS is expected to observe the faintest objects and obtain extremely sensitive spectroscopic data either through first-hand observations or via deep followup of some of the exciting events in the Universe.

India's contribution to the design of WFOS is significant. The India-TMT team contributes to five major subsystems of WFOS: Mechanical design of Grating Exchange system (GRX), Camera Rotation system (CRS) and Filter Exchange system (FRX), optomechanical design of the Calibration system (CAL) and design and development of the Instrument Control Software (SWE). The close involvement of India-TMT team in science instruments will enable us to understand the complexity of instruments and aid us in successfully calibrating the data to maximise the science returns from the instrument for the future astronomy community in India.

(To be continued...)

WFOS-India core team: Devika Divakar, K V Govinda, Harimohan Varshaney, T S Kumar (ARIES), S Ramya, T Sivarani, S Sriram, K Sudharsan, N Viswanatha

(Ramya Sethuram is a Project Scientist at India-TMT, IIA. Her research interests include galaxy formation and evolution of dwarf galaxies, low surface brightness galaxies, star formation studies in galaxies and astronomical instrumentation.

Sivarani Thirupathi is a professor at IIA. Her research interests are stellar archeology with metal poor stars, exoplanet host stars and astronomical instrumentation.)

Storm In A Tea Cup

U S Kamath

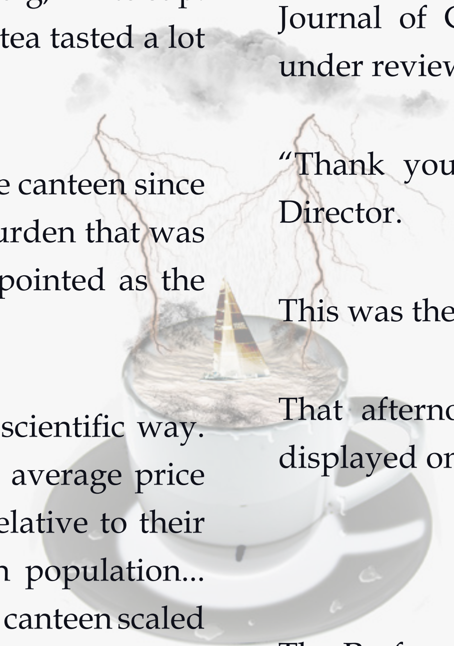
The Professor entered the Director's office.

"Have a seat," the Director said.

The Director was browsing through the report, his report.

The office boy placed a cup of tea on the coaster. It was the same tea available in the canteen but served in a big, white cup. He began sipping the tea. In this ambience, the tea tasted a lot better than in the canteen.

Tea and coffee had been priced at 2 rupees in the canteen since long, adding its bit to the ballooning subsidy burden that was eating into the budget for science. He was appointed as the one-man committee to suggest a revised price.



He had attacked the problem in a thoroughly scientific way. It was a multidisciplinary study – the moving average price of coffee powder, tea leaves, sugar and milk relative to their proportions in a cup... in cities comparable in population... fluctuations in the LPG refill prices... prices in the canteen scaled to the average pay of Class IV employees in the institute adjusted for consumer price inflation... effects of the pay commission hikes taking into account the delays in payment of arrears... estimated losses due to spillage, spoilage, over-production... regressions, chi-squares tests, high-order polynomial fits, simulations had been rigorously employed. Thus, the revised calculation had given 4 rupees 42 paise. It was an objective, data-driven report that would have made anyone reach the same conclusion except for the recommendation part. It was here that the Professor had used his subjective, humane side and presented cogent arguments to bring the price down to 4 rupees. This exploration covered sociology, economics, history, tradition and health. He was particularly proud of this section in the report. In his own small way, he had answered a perennial question, "What is the practical use of astrophysics to society?" As an added bonus, his paper, Economic and socio-cultural aspects of tea/coffee-drinking in an astrophysics institute and its effects on scientific productivity, submitted to the Indian Journal of Contemporary Science and Modern Culture, was under review. He smiled to himself.

"Thank you, Professor. This will be very useful," said the Director.

This was the signal that the meeting was over.

That afternoon, the office order for the revised prices was displayed on the notice boards.

*****

The Professor was in his chair, shivering, staring at the bolted door.

"Professor murdabad! Union zindabad!" shouted the crowd, banging on the door.

The members of the employees' union were evidently furious. He was unable to understand why.

****

Chaay Tapri (Tea Stall) Watercolors Artist: Medha Atre Kulkarni

The President and Secretary of the union went to the nearby tea-stall. It was a push-cart perched on a closed drain that doubled as a footpath. The vendor placed two thumb-sized plastic cups of tea and a cigarette on the counter.

They lifted the cups gingerly. The tea got over in two sips. The cigarette took longer to finish.

"Ridiculous," said the President. "Five rupees for canteen tea!"

The Secretary shook his head.

They gave twenty rupees to the vendor and left.

THE END

(U S Kamath is an Associate Professor at the Indian Institute of Astrophysics)

Abstract Art by Maya

" Cosmic Dance"

(Maya Prabhakar is a DST WOS-A Fellow at the Indian Institute of Astrophysics)

The Mysterious Exoplanets

Suman Saha

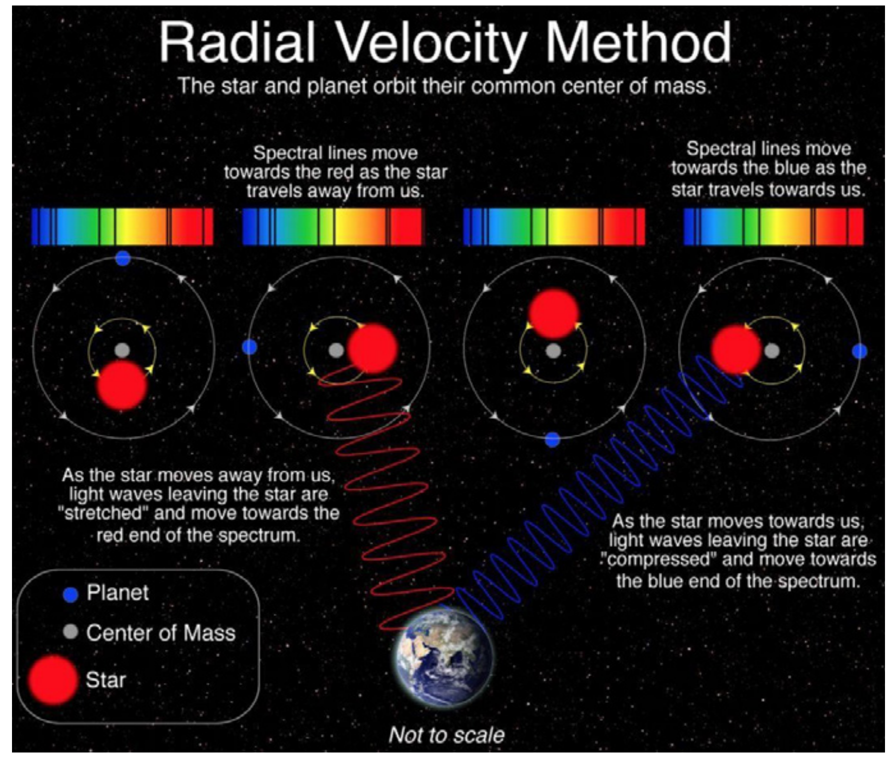
(Credits: ESA\Hubble, M. Kornmesser)

Just like the planets in our Solar system orbiting around the Sun, there are planets outside the Solar system orbiting around other stars. They are known as the Exoplanets (or Extra-solar planets). By definition, planets are much smaller than the stars and unlike the stars, they have no direct source of light but reflect the light from the stars. The starlight reflected by them is too little compared to the light coming directly from the star. This makes it extremely difficult to detect the Exoplanets by direct imaging. However, several indirect techniques have evolved over the past few decades to detect them.

The first confirmed Exoplanet was discovered in 1992 by Aleksander Wolszczan and Dale Frail. They found two planets orbiting around a pulsar, named as PSR1257+12, using the pulsar timing method. and the planets named as PSR1257+12 c and PSR1257+12 d. Pulsars are rapidly-rotating Neutron stars, which are the collapsed cores of supergiant stars (10-25 solar-masses) post supernova explosion. Pulsars have an extremely high magnetic field and emit beams of electromagnetic radiation from their magnetic poles. If the magnetic poles do not coincide with their rotational axis and the observer is somewhere in the path of the beam, pulsating beam with an extremely high and precise frequency can be observed. However, if an Exoplanet is present, this frequency varies due to the gravitational pull of the planet. The detection of this variation in pulsation is the basis of the pulsar timing technique. This method is so precise that Exoplanets much smaller than the earth can be detected. Since this method practically involves the detection of the gravitational pull of the planet on the pulsar, it also provides the accurate mass of the detected planets. However, this method is only restricted to exoplanets around pulsars, which are too rare.

In 1994, another planet was discovered around the pulsar PSR1257+12 using the same method, making it the first and only pulsar to date with three known planets. Till then, planetary systems have been found around three more pulsars. Usually, planets are not expected to be found around pulsars, since they are the end phase of stars and have gone through the supernova explosion, which emits enough energy to tear apart any existing planetary system. So, this discovery meant only one thing, the second phase of planet formation from the supernova remnants. The three planets around the pulsar PSR1257+12 are later named as PSR1257+12 b, PSR1257+12 c, and PSR1257+12 d, following the exoplanet naming convention as adopted by the International Astronomical Union (IAU) (suffix 'a' is not used since it represents the star itself). The planet PSR1257+12 b, which was discovered in 1994, has a mass just around 2% of that of Earth. It is the lowest-mass planet yet discovered by any observational technique.

When a planet orbits around a star, the star also moves in a very small orbit of its own around the center of mass, due to the planet's gravity. This leads to a variation in the radial-velocity (to-and-fro motion) of the star, which can be detected as a Doppler shift in the star's spectrum (a red-shift for out-going and blue-shift for incoming). This is a very powerful technique for the indirect detection of Exoplanets, known as the radial-velocity method. In 1995, Michel Mayor and Didier Queloz discovered the first exoplanet around a main-sequence star (stars with hydrogen fusion), named as 51 Pegasi, using this method. The planet is named as 51 Pegasi b. This discovery is awarded with the 2019 Nobel prize in Physics. Although the radial-velocity method involves the detection of the effect of the planet's gravity on the star, the limitation comes from the fact that the radial-velocity is just a one dimensional projection of the whole effect. This means, instead of providing the actual mass of the planet, the radial-velocity method only provides the minimum mass of the planet, mathematically written as (M * sin i). M is the actual mass of the planet and i, the inclination angle of the planet's orbit with respect to the observer. Since i can not be determined from the radial-velocity observations, the true mass remains undetermined.



(Credit : Las Cumbres Observatory).

The discovery of 1995 was important for another reason. The discovered Exoplanet, 51 Pegasi b, was like nothing ever known of. This planet was very similar to Jupiter in size, but was orbiting extremely close to the star (much closer than the Mercury in our Solar system) with a very small orbital period. This discovery led to the introduction of a very distinct type of Exoplanets, known as the hot-Jupiters, due to their Jupiter-like size and very high temperature due to close proximity to the star. Since then, more than 500 hot-Jupiters have been discovered. Since they are orbiting so close to the stars, these planets are tidally locked, meaning only one hemisphere of the planet is always facing the star and the other remains permanently faced out. You must have noticed that you can always see the same face of the Moon, which is also due to its tidal locking with the Earth. The discovery of hot-Jupiters seriously challenged the then existing planet formation theories, since a planet this huge can not be formed so close to the star. It will get teared apart by the extremely powerful tidal force of the star during the formation phase itself. This led to theoretical speculations that these planets must have been formed farther away from the star and then must have migrated to a close-in orbit. However, there is no sufficient observational proof to verify these theories and even after 25 years of first discovery, the mystery of hot-Jupiters continues.

So, are there any cold-Jupiters too? Of course, we have one..., no, two in our own Solar system (yes, Saturn is a Jupiter-like planet). But, are there any discovered outside our Solar system? What are the other types of Exoplanets discovered? Are there any other techniques to detect them? Where is the future of Exoplanet science going? The mystery continues in the next issue. Till then...

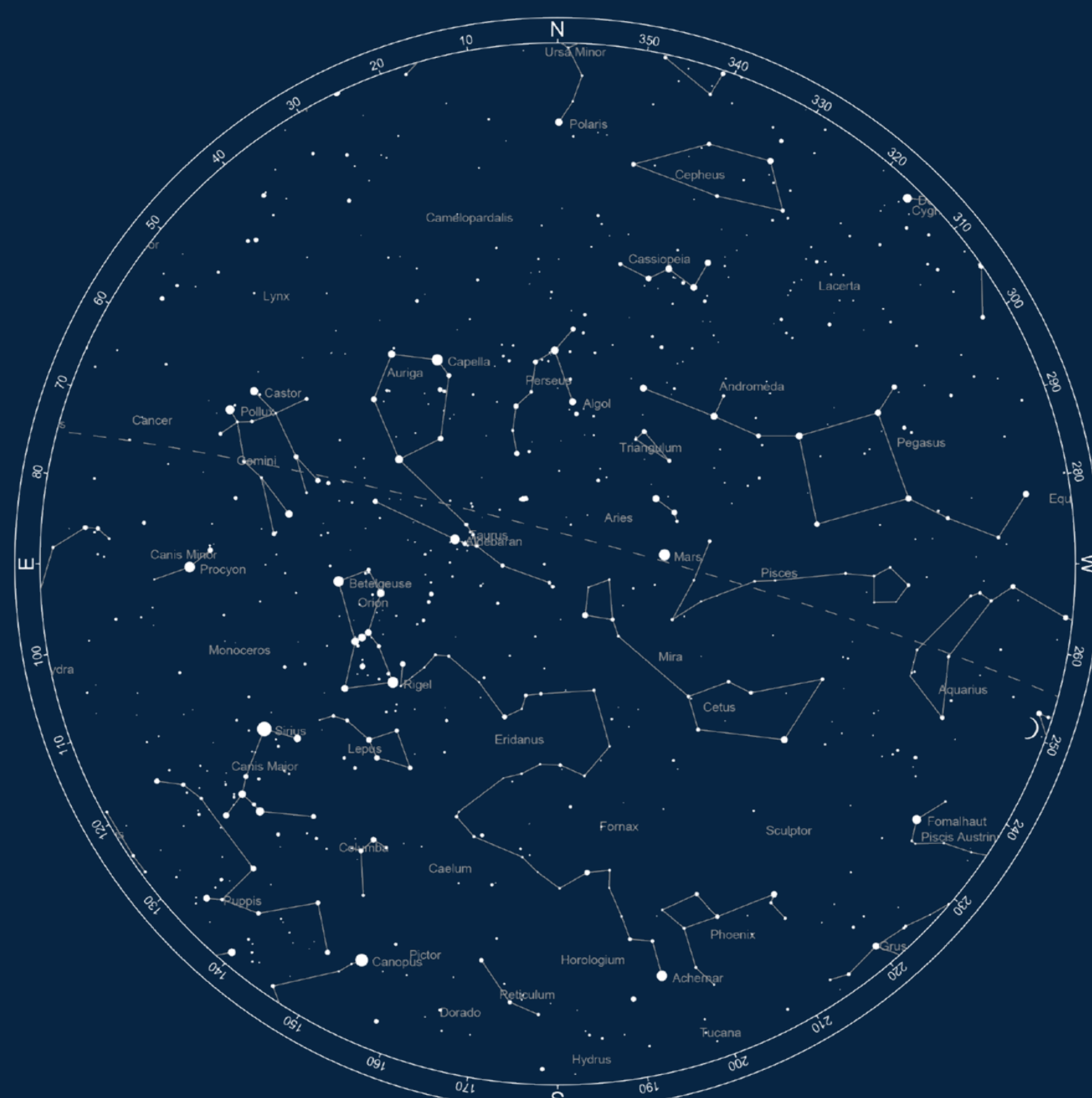
(To be continued)

(Suman is a senior research fellow at the Indian Institute of Astrophysics. He works on Exoplanets and keeps a keen interest in science fiction.)

January 2021

Location: Bangalore , 12.9791°N, 77.5913°E
Date: 15th January 2021
Time: 20:00 IST

Watch out for



January 2, 3 - Quadrantids Meteor Shower.

The Quadrantids is an above average shower, with up to 40 meteors per hour at its peak. It is thought to be produced by dust grains left behind by an extinct comet known as 2003 EH1, which was discovered in 2003. The shower runs annually from January 1-5. It peaks this year on the night of the 2nd and morning of the 3rd. The waning gibbous moon will block out most of the faintest meteors this year. But if you are patient, you should still be able to catch a few good ones. Best viewing will be from a dark location after midnight. Meteors will radiate from the constellation Bootes, but can appear anywhere in the sky.

January 24 - Mercury at Greatest Eastern Elongation.

The planet Mercury reaches greatest eastern elongation of 18.6 degrees from the Sun. This is the best time to view Mercury since it will be at its highest point above the horizon in the evening sky. Look for the planet low in the western sky just after sunset.

* Everyday stars will rise 4 minutes earlier than previous day

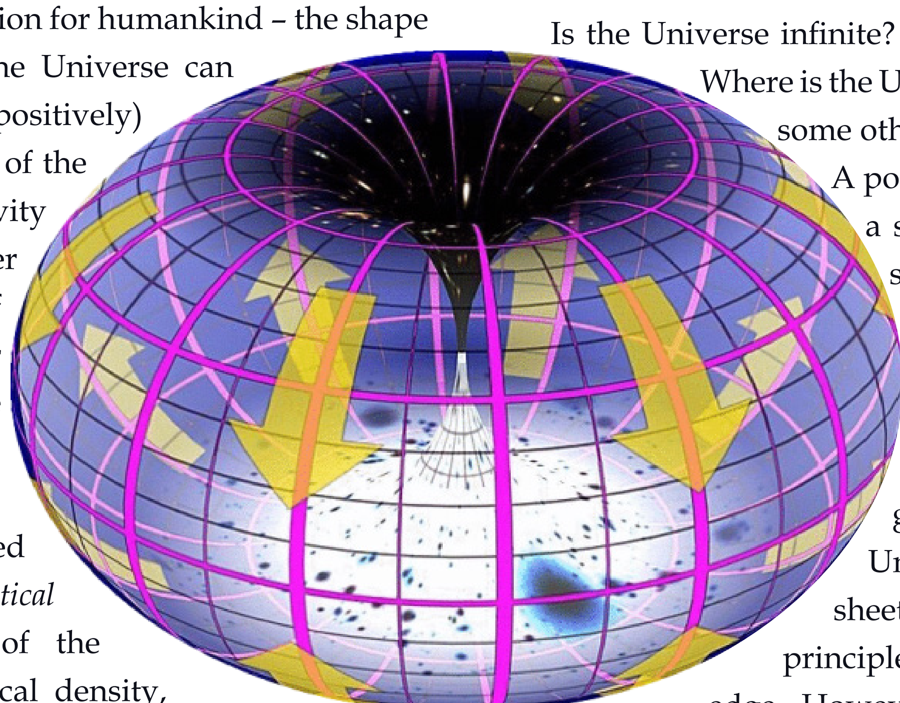
The Shape Of The Universe

Objects in the Mirror are Closer than they Appear

Fazlu Rahman

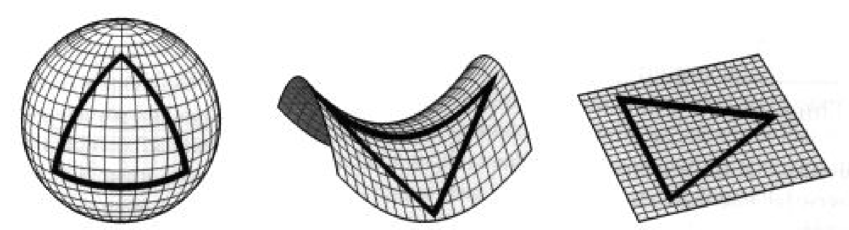
Objects in the Mirror are Closer than they Appear – A very familiar sentence to all of us. Though this is a safety warning written for the drivers who may mistakenly assume that the car behind them, as seen in the mirror is far away, given its small size, it has become a widely used catchphrase in many contexts. Here, physics is elementary. Convex mirrors, with their curvature, are used as rear-view mirrors in the vehicles to give drivers a wider field of view and to avoid blind spots. This convexity of the mirror will make the size of the object seen in the mirror smaller giving the driver a wrong notion that the object is far away.

This interesting concept in our daily life is actually helping us to get the answer to a life-long question for humankind – the shape of the Universe. Geometry of the Universe can be flat or curved (negatively or positively) depending on the matter content of the Universe; thanks to general relativity by Einstein, which relates matter distribution to the geometry of space-time and on which our improved understanding of the cosmos relies.



The three-torus model of the universe. (Illustration by: Bryan Brandenburg)

We define the density required to make the Universe flat as *critical density*. Suppose the density of the Universe is more than this critical density, the Universe is positively curved (closed Universe), and if it is below the critical density, the Universe is negatively curved (open Universe). What are the consequences of these geometries on our expanding Universe? If the Universe



is closed, the matter density is dominant enough to overcome the expansion and will make the expansion eventually stop and reverse back. If the Universe is flat, the expansion rate will decrease in infinite time. For a negatively curved geometry, the Universe will continue expanding forever!

Is the Universe infinite? What is the edge of the cosmos? Where is the Universe expanding into? These are some other exciting discussions alongside. A positively curved surface like that of a sphere has no boundary, and the surface is finite. If the Universe is closed, it will be finite with no edge similar to that of a 2-D sphere. For a flat or open case, it can either be finite or infinite, given the global topology of the Universe. If the Universe is flat as a sheet of paper, the cosmological principle demands it to be infinite with no edge. However, if the flat Universe has the shape of a doughnut, it can be finite with no boundary like that of a sphere.

Now, how to measure the shape of our Universe? For any flat geometry, the Euclidean laws that we learnt in high school will suffice perfectly – the sum of the angles of a triangle is 180°, no two parallel lines meet ever, etc. To know the curvature of any space, we can check if these laws are valid or not. On the surface of a sphere, the sum of all the angles of the triangle is greater than 180° while on a negatively curved surface, say a hyperboloid, that sum is less than 180°. So, the test is simple – draw a giant triangle in the Universe and see if the sum of angles adds up to 180°.

To do this practically, we will come back to the story of convex mirrors in our vehicles. If we know the actual size of the object seen in the rear-view mirror, and if the object is seen smaller in the mirror, we say that the mirror is curved. If both the actual size and apparent size match, the curvature of the mirror is zero. The same idea can be applied to know the shape of the cosmos - we look for objects whose original sizes are known a priori and see how much their sizes vary under observation. So it is as summing the triangle's angles and checking if they add up to 180° as per the Euclidean geometry.

Objects in cosmological scales whose size is known to us are called standard rulers. In the early universe, one such ruler is the sound horizon; the maximum distance travelled by the sound until the Universe becomes transparent to photons. This scale can be measured using the observations of Cosmic Microwave Background (CMB), the relic light coming from the hot big bang. Astronomical surveys looking for the large scale structure of the Universe can also measure this horizon scale, giving us hints about the curvature.

Given the powerful telescopes and high precision measurements in cosmology, recent results from CMB missions and galaxy surveys support the fact that the shape of the Universe is flat, i.e., we follow those high-school level Euclidean laws when dealing with the geometry of the cosmos. But, the story is not complete - our studies also say the expanding Universe is accelerating; the dominant entity in the Universe is dark energy having negative pressure. We need to determine the true nature of dark energy to know more about the fate of the Universe. In short, the upcoming mega telescopes designed in this direction will resolve the million-dollar questions on the apocalypse - Big Freeze, Big Rip, or Oscillations Forever.

For further discussions, please write to fazlu.rahman@iiap.res.in

(Fazlu Rahman is a Senior Research Fellow at IIA. He works in the field of observational cosmology)

My life at IIA

Vaibhav Pant

I have always had a fascination towards science since my childhood. I used to study books and articles related to scientific theories and discoveries as a child. After finishing secondary school, I took up Mathematics and Biology since I did not want to miss out on any stream of science. I joined St. Stephen's College of the University of Delhi for graduation in science, and was awarded the Kishore Vaigyanik Protsahan Yojana (KVPY) fellowship from the Department of Science and Technology, India. During this time, I had an opportunity to do a project in Solar Physics at the Indian Institute of Science (IISc), Bangalore. That's when I realised I had a desire to pursue Astrophysics, specifically Solar Physics, for higher studies.

While searching for the institutes across India which offered higher education in Astrophysics, I came across the PhD program at the Indian Institute of Astrophysics (IIA), Bangalore. I decided to apply for IIA for a direct PhD after my post-graduation studies. During my post-graduation days at the Indian Institute of Technology (IIT), Guwahati, I got a chance to work on a scientific project at the Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital. This indeed made me realise that research is the career I would want to pursue further. I applied for IIA's direct PhD programme, and I was selected for the same. I distinctly remember that during my PhD interview, the panel asked me if I would like to work on general Astrophysics problems or on a new Indian Solar mission named ADITYA. Without losing a second, I had replied that I would choose to continue working in Solar Physics. I guess this predisposition was because of my experience working on various Solar Physics projects in different research institutes as a part of the Kishore Vaigyanik Protsahan Yojana (KVPY) fellowship.

I joined IIA in the summer of 2012. I had the experience of staying in a hostel during my master's days; however, IIA's hostel Bhaskara was a bit different. I consider myself a selective talker, due to which I used to interact with very few people at IIA during the initial days. During my first year at IIA, we were taught advanced courses in Astrophysics, which was jointly done with the Joint Astronomy Programme (JAP) students from IISc. This was one of the most exciting but tiring days of my PhD. I believe that the course work is the last opportunity where a PhD student is taught something new. Once the research career starts, we learn new things instead of being taught.

I really enjoyed the course work. In my opinion, the IIA-JAP course work is one of the best in Astrophysics. Starting from the microscopic behaviour of fluids to macroscopic equations governing the dynamics of stars and the universe, I enjoyed every bit of it. Along with the course work, there used to be regular presentations that students give to the class. This boosts confidence and inculcates the habit of presenting one's work in front of a general audience. Moreover, this helped me to find the shortcomings in my understanding of a topic, as I feel that we understand something best when we explain it to others. We also had projects along with PhD course work, which gave a glimpse of the real research awaiting us in the future. Being a research institute, IIA has always encouraged students to attend different talks on Astronomy and Astrophysics as a part of IIA colloquiums, seminars, workshops, etc. This helped us to stay updated on the current research in different fields of Astrophysics.

As I was determined to do research in Solar Physics, I joined Prof. Dipankar Banerjee's group for my PhD. He had a large group, and I feel that I greatly benefited from regular interactions and discussions with group members as well as my supervisor. Interactions and discussions with researchers, especially in your own field, are quite important in research. The suggestions and criticisms of group members are essential in improving the quality of research. The Solar Physics group and research facilities in IIA have helped me to shape my early research very well. I recall days when I would simply gatecrash the office room of my supervisor and discuss research, life, philosophy and much more. My supervisor always encouraged my interest in everything. Time flew, and soon my seniors went for postdoctoral positions, and in no time, I realised that I had become one of the senior-most members of the group. During my final years, I guided a few internship students for their projects, along with my PhD supervisor. This helped me develop an independent thinking capability, which is crucial for a researcher. My supervisor had many national and international collaborations. I benefited from this, and later, it helped me expand my horizon and collaborate in India and abroad. At IIA, I was always encouraged to attend national and international meetings to disseminate my work. I feel this is something vital during one's PhD so that they can publicise their work in the community, know about what others are working on, and it helps one to expand their collaboration.

"Though research itself takes a lot of time during PhD, we still get a fair amount of time to pursue our hobbies. In my free time at Bhaskara, I touched upon those subjects which I always wanted to learn."

Though research itself takes a lot of time during PhD, we still get a fair amount of time to pursue our hobbies. In my free time at Bhaskara, I touched upon those subjects which I always wanted to learn. During my fourth year of PhD, I started reading about neuroscience and realised that the image processing techniques we use in Solar Physics and computer vision are similar to the image processing methods that a human brain employs for image identification. These things still fascinate me, and I am glad I continue to read about neuroscience. Apart from spending time for research at IIA, I spend most of my time at Bhaskara watching IPL and cricket. I, with my roommate, explored many restaurants in and around Koramangala, Bangalore. We used to go once a week outside for dinner. I am not crazy about travelling, so I explored only a few places outside Bangalore. I visited Belgium several times during my PhD, and I won't be lying if I say that Belgium has always treated me well.

Eventually, the time came when I had to submit my PhD thesis. PhD thesis writing is a tedious task which takes a lot of time and sometimes is monotonous. I remember completing several TV series while writing my thesis. After submitting my thesis, I thought all went well, but it was not over yet. The main ordeal starts after thesis submission. I applied for a few postdoctoral positions and I was offered one at KU Leuven, Belgium. I wanted to get the thesis defence done as soon as possible, before leaving India. Since IIA's PhD students are awarded their PhD degrees from Pondicherry University (PU), we have to go to Pondicherry for all the administrative work related to the thesis submission and defence. However, the administration of PU was understanding and I got my thesis defence done in six months, after which I left IIA with many mixed memories. I will always cherish my time spent at IIA.

(Vaibhav is a postdoctoral fellow at Instituto de Astrofisica de Canarias, Tenerife, Spain. He is investigating the role of magnetohydrodynamic (MHD) waves in heating the solar corona using numerical simulations and observations.)

Kavalur Early Days (1962-1968)

KAVALUR EARLY DAYS 1962 – 1968

Venkatesh

A series of visual delights reminiscing some of the early days of Kavalur

①

KAVALUR in the Javadi Hills of Tamilnadu, where the lone eagle soars high in the clear sky, the peahen struts glamorously in her surroundings. and where astronomers of the Indian Institute of Astrophysics probe the mysteries of the Universe.

The story of the Observatory at Kavalur is a story less than two decades old. Poor observing conditions at Kodaikanal, specially ~~at~~ during the night hours, prompted the search for a site for a new field station for stellar telescopes. A site survey team set out in April 1962

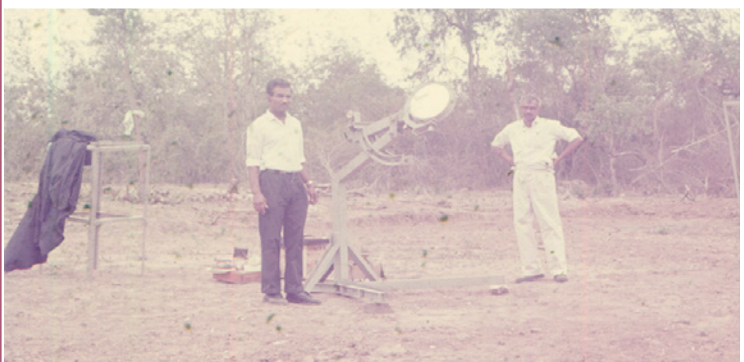
Kavalur Village Area, Apr 1962

Map reading on the first visit through kavalur, April 1962

On the site at Kavalur, Apr. 1962

to examine observing conditions in the Yellagiri and Javadi Hills. The team set up camp deep in the ~~forest~~ interior of the forests on Yellagiri principally inhabited by the tribals referred to by the urban folk as the Malaya alees. ~~Jack fruit, ~~some coffee~~ lantana bushes and cloudy skies~~ A portable telescope was used to study the ~~dep~~ image definition and quality which astronomers refer to as seeing. ~~Bap locating~~

This was how members of the site survey team crawled ~~walked~~ through the lantana bushes in the present campus of the Observatory



Raheem at Kavalur before the hut, Aug.14,1968

kavalur hut getting ready (1968)

The dirt road with its irregular surface ~~shatters us~~ jostles us appreciably before we enter the premises of the new Observatory. The sentry's salute snaps us into the awareness of entry into a new domain of meaningful activity.

(Venkatesh S. works as Research Assistant(Observations) at Vainu Bappu Observatory, Kavalur)

Bappu and Forest Guard, Kavalur May 1962

M.K.V.Bappu at Sandal Wood-depot near Jamnamathur Apr 1st 1962

First Visit to Kavalur, Apr, 1962

Enroute to Kavalur May 1962

Forest Rest House, Kavalur Apr. 1962

Credits: IIA Archives

Life-Changing Experiences Through IIA Outreach

Megha

Like many, I joined IIA with lots of dreams and passion. Along with mastering the subject, I always wanted to contribute to society in whatever way possible. While I was not quite sure how I could proceed with this dream, the IIA Outreach program came in front of me like a boon. Along with my batch-mates, I attended my first outreach meeting in the "Bhaskara telescope room" (a small but inspiring meeting / extracurricular activities room in our hostel terrace) conducted by our seniors. We had a glimpse of how to teach astronomy basics to school kids through handmade astronomy kits, followed by identifying constellations in the light-polluted Bengaluru sky. That is how I started my journey in IIA Outreach. This meeting was very stimulating as its motto was to inspire underprivileged school kids towards basic sciences.

Being a junior, I observed my seniors who were very good at explaining science in layman language to the kids through small experiments, activities, and beautiful presentations. Being a local language (Kannada) speaking person, I could quickly bond and interact with Kannada medium school kids. While trying to explain the concepts to them, I understood that I could do this very well, and I really enjoyed doing it. We always planned what to present such as a general talk on introductory astronomy, demonstration of astronomy kits, or observing through a telescope. However, every time we made an effort to improvise on this by conducting new group activities and some exciting physics experiments, which are easier enough for the kids to repeat on their own. Therefore, every new Outreach allowed us to push ourselves further to adopt a novelty in our approach. This led to numerous brainstorming sessions, which were very refreshing and connected us with our basic science roots. More than what we taught, we gained immense

Outreach enthusiasts in an informal meeting with Dr. Gajanana Birur at Bhaskara Guest House, IIA, October 2019.

knowledge and insight from the countless fascinating questions posed by the inquisitive young minds. Therefore, each school Outreach session became a powerful platform for learning, understanding, and improving the group working spirit. It enhanced our weekend productivity, providing a welcoming break to our mundane life.

While participating in Outreach events, we connected with inspiring personalities like Mr. Sridhar P., an IISc graduate. He devoted himself to the "Akshara Foundation" to teach computers and robotics in the local Government schools. These kids, who initially did not even know how to switch on a computer or speak in English, are now able to build their robots under their teacher's guidance. It was very satisfying to know that his efforts paid off through his students' national and international level award-winning performances. We also met Dr. Gajanana Birur, an IISc alumnus and a Principal Engineer in the Mechanical Engineering Division at NASA's Jet Propulsion Laboratory. He also worked on the Mars Curiosity Rover project. He has adopted several government schools in his village, and a few in Bengaluru. He is currently working on improving those schools by collaborating with "Teach For India" fellows. He was immensely enthusiastic during our interaction and provided inspiration for enhancing and extending our Outreach plans. We were driven by his energy and dedication towards propagating science education to the underprivileged students.

The interactions with many such eminent personalities sprouted an idea of organising a Teacher Training Program (TTP) by few Outreach enthusiasts at IIA. This event aimed to invite about 50 teachers, primarily from Government schools, to cover basic science concepts through presentations and elaborate hands-on sessions using everyday household items. In this way, skilled teachers could further motivate their students, enabling us to reach more students through each teacher, snowballing our efforts of spreading knowledge in every nook and corner of society. Our first TTP took place in June 2017 at IIA main campus. The enthusiasm of teachers even drove us to skip lunch break and engage in discussions. The program was a great success because they accompanied their students to attend our next National Science Day celebration. They identified some of us and eagerly introduced to their students, remarking that we were the ones who presented them with some exciting experimental ideas. Along with the students, teachers also noted down the steps of our new science experiments to recreate them for those who could not attend that event. I was awestruck by these responses, which drove me again to participate in our next TTP, taking place in September 2018.

Government School teachers with Outreach team during TTP, June 2017 at IIA main campus.

I also participated in a few Solar and Lunar eclipses events to educate the crowd regarding the prevalent superstitious beliefs practised during an eclipse. One of the most significant Lunar eclipse events (a super blue blood moon) was held at Lalbagh, Bengaluru, by the IIA Outreach team on January 31, 2018. We interacted with a vast audience consisting of children to senior citizens. Though it was tiring, at the end of the day, we were so satisfied that we could convince a few audience members to reject some superstitious beliefs. As it is easy to preach and hard to practice, I am also content that I could positively influence my closed family members to get rid of superstitious practices during an eclipse.

Another unforgettable experience was an Outreach event at Snehagram, a vocational training and rehabilitation centre for HIV positive kids, situated in Krishnagiri, Tamil Nadu. Their program has a facility to accommodate about 200 children, who are provided with academic learning opportunities and developing life skills and values to lead a responsible social life. Honestly, I was a bit sceptical about joining the Outreach team for this event because of my own prejudices. But I wanted to come out of my mental barrier by actively participating in this event. This decision led to an eye-opening experience, giving me an entirely new perspective towards the HIV-affected community. We interacted on astronomy, demonstrated a few optics experiments, and had a pleasant sky-watching session with them. They posed challenging questions to us, also including a discussion on life and beyond. We learned about their daily routines, classes, healthcare, diet, etc. from their caretakers.

Outreach team with Seva Bharath Trust Government Higher Primary School, Bengaluru, August 2015. This school has a Robotics lab funded by the Akshara Foundation.

We shared a lovely dinner with them, sitting side-by-side, savouring the fresh vegetables and dairy, nurtured by them with love and affection. Those kids were physically fit and hardworking, eager to learn new things, and filled with life skills, which most of us lack. At the end of the day, they taught us to live our lives to the fullest. During our journey back to Bengaluru, none of the team members could speak. Yet, our silence spoke about everything we experienced that weekend.

I could not participate in all the outreach activities during my stay due to workload, but the ones in which I had been involved never left me without valuable life lessons. I will always carry these beautiful experiences with me. I heartily thank all the IIA Outreach team members who helped me grow as a person during my PhD days.

(Megha Anand is a Post Doctoral Researcher at IIA. She works on polarized radiative transfer in solar and stellar atmospheres.)

Astrophotography

Orion Nebula

"Orion Nebula is one of the most famous deep-sky objects, which most beginners in astrophotography target. Even I did the same. My first attempt with Orion Nebula was a single exposure of 30 s, ISO 3200, in December 2018. But the core area got overexposed. Since this was my first attempt on DSO imaging using my gears, I was so excited and planned for multiple targets. So I did not give much time for any particular target. Whenever I take my telescope gears out, my friends will join me, and I will have to spare time enjoying the sky through the telescope.

Later in January, I planned the second attempt and decided to concentrate only on one object – Orion Nebula. This time I didn't inform anyone. My wife was there to help me and one security to ensure no bison around. I captured the beauty in different exposures, starting from 10 s to 300 s at ISO 800. Ten frames per exposure, except for 300 s - 5 frames only. Total 55 light frames spending more than 4 hours under the clear sky. I also took ten dark frames for each exposure. Though it is necessary, I did not capture any flat frames - I did not know how to take it. While the camera was automatically capturing the images, we enjoyed the night sky through our binocular lying on the ground.

Winter nights are always chilling at Kodaikanal, but that night, I did not feel it at all. Maybe because of the kick from the stars.

I did the post-processing using Deep Sky Staker and Adobe Photoshop/Lightroom. "

\- Anand M N

Gears Used:
Camera: Nikon D5100
Optical Tube: Skywatcher BK P130DS F/5 Astrophotography Reflector (Newtonian)
Tracking Mount: Skywatcher HEQ5 Pro GOTO Mount.
Exposure: 10 s,30 s,60 s,120 s,180 s – 10Frames, 300 s – 5Frames
ISO: 800
Intervalometer: Aputure Intervalometer for Nikon.
Location: Kodaikanal Solar Observatory, Front of the auditorium
Altitude: 2343m
Temperature: ~6 °C (As per IMD, Kodaikanal Record)

(Anand M N is a Junior Research Assistant at Kodaikanal Solar Observatory of Indian Institute of Astrophysics)