PHYSICS DEPARTMENT

NEWSLETTER

IIT BOMBAY

AUTUMN 2024 ISSUE

INDEX

DGSec's Message

Hello everyone,

I am delighted to welcome you to this edition of our department newsletter! The Physics Department at IIT Bombay, one of the oldest in the institute, continues to thrive with its rich legacy of unity in diversity, attracting brilliant minds from various backgrounds.
This year, we are excited to launch a magazine that compiles engaging interviews with our faculty and insights from students and doctoral candidates. We aim to highlight current research trends and experiences that reflect the dynamic spirit of our department.
We have much to celebrate! Our proposal for the satellite-based x-ray detector laboratory, Daksha, is set to join the international GROWTH consortium, marking a significant milestone for our experimental efforts.
Our alumni continue to make us proud, holding influential positions worldwide and contributing to national organizations like ISRO and the National Institute of Oceanography. With a dedicated faculty of nearly 50 members, we look forward to expanding our infrastructure and enhancing our global presence.
I encourage you all to delve into the newsletter, explore the fascinating research, and draw inspiration from the experiences shared by your seniors and faculty. Your engagement is vital as we continue to strengthen our community.
Thank you for your commitment and enthusiasm!

Best regards,
Abhishek Chhipa
General Secretary
Physics Department
IIT Bombay

Editor's Note

Hello Everyone,

The Editorial Team is thrilled to present the Department Newsletter for Autumn 2024. This year's theme revolves around astrophysics, one of the most exciting and sought after field in physics. Our members have skilfully brainstormed and presented articles that are easy to read and provide a lot to learn.

We begin with an introductory article on pulsars. It explains the fundamentals concepts associated with pulsars while avoiding all the complications making it easy to understand for beginners. Next is an article on Active Galactic Nuclei, an interesting astronomical concept that's not explored till the high school level. After each article we have provided references, so that students who are interested in learning further can help themselves. Now, every time we hear the word 'astrophysics' the first faculty to pop in our minds is Prof. Varun Bhalerao. We present to you his interview in which he describes his journey in the field of astrophysics.

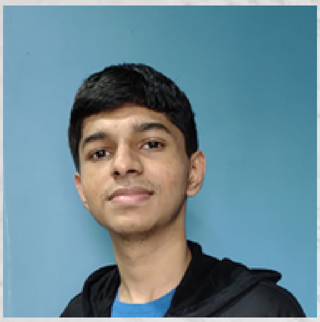
For the non-core junta we present an interview of one of our machaxx senior Shravya Suresh who has interned at Goldman Sachs, in which she talks about her internship experience as a quant analyst. We then have an article on the research wing of physics department: The Journal Club, in which we discuss about it's goal and how it is trying to achieve it. We then move on to students' corner, which will highlight student contributions for the newsletter and showcase pictures containing memories we have made throughout this sem.

Hope you enjoy the newsletter

Thank You!!

Kshitij Bahadarpurkar
Editor-in-Chief
Student's Association of Physics Department

The Creators



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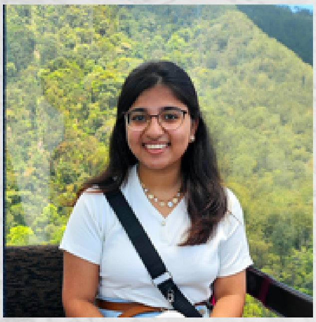

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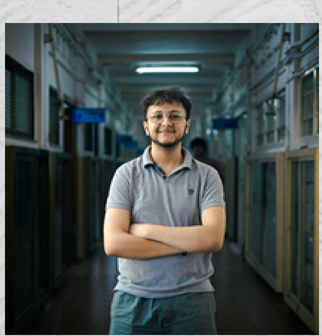

Devanshu

Design secretary

A Brisk Walk in the Realm of Pulsars

-Mahesh Balwade (PhD 5th Year)

I. Introduction

A pulsar is a rotating neutron star that emits radiation from its magnetic poles [1]. Its radiation is visible only when its magnetic pole faces Earth, similar to a lighthouse. This distinct emission allows us to use it as a precise galactic clock. Jocelyn Bell, who was at the time a Ph.D. student of Prof. Antony Hewish, made the initial discovery. Prof. Antony Hewish was awarded the Nobel Prize in physics for their discovery of pulsars in 1974 alongside Sir Martin Ryle. The period for these pulses ranges from milliseconds to seconds. I have shown an animation of the second pulse in Fig. 1. Pulsars are crucial in astrophysics as they played a key role in the discovery of gravitational waves, another fascinating astronomical phenomenon. The discovery of pulsars has revolutionized our understanding of the universe.

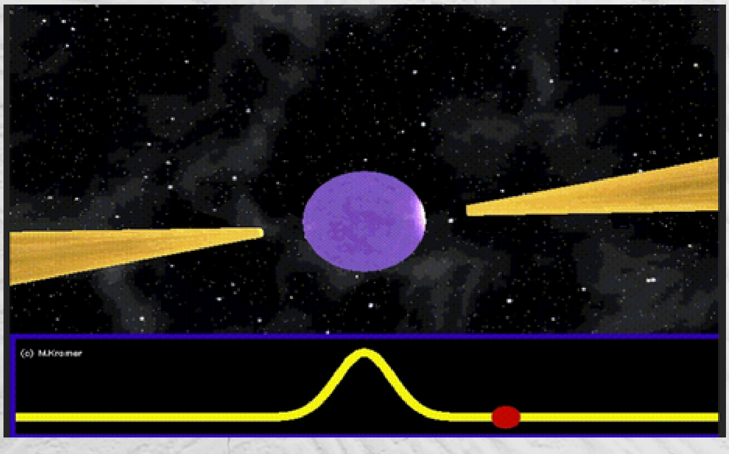

Fig. 1: Pulsar Star, Animation
Reference: By Michael Kramer - http://www.jb.man.ac.uk/~mkramer/Animations.html, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=2848650

II. Formation of Pulsars

At the end of his life, the massive star dies into a compressed core when its fuel is over. The core collapses under its gravity, resulting in a supernova explosion, leading to electrons combining with protons to form neutrons [2]. The remnant core now comprises only neutrons, hence called a neutron star. Some of them have high rotating speeds along their spin axes. Alongside this fact, neutrons have intrinsic magnetic momentum. The combined effect causes neutron stars to have powerful magnetic fields, which cause them to emit energy in the form of electromagnetic radiation. When the Earth periodically passes by its magnetic pole, it notices the radiation in the form of pulses. Hence, a pulsar name is given to these types of neutron stars.

III. Characteristics of Pulsars

Pulsars are known for their fast rotation, powerful magnetic fields, and consistent emission of electromagnetic radiation. These characteristics result from the pulsar's compact size and high density, which cause them to spin incredibly fast and generate intense magnetic fields. When a regular star collapses to become a pulsar, the magnetic field is conserved, resulting in a significant increase in the surface magnetic field strength. The magnetic field shape of pulsars is generally dipolar, and a magnetosphere is created around the pulsar . These stars typically have a gas density decreasing from 1042 cm3 at the center to 1012 cm3 at the surface. Normal pulsars usually have a magnetic dipole strength of about 1024 Gauss m3 [3], a mass similar to that of the Sun, and a rotation period of around 0.1 seconds, resulting in a significant angular momentum. These values are tremendous, which gives an idea of the strength of the pulse of radiation.

IV. Types of Pulsars

Pulsars are categorized depending on their source of power and radiation. There are three types: mainly 1) rotation-powered pulsars, where the loss of rotational energy of the star provides the power 2) accretion-powered pulsars, where the gravitational potential energy of accreted matter is the power source (producing X-rays that are observable from the earth) and 3) magnetars, where the decay of an extremely strong magnetic field provides the electromagnetic power [1]. The mechanisms of each type of pulses are complex and distinct. Pulsar is an ongoing research field with many questions to solve [6]. Interested readers can follow further information using references given at the end.

V. Conclusion

We have briefly discussed about pulsars and their formation, characterization, and types. Pulsars are key astronomical objects studying gravitational waves, etc. Pulsar searches are still ongoing to find remarkable phenomena like the highly anticipated pulsar-black hole binary or a pulsar orbiting closely around the black hole at the center of our galaxy. In summary, pulsars are key astronomical objects in understanding the universe.

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Active Galactic Nuclei

-Vansha Hansda (B.Tech 3rd Year)

An active galactic nucleus (AGN) refers to a dense region at the center of a galaxy, comprising an active supermassive blackhole, emitting strong electromagnetic radiation of all wavelengths. A supermassive blackhole is called "active" when it is actively accumulating matter from its surroundings under gravity.

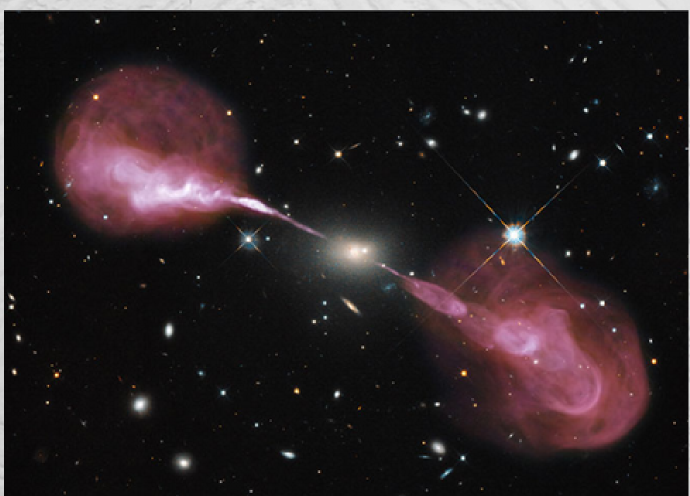
Discovery of AGN

Carl Seyfert's observation of unusually bright and dense galaxy centers with broad emission lines in 1943 led to the foundation for the study of AGN. The development of radio astronomy in the 1950s further advanced AGN research, with discoveries of sources like Messier 87, Centaurus A, and quasars - extremely distant, powerful objects.

Classification of AGN

AGN are broadly classified into two types : radio-quiet and radio-loud. Radio-loud AGN eject large scale radio jets, which account for a major fraction of their observed energy, specifically in the radio part of the electromagnetic spectrum, whereas radio-quiet AGN show energetically insignificant amounts of radio emission.

The image shows the radio jets of Hercules A galaxy. [Source : space.com



Seyfert Galaxies

Seyfert galaxies are radio-quiet, and look like the usual spiral galaxy, except that they have an extremely energetic, luminous core that outshines the rest of the galaxy. They show strong emission lines, indicating high energy processes in their core. They emit electromagnetic radiation through the entire spectrum, specifically in the UV and X wavelengths.

Quasars

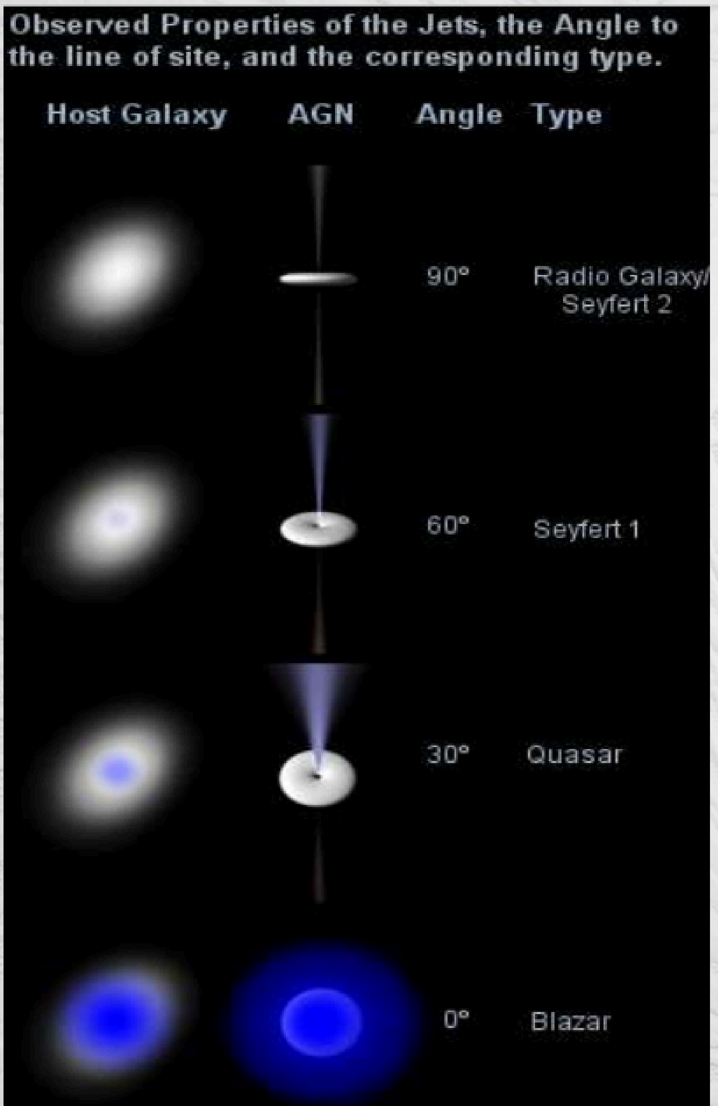
Quasars, or quasi-stellar objects, are extremely luminous AGN. When they were first discovered, it was observed that they look similar to stars (hence "quasi-stellar") in visible-wavelength images, but emitted a considerably large amount of radio waves compared to typical stars. Later, detailed images from the Hubble showed that they occur in the center of galaxies. On calculating their redshifts, it was found that they are extremely far, suggesting their formation during the early stages of the universe. The nearest known quasar is about 600 million light years from earth. Both radio-quiet and radio-loud quasars have been discovered, with the majority being radio-quiet.

Blazars

Blazars are AGN having their relativistic jets pointing directly towards the earth, hence appearing very bright. They look very compact and point-like in visible wavelength.

BL Lac Objects

BL Lac Objects are a type of blazars, having highly varying brightness and strong optical polarizability. They are named after their prototype, an active galaxy called BL Lacertae, which was initially mistaken as a variable star in the Milky Way. BL Lacs have weak emission lines, which are nearly absent in the visible region.



OVV Quasars

Optically violent variable quasars are another type of blazars. As their name suggests, they have strong optical variability, showing changes of around 50% in the visible spectrum within the span of one day. They emit strong radiation over the entire spectrum, specifically in the X, gamma and radio wavelengths. They are much more energetic than BL Lacs.

Radio Galaxies

These are similar to blazars, except that their jets do not directly point towards the earth, hence their emission is devoid of the high optical variability of blazars. Clearly, they are radio-loud, having luminosities of up to 10^39 W in the radio wavelength region. Their emission spectrum is greatly affected by the interaction of the jets with the intergalactic medium.

The Central Engine of AGN

Supermassive Black Holes

Black holes form from the gravitational collapse of extremely massive stars. Supermassive black holes typically have masses exceeding 10^5 times that of the Sun. They can grow in size through mergers with other black holes or by accreting matter from their surroundings. Nearly all galaxies contain supermassive black holes at their centers. Some of these black holes actively and rapidly gather significant amounts of matter, usually in the form of interstellar gas. This accumulation leads to phenomena such as extremely high luminosity and the emission of vast amounts of energy, which are observed in the cores of those galaxies. These active black holes are referred to as active galactic nuclei.

Accretion Disks

The strong gravitational field near a supermassive black hole changes significantly over small distances. This variation causes a difference in gravitational pull between objects or points that are closer to the black hole and those that are farther away. This difference in force is called a tidal force and leads to the stretching of objects as they approach the black hole, a phenomenon sometimes referred to as spaghettification.

In addition to tidal forces, the rotation of the black hole generates angular momentum, which prevents matter from falling directly into the black hole. Instead, the matter spirals inward, forming a flattened accretion disk, typically at the equatorial plane of the black hole. The matter in this disk slowly moves closer to the black hole as it loses energy and angular momentum over time.

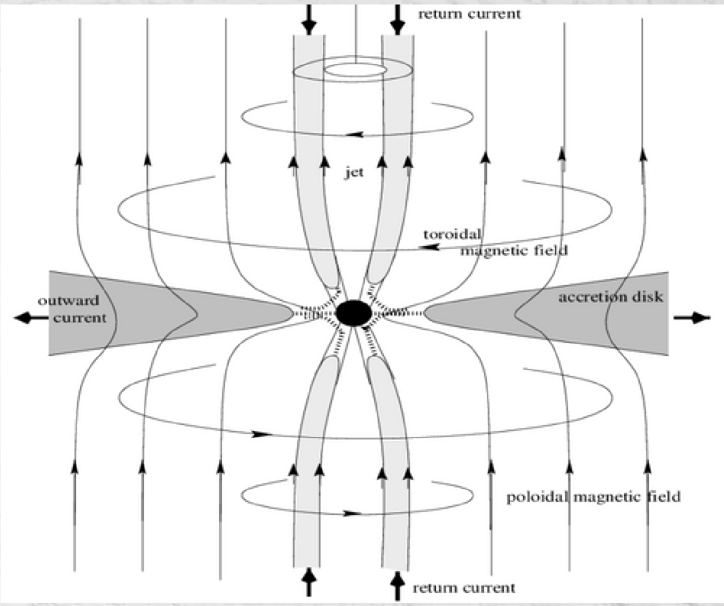
Supermassive black holes acquire material for their accretion disks from several sources, including the tidal disruption of stars that venture too close,molecular clouds passing nearby, the interstellar gas and dust in their immediate surroundings, and the influx of matter during galaxy mergers.

The image shows the tidal disruption of a star by a black hole. [Source : scitechdaily.com]
Read about accretion disks in a more detailed manner here : arXiv:2302.07925

Relativistic jets

Relativistic jets are highly collimated beams of ionized particles, accelerated to speeds very close to the speed of light, carrying a huge amount of energy. Their formation and behavior is a result of the interaction of plasma with magnetic fields, which is studied under magnetohydrodynamics.

The accretion disk's differential rotation very close to the black hole results in the compression of the magnetic field in that region. This compressed field stores a huge amount of energy, which is released as particles are launched at speeds close to the speed of light, along the rotational axis of the black hole.



The image shows magnetic field lines around the black hole and accretion disk. [Source : researchgate.net]
Read more about relativistic jets in a detailed manner here : arXiv:1812.06025

Radiative Processes in AGN

AGN emit radiation across the entire electromagnetic spectrum, from gamma rays to radio waves. Radiative processes study the processes by which energy is emitted, absorbed or scattered from matter, in the form of electromagnetic waves. Some of the main radiative processes in AGN include

- Bremsstrahlung radiation : This occurs when high energy electrons decelerate on passing near ions in the hot gas surrounding the black hole. This process produces X rays, and is common in the corona of the AGN.
- Synchrotron radiation : Charged particles, primarily electrons, spiraling around magnetic field lines at relativistic speeds emit synchrotron radiation. This radiation spans a wide range of wavelengths, from radio waves to X-rays, and is responsible for much of the emission seen in jets.
- Inverse Compton scattering : High-energy electrons in the corona or jets collide with low-energy photons from the accretion disk and boost them to higher energies. This process results in the emission of X-rays and gamma rays. In AGN, this can be seen in the jets as well as the region surrounding the black hole.
- Line emission : In the gas clouds near the AGN, atoms and ions are excited by the radiation from the accretion disk or corona. As these excited particles return to lower energy states, they emit photons at specific wavelengths, resulting in emission lines. Broad lines (e.g., H-Balmer lines) come from fast-moving gas close to the black hole, while narrow lines come from more distant, slower-moving gas clouds.

Effects of AGN on star formation and galaxy evolution

AGN influences the interstellar medium (ISM) of its host galaxy through mechanisms like radiation, winds, and jets, resulting in two forms of feedback : negative AGN feedback and positive AGN feedback. These feedback mechanisms are crucial for understanding how AGN contributes to the broader dynamics of galaxy evolution.

Negative AGN Feedback

This occurs when the energy outflow from the AGN heats up the ISM, preventing gas from cooling and potentially expelling gas from the galaxy. The lack of cool gas inhibits star formation, leading to what is known as "quenching." This feedback mechanism contributes to slowing or halting star formation in the galaxy, affecting its overall evolution.

Positive AGN feedback

In some cases, AGN outflows can compress parts of the ISM, increasing gas density and creating favorable conditions for star formation within the outflow. This results in morphological changes in the galaxy and potentially triggers a new wave of star formation. These newly formed stars may also contribute to further shaping their environment through processes like supernovae. This feedback promotes star formation and is termed "positive AGN feedback."

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The Astrophysics Journey of Prof Varun Bhalerao

-Interview taken by Ananya Priyaroop (B.Tech 2nd Year)

Sir, the first question is what inspired you to pursue this field and can you share a little insight about your journey on how you got into astrophysics?

Okay, so my astrophysics interest started like everybody's astrophysics interest which is that it is fun to look at stars, right. As a kid you ask anyone and moon is nice to look at, stars are nice to look at. Many people at some point also want to become astronauts, I am not sure if that was part of my phase ever but I just like looking at stars, okay.

In high school I got to hear about astronomy Olympiad and then my school used to keep sending people for various quizzes and what not, so I was on the team that was sent for this and I did reasonably well there and that is when I first got to study astrophysics and I said hey this is fun, maybe I should do this and I went to the Olympiads, I got to learn more astronomy, I got to interact with astronomers and I said okay, maybe I like this. Then JEE happened and in my first attempt I didn't get a great rank. So I joined IIT Bombay or registered in IIT Bombay but didn't actually join, okay and then I gave a second attempt and I said I want to do physics only, I want to take EP.

But this time my rank was too good unfortunately and then you can't take EP with too good a rank, right. It's happening more commonly now but so I joined IIT Bombay finally in 2002 at that time this was extremely uncommon. So I ended up joining Elec and then I realised that Elec is also fun, right.

Now that also pointed to a problem, if I keep trying more things then I will find them fun as well. So I said maybe I should stop trying to find new interest areas and work on the ones that I already have. So at that point during my undergrad in Elec I tried to do more astro projects because I was clearly enjoying astro as well.

So I did some internships, one project with NCRA, one with someone in TIFR, course project wherever there was leeway I would steer my course project to get closer to astrophysics so that would make it interesting and then for higher studies I said okay I like engineering, I like astrophysics, is there a way I can do both and the answer is yes there is. Usually when you think of astrophysics you first think of people working on telescopes and then you think of theorists, right. So if I ask you to name famous astrophysicists you will very likely not name people who look through telescopes barring maybe Galileo, you will name people who actually did theory, right.

You will name people like Hawking or Einstein or Narlikar or anyone else, right and they are all theorists but someone has to build those telescopes, right and that is instrumentation people. So that is a fraction of astronomers who actually know how to make instruments and make those instruments, use them themselves and make them open for others to use. So that is what I do now.

So we build telescopes for use in astronomy and that is the story. One thing led to another, kept finding interesting opportunities and kept moving towards it.

Were there any challenges you faced early in your journey because India was not developed enough at those times?

I am not that old, okay India was developed, India was not well developed in space is kind of true, okay. So if you look at early journeys of astronomers in India they had a very hard time, right. But when I was a student we already had GMRT which was the world's largest radio telescope, right.

This was set up in 90s, right. We had 2 meter telescope at Hanle which was also set up in late 90s. So we had the Venugopal telescope which till I think late 80s, early 90s had been the largest telescope in Asia.

This is in Kavlu, okay. So these people had worked very, very hard to get astronomy off the ground and then the next generation was having things a little bit easier. What was not great at that time though were the salaries, okay.

So at that time the salaries for scientists were really, really bad. IT boom was just taking off and salaries in private sector had started increasing quite drastically. But by the time I finished my studies that problem also got fixed.

By the time I finished my undergrad itself actually and I talked to some of my mentors about this and they said look the salary number itself is not the only thing you should look at. You should look at things that go with it, what are the perks you get, what is the quality of life you get. As one of them put it saying I went for my reunion.

That person went for their school batch reunion after some 30 years, 40 years whatever. He was the one with the most hair still left on his head, right. Lowest amount of stress, enjoying his work and things like that.

So that was something that was a challenge. There were limited places where you can actually do an undergraduate degree in astrophysics. That has improved only in the last few years, many IITs and universities starting astro departments and things like that.

Other challenges were there, how as a youngster do you choose physics when everyone else around you is telling you to do engineering and how do you say no to a job and go for a PhD instead. Getting PhD was always a hard thing, right, because I was competing with people who had done physics and I had to then break through that to get an admission into an astronomy PhD program and I wasn't 100% sure I will get it. So I also applied to PhD positions in electrical engineering and if I had not gotten PhD admission in astro then things might have been different for me completely.

So there were things which were different but still shaping up for astronomy. Now your issue you said is focusing on space and I am going to take a small detour before going to your next question which is the difference in astronomy and space science. Astronomy and astrophysics is about studying things in space.

It is implicitly about studying things that are naturally in space, right. So going from near to far you are talking about moon, asteroids, sun, planets, other stars in our galaxy, other galaxies, birth of the universe, birth, life and death of stars, all of that is astronomy and astrophysics. Putting things in space is space science.

In between these two is planetary science where you can study Jupiter from here or you can send a probe to Jupiter. That is both planetary science but launching a satellite for internet telephony or for watching cable TV and all of that is also space science and you can be very sure that owners of Star TV and Z TV and so on do not care about how stars are born and a lot of astronomers do not care about how many satellites Starlink launched last year. In fact they are annoying to us because from the ground those satellites actually contaminate our images.

There are streaks going through our telescopes are highly sensitive looking at faint objects and I see satellites going through that is noise for me, right. Space science is something that is booming up only now and we are actually in the rising phase of it around the world and in India. It is a field that is picking up.

There are two startups from IIT Bombay. There is one from our alumni and one from one of our current faculty. We are expanding more into various areas there.

So space science is something which is rising now. Astronomy is something which is also doing really well right now but has been doing well for a while. In fact as a career choice astronomy is an awesome option.

If you look at all the what are called mega science projects, right, the large R&D projects that are happening in India most of them are astronomy, right. So you have LIGO India. You have the 30 meter telescope.

You have the Square Kilometer Array. You have a bunch of space telescopes that are being planned. There are good planetary missions being planned.

So all of these massive infrastructure projects in physics, a large fraction of them is actually astrophysics projects.

Could you tell us what you are working on right now?

Okay, so what I do when I say what I am working on, the real answer is that I do nothing. My students do everything, okay.

So I am now answering on their behalf. So we have three main areas that our group works in. The first is this satellite called AstroSat which was launched almost exactly nine years ago, 22nd of September.

So nine-year-old satellite. I was part of the team that built it. At that time I wasn't in IIT Bombay but AstroSat carries five types of telescopes and one of them can detect these explosions in space called gamma ray bursts.

So my group leads the study of those explosions. So we have students who go through the data and find these GRBs, then we study them, analyze them, figure out where they are in the sky, study their polarization. That is one.

Second is a project which got completed soon after I came to IIT Bombay which is IIT Bombay actually jointly owns a research class telescope in Ladakh along with the Indian Institute of Astrophysics in Bangalore. This is somehow something that a lot of students don't actually know. Don't be surprised that you don't know.

Most students don't know. I don't know why. It's ultra cool that IIT Bombay actually owns a telescope.

So this is called the Growth India Telescope. The aperture is about 70 centimeters, so 0.7 meter telescope and it is India's only fully robotic optical telescope. So and all the automation by the way was done by our students, one PhD student and a huge army of undergrads.

Many from EP, many from other departments as well. So Growth India Telescope, the idea is that we use it for what we call time domain astronomy. We use it to study things that change in the sky.

And the telescope can respond autonomously to it. The data gets downloaded. The site is so remote that we don't have internet there.

So we have a dedicated ISRO satellite link to download that data to Bangalore. From Bangalore it comes here. Even the data processing is automated.

And our students keep working on interpreting that data and that's where you need the creativity. If I have to do the same data processing every day, I don't need a scientist to do that. But I can train my computer to do it.

And when I say train, I don't mean AI, ML, normal algorithms which we have automated. And then you need the scientist to do the creative part of science, the interpretation. So if you are up every night just pressing buttons at a telescope, then you are going to spend the entire day sleeping instead of thinking about what you saw.

You will sleep instead peacefully at night, let the telescope do everything. And in the end, we actually come and analyze and interpret that data.

And the third thing is this (Daksha). So this is a 3D printed model of a proposed space telescope called Daksha. It doesn't look like a telescope, what you would think like. This is what the satellite will actually look like.

And Daksha is a mission led by IIT Bombay, along with PRL Ahmedabad, IUCAA Pune, RRI Bangalore and a bunch of ISRO centers. And the project is to make two space telescopes that will be the world's most sensitive space telescopes. There are faculty members from physics, from ILEC, MEC and AERO.

From physics, we have Suddhasatta Mahapatra, Archana Pai and myself. And we are working hard on building the satellite, developing all the science cases and everything. So in terms of what it can do, it will also detect explosions in space.

So if you ask me, basically, we are a group of kids who make toys to watch things go boom. That is accurate enough research summary. Except that our toys are large and things going boom are even larger.

How do you see your work contributing to the broader goals of the Indian space program?

So the work that we are doing here, see as the department of physics, there is an important choice that we always have to make, which is different from what rest of IIT does. Which is that whether our research should be fundamental research or applied research. And largely we sway towards fundamental research.

The engineering departments do all the applications. Why are we building Daksha? We are not building Daksha to demonstrate our abilities in the space program. We are building it to study astrophysics.

It will lead to spin-offs. It will lead to a lot of spin-offs. But they are all incidental.

They are not our primary goal. We have trained more than 50 students at various levels going from undergrad students, master's students, project students, PhD students in actually how to build hardware for space. We are trying to start a new, set up a new lab where we will train more students on all of this.

So the manpower development that we do and so on are things which will actually contribute to the space program. The know-how that we develop can apply to other missions if we choose to. But that is not what is driving us.

So there will be contributions but they will not be as the primary goal of this work. What I am trying to do in parallel is, so I am also the faculty advisor for the student satellite program. And through the student satellite program is where we are trying to actually develop new things and actually get more launches for satellites fully built by students.

And that will be a more direct contribution to the space program as opposed to things like Daksha right now. There are some other spin-offs that we are looking at. For example, the same technology and algorithms that we use to study variable stars and gamma labels and so on can very easily be ported to study debris in space or keep track of satellites.

Now when companies are talking about launching tens of thousands and even lakhs of satellites at this point, space collisions and keeping track of things, finding your way through them, space traffic is a reality right now. And we actually have the best expertise in the country to be able to handle those kind of issues right now.

What do you think are the biggest unanswered questions in astrophysics?

Yes, and that is actually astrophysics in that sense is the biggest canvas for questions that we can get. We do not talk small at all ever. So when I say something is a small explosion, it means it has enough energy to destroy earth once instead of million times right.

That is the scale at which we are talking. The burst that we study for example, these gamma ray bursts emit more energy in a second than the sun emits in its entire lifetime okay. We are trying to use this to answer several interesting questions.

I will tell you the questions which interest me the most okay. So the research was what my group is known for is the study of electromagnetic counterparts to gravitational wave sources. I am sure you have heard about gravitational waves and LIGO and things like that.

A lot of these gravitational wave sources are usually black holes colliding with each other. And the collision of black holes, black holes are black, no light. So you cannot study it in electromagnetic radiation.

But there are also these objects called neutron stars which are 2 to 3 times the mass of the sun typically and radius is maybe 15 kilometers or so, extremely dense. At their cores, the density is a factor of 2 to 3 higher than the density of atomic nuclei right and those are states which we cannot achieve on earth. So neutron stars are the most extreme labs in nature.

The highest known magnetic fields in the universe exist on a class of neutron stars called magnetars. The highest surface gravity is on neutron stars except black holes of course but they do not have a surface right. The highest densities in the universe are in the centers of neutron stars.

They are formed by the death of massive stars. So it is the most extreme scenarios that you can imagine and we want to study those with Daksha and with growth India telescope and so on. So what we can do is that when these neutron stars collide, they emit gravitational waves but of course they also disintegrate in the collision and some stuff falls into become black holes, some stuff gets thrown outside.

The details of these collisions allow you to probe for example what is called equation of state of ultra-dense matter. How does matter behave when you compress it so much that a spoonful will weigh more than Mount Everest right. How do you, so there is something called R process nucleosynthesis okay.

So you might have heard this saying that you are all made of stardust right. So universe started off with hydrogen, little bit of helium, almost nothing else right. So all the carbon, nitrogen, oxygen that is necessary for life was formed inside of some star and then spread out when that star died.

That does not explain why there is gold on earth okay. Stars cannot form gold. You may remember from your introduction to nuclear fission and fusion that there is something called a binding energy and a mass deficit and so on and fusion is energetically favourable all the way up to iron but not beyond that.

If I try to fuse iron and some other nucleus or heavier nuclei, I actually have to spend energy in doing fusion rather than gaining energy out of it. So it does not happen very easily. It can happen when there are neutron rich environments and what better neutron rich environment than a complete neutron star that is being disrupted.

So all the gold, silver, platinum, lanthanides in the universe are all formed in neutron star mergers and those conditions are so extreme that even with LHC, we are orders of magnitude far from creating that and the universe does that for you for free. You just have to look for them and study them. So equation of state of ultra-dense matter, how fast is the universe expanding? How are all these interesting elements formed? These are some of the questions that my group is interested.

Can you talk about how India's role in global astrophysics has developed in recent years?

That is an interesting question. So we have gone through an interesting transition in the last decade or so where we are actually shoulder to shoulder with global astrophysics and we have done it in multiple ways. A lot of the young generation of astronomy faculty around the country are people who went abroad for either PhDs, postdocs, whatever, built collaborations but then came back to India and started leveraging those collaborations.

So we have people who are part of all the largest studies happening around the world. Then we started upgrading our local hardware. The world had space telescopes, we launched AstroSat.

World had robotic telescopes, we built Growth India telescope. So that was part two. In some cases we were already leading.

Things like GMRT was in front ahead of the rest of the world before the 2T radio telescope did the same. Then the third thing we said is that we can't keep catching up forever because the world has a great lead in front of us. So we said let's go and join some of these international projects because astrophysics projects have now come to a scale where it is difficult for a single country to pay for all of it.

So we have joined all these international projects like the Square Kilometer Array radio telescope, the 30 meter optical telescope and so on. And then the fourth thing we are doing is we have plans to bridge the gap in between. So our current largest telescope is 3.6 meter.

We have joined hands with the world to build a 30 meter telescope. We need something in between. So there are plans to build a national large optical telescope which will be a 10 meter glass telescope in Ladakh.

There are plans to build all of these other classes of telescopes across wavelengths and so on. So we are now trying to make sure that we bridge the gap in between because you can't have, for example, just after finishing your undergrad, if I give you an opportunity to use the Hubble Space Telescope or JWST or something, you wouldn't know what to do with it. You have to gradually learn how to use larger and larger telescopes and what useful thing to do with those larger and larger telescopes.

So we are trying to bridge that gap to make sure all of that also happens. Some interesting exercises that have been done recently is that the Astronomical Society of India has just put out a vision document that describes what the focus of the Indian astronomical community will be for the next 15 years. ISRO is doing an exercise called Space Science Roadmap Formulation which talks about how will ISRO focus on science in space in the new era of commercial space explorations.

So there will be ISRO's commercial angle and building manned space flight missions and all of those things. But what about X-ray telescopes which need to be in space? What about Aditya L1 which had to be launched so that it could observe the sun continuously? What planetary explorations? Do we want to do one more Chandrayaan, one more Mangalyaan? Do we want to go to Venus? So ISRO is doing a formulation for Space Science Roadmap like that. The office of the PSA, Principal Scientific Advisor to the Government of India has recently released something called MSV2035 which is a vision for mega science projects in all fields of science to be done in the next decade.

So there's a lot of well-meaning and very smart people who are actually planning out how these activities should pan out in the future as well. So our good position is going to become even better.

Sir, some personal insights. You were a student here. Now you're back as a professor.
So, what major developments and changes do you see?

Some things never change. Student culture is largely similar. There was some reset that happened because of the pandemic because hostel culture changed quite a bit.

Hostels are now larger. I was in H3. So a hostel wing used to have 25 people and there were a lot of open areas in between for playing and things like that.

And if you look at newer hostels, that's no longer possible. Overall, the enthusiasm level of students is also similar, but the exposure has increased quite a bit. So students coming in today actually have access to more resources and they use them well.

So I think students now know more probably than I knew in my undergrad days. Some things which are not good is that there is an obsession over PORs. And I think students stress out a lot about a lot of things.

Your internship season begins like eight months before it should. Your placement season has runners whose job is to go around and just make sure that there are seats available or whatever. There are rules for, there's essentially a market for cheating in elections, right? There are rules for how many votes penalty you get for breaking what rules.

And some of these things, if you look at it as a student and how they progressed over time, they sound reasonable. If you look at it as an outsider, they just sound crazy. One more thing which has drastically changed is the student fests.

They have gotten larger, but they've also become more disconnected from IIT Bombay. My student days, Mood Indigo was an inter-college competition which had some performances in it. And the competition would have a large number of participants, participation from IIT Bombay.

Tech Fest was a set of tech competitions which had some big shots coming and having some tech-related talks or tech-related shows, exhibitions in between. Now there are hardly any competitions. And the role of IIT Bombay students has become a completely managerial role.

And that saddens me because we are hosting, I mean, we might as well host IFA Awards or Cricket World Cup or something, right? And you'll get the same set of PORs, but you will get exactly as little gain in tech or cult or whatever from doing those as you get right now from Mood Indigo, Tech Fest. One more thing that has changed is campus is a lot more crowded in terms of number of buildings that we have. And that will only go increasing because student strength is much larger.

All departments put together was 450 people. Now all departments put together is 1400 students.

Is there anything you would like to add or emphasize about the future of astrophysics in India?

It's really a good field to be in right now. Okay, there are several good things in favor of astrophysics. I already told you about the mega science projects that we are part of now.

It's going to be a decade before many of these are actually fully operational, which means that the current students are going to be young faculty when those projects are online. So the job of the current, current senior astronomers will have long retired. Current mid-career astronomers will be senior people whose job is to set up and manage those facilities.

But it's the young people who will, who are students now, who are going to come in and do all the cool science with that. Another thing that is really nice is job prospects are pretty good. Academic salaries are not too far from industry core salary.

Go into finance or whatever, then you get all these fancy stories about someone getting a one crore package and all that. But if you look at median salaries, my batchmates who stayed in core engineering areas versus my salaries are actually not very different. And the perks I get are far more than what anyone can imagine.

I get to stay on this campus and what more do you want? You walk in from, so you might not know, but yesterday people were outside campus. There was a traffic jam where people took four hours to go through. And inside campus, we are blissfully ignorant of all of this.

You get all other facilities and everything. Now, these are things which you don't think about when you're 20 and you're trying to get your first job. But they start mattering when you're 40 and you're staying with your own family and things like that.

Oh, there's a swimming pool. My kid can walk to school. These kind of things start and those are present in all academic areas.

And one more thing which is very interesting is that there is an increasing transition or transition from academia to industry is becoming easier. Right. So 20 years ago, if you were a PhD in astrophysics and you don't get a scientist job, you're screwed.

You don't know what you want to do. Now, again, with increasing space industry on one side and increasing data science applications on the other, there's a huge demand, surprisingly, for people with PhD in physics, because if you really... When you as students think of AI, you think if you learn scikit-learn, you get AI. But when you actually go deep and you talk to people who are developing data science further, developing AI further and so on, there's a lot of physics-based modelling that goes in for a lot of things.

So having the ability to solve problems, having the physics algorithmic training and so on makes a huge difference. So there are also a lot of exit paths if at some point you want to leave astro for whatever reason. So it's a pretty good time and we should enjoy it right now.

We don't know what it will be 50 years down the line, but the next decade or two are going to be awesome, for sure.

Could you tell us if there are any project openings under you? And what should be the prerequisites?

Yes, there always are. And so students do this nice thing called SURP and WURP and all the research project things.

And I really like that idea, so I support it very strongly, which means that I take students through that. So every year I float six to ten projects in SURP and I select students from that. It's a very large group. I have currently some 25 students working with me. I have five PhD students and 20 undergrads plus masters plus project students put together.
In undergrads there are a lot of people interested in Astro and will take that and will support that with more formal training. They do good work, about half the students with me end up publishing or co-authoring a paper on their project.

So, yes, there is always scope. Here is a lot more demand of astrophysics projects than supply of astrophysics projects, which is why this standardized selection procedure through SURP and everything is what I prefer for taking to it.
What I would also suggest is that there are a large number of self-study resources that are available. Okay,For example, as a part of the Growth collaboration, we had the first ever Growth winter school at IIT Bombay and we created this awesome idea where we had Python notebooks and all the data that you need for running those Jupyter notebooks is all available. The notebooks are available online, and we also recorded the lectures where these notebooks were solved interactively for the first time. All that material is available of them, and that has been built on further and we did two more summer schools abroad after that. Kritika has its own introductory astronomy notebooks. KSP, the summer projects that they do is a very good avenue. Just attending Kritika lectures, talking to like-minded students, colleagues of yours, visitors who come in to give talks and so on. These are all avenues that you have. So, on my group's website I've put a bunch of resources, for example, where you can read more about Astro at a sensible level, sensible goes in both ways, something that will make sense to you and something that is not Mumbo jumbo or conspiracy theories or whatever. So a bunch of those resources are available. So if you're interested, don't wait for our project. Start learning by yourself. That has two advantages. It convinces when you come and talk to me in SURP next year, it tells me that you actually have a serious about astronomy as opposed to just casually looking at the moon, for instance. Second is whenever you do join my group or any other groups, there are four other faculty members in the department to do astronomy. Archana Pai, Shankaranarayanan, Vikram Rentala, and Rahul Kashyap. So any of us when you join, if you have already been doing this Astro, then you can start your actual project much faster. You're learning curve is reduced drastically.

Intro to Quant with Shravya Suresh

-Interview conducted by Pradhicksan CM (B.Tech 3rd Year)

We'll start with a formal introduction.
Can you tell us about yourself?

Hi everyone.
I'm Shravya I'm currently a final year B.Tech. student in Engineering Physics and over my 3rd year summer I interned as a risk analyst at Goldman Sachs in Bangalore. I've been pretty much interested in tech for a while here in insti, besides, a lot of the non-core side as well. But tech has been something that I've enjoyed a lot and wanted to pursue through my 3rd year intern. Coming to hobbies, I like to dabble into music a little bit. I pride myself in being an amateur at chess, and I like playing table tennis as well.

What are Quant roles, how would you explain it to someone who have not got much exposure to the field?

Broadly speaking, a quant role essentially is when you apply mathematics, statistics, and a little bit of computer science algorithms to solve financial issues and tasks. People in quant use these kind of mathematical and statistical backgrounds to tackle certain financial problem statements or any certain projects which the company takes on, maybe to grow their financial markets or to identify whether there are any potential risks in certain portfolios. For example, let's say a company X is holding a certain portfolio. So using the financial data over several years, you would perform some analysis, devise algorithms, or use statistics to understand how much risk there is to continue holding that portfolio and determine the best further course of action.. Those are kinds of analysis that we can do based on the mathematics and test statistics that we apply.

What got you into Quant role? Was there any specific Aha moment where you realized "I'm going into Quant role "?

So at the end of my second year, moving into 3rd year, I was just interested in getting a tech role. I wasn't completely aware that there were so many bifurcations within tech itself. And I certainly wasn't aware that Quant itself has so many different applications in the corporate world.. I was just interested in applying for tech companies and giving it my shot wherever I could. When Goldman Sachs came for recruitment, first of all, I knew how big a name it was. Second of all, even though they are an investment bank, they were coming for a tech role, which is what I was looking for. So I was very much interested and applied for it out of the interest of getting an internship that would give me technical experience. And I suppose the 'Aha' moment for me was just when I realized that I was interested in machine learning and data analytics, which had slowly developed over my second year. When I started the CMInDS Minor, I found the whole concept of exploratory data analysis quite interesting and intuitive. And then I progressed towards Natural Language Processing and exploring a little bit more, so after spending a fair amount of time in the ML domain, I realized that I do enjoy analytical work and applying the knowledge I'm gaining more than just learning things theoretically. So yeah, I think that's where it came from.

How did you prepare yourself, say technical skill-wise, interview wise for this role?

Firstly, when anyone start preparing for a tech role, you start doing DSA because everyone's of the opinion that when you're doing tech, you have to do Data Structures and Algorithms because without that you won't get anywhere. I would say that is actually partially true, because there are a lot of companies that come for non-DSA related roles. For example, Microsoft comes for a pure ML role itself and that particular test is entirely based on ML. So like that, Goldman Sachs also came for 2 roles - Quant and CS - but even in the quant test, they did ask some data structures questions. And I think the reason why they ask that is mainly to see how you apply yourself given any situation. The kind of problem statements that they give you in a data structures question is more in terms of how you apply the concept that you already know (as a data structure in this case) and how you approach a problem and solve it, which is again what every company is looking for. They look for problem-solving. So I tried to prepare data structures well. And besides that, I practised some quant-related questions. The placements cell had a lot of daily practice quant tests, and I found those very, very useful. There are a lot of quick Maths questions based on probability, statistics, unitary methods, quick arithmetic, and so on. I found them really good and I think they helped me in the tests as well, especially Goldman's test. Theoretical DSA knowledge also helped me a lot in the company tests. So all in all I would say, even if you're preparing for a Quant role, don't slack too much on the DSA preparation. And apart from that, I was recommended a couple of good quant books by some seniors. For example, there's a book called 'Heard on the Street', which has a lot of good brain puzzles and quick-solving puzzles which are very useful. And Brainstellar is another good reference to use.

With respect to IITB courses, honestly, if you've done a couple of probability courses or you have foundational probability knowledge, you should be comfortable on the quant side at least. Beyond that, it's more about practicing puzzle-type of problems, similar to those in the resources I've mentioned, because that is where the application comes into picture. Because it's more about how to apply those concepts whilst practicing all these different kinds of puzzles.

Can you walk us through the selection process, your test and interview?

We had to submit our resumes firstly, I remember signing my 2-page tech resume for Goldman Sachs. They had an offline test comprised of 2 parts back to back - One hour of Quant and then one hour of CS. The Quant test had about 20 quick math arithmetic questions, along with 4 small coding DSA questions at the end. The CS test had about 20 theoretical questions based on data structures followed by 4 more coding data structure questions. In our time, we were asked to compulsorily give both the Quant and the CS tests. Later on, I was shortlisted for the Quant role, among a total of about 100 of us. Cut to the day of the interview: interviews started around 5 PM on the Sunday of Day 1 Tech weekend, and there were about 5 to 6 different panels spread across the LHC. I think, based on which kind of role we were shortlisted for, we were sent to different panels, and each panel had around 3 different recruiters. Everyone had a different number of interviews; it seemed to be very subjective. I figure they interviewed us based on which team they found us fit for. So naturally, the kind of questions asked by each panel were also very different.

The panel which I was sent to seemed to be the ML-Statistics oriented one, since they were mostly asking such related questions. I had 3 rounds, but there were a lot of people who had only 2 rounds and still got selected. The number of rounds tended to vary based on how the recruiters found you - whether they liked you and felt like you were a good fit for their team, or if you'd fit better in another team, etc. My first round lasted about half an hour, the second round just about 10 minutes and 3rd round about 20 to 25 minutes. All 3 rounds are technical. Only in my was I asked the only HR question in the process - 'Why do you want to join Goldman Sachs as a summer analyst?' other question was mostly technical, and it was heavily based on my resume. Now here's an interesting anecdote In the first 2 rounds the recruiters asked me to walk them through my resume. on my tech resume, the first project which I had written under 'Key Projects' had the word 'regression' in bold on the first line.

And the moment they saw that word, they didn't look at the rest of my resume, they just stopped there and said, “Okay, you know regression? What is regression?”

And then they asked me a couple of basic questions on regression, after which they moved on to some basic puzzle questions. I was asked a little bit about compound interest versus simple interest. They asked me a couple of Baye’s theorem questions and in the second round they asked me a profit and loss question. In 3rd round, they asked me about the properties of the Gaussian distribution.

So that was my panel, which was asking mostly these kind of questions. There was another panel that asked a mix of quantitative and DSA questions.

Then there was another panel that was asking finance-related questions, I think maybe because these people had finance-related projects on their resume, such as a Fin-search project. And then of course, the CS-side panels were asking core data structures-related questions.

We'll get to your intern experience. How did you enjoy your internship? What was a typical day in your internship like?

The thing about Goldman Sachs is that their people culture is excellent, which means your work-life balance is excellent.

First of all, the Goldman Sachs office in Bangalore is very elaborate. There are 3 multi-storied buildings entirely dedicated to Goldman Sachs, housing the vast diversity of divisions of the firm. The cafeteria has several stalls selling delicious food, and of course, unlimited coffee in the pantry. Among non-edible joys, we were also gifted some merchandise. Overall, a typical day in my life was such: my team would log in around 11:30 am or 12:00 noon, and their meetings with members from London and New York would take place towards late afternoon and the evening.

I would prefer coming relatively early in the morning to get work done before the team comes in, so I could get feedback based on the work. So I used to go to the office around 9 am and power through my work amidst the silence of the empty office halls. And when the team would arrive I'd get my daily reviews done with my mentor. Initially, I used to log out around 5 pm (like a proper 9 to 5), but then as the days progressed I used to stay till say 7:30 - 8pm.

The kind of project that I was given was something that the team wanted to implement as part of their daily processes. So I had to work very closely with the team, especially on the technicalities. For different parts of my project, I had to consult different members of the team, which helped me understand their current work and the projects undertaken by them. This also helped me network really well with the team. So I was able to grow closer to the team as well.

What was the most enjoyable or memorable part of your internship?

The most enjoyable part was the team for me. No question. The thing about me is, even here on campus, I value the kind of people who I work with . If I have the best team with me, even the most monotonous work becomes enjoyable. The team that I had gave me so much energy that even if I finished my work, I’d be looking for ways to help them out in theirs (bless them, they never outsourced their work to me). My team completely took me and my co-intern in as members of the team.Whether it was going out for a movie, going out for dinner, or just sitting on the grass for hours at lunchtime, we always felt like member of the team, not just interns. I remember, there was a long weekend and the team was planning a trip to a hill station nearby, and they just looked at me and my co-intern and said “You guys are interns, you're in. You don't have a choice.

You have to come.” And they also got me back into the habit of playing table tennis, badminton, and chess chess as well. So I think the best experience was just interacting with the team because I've made connections for life now.

What suggestions do you have for someone who is targeting these Quant roles?

Ah, so I tend to be a little wary about giving advice because most people prefer to find their own way. And I'm still learning too. But, out of my own experience, I would say, our EP curriculum actually teaches us a lot of statistics and math, which you can apply in so many real-life scenarios. And fundamentally, the concepts that I applied in my project on my internship were things that we actually did learn in EP courses. And our curriculum makes our foundation so strong that we can handle any kind of application now. So if you're even remotely interested in tech or data science or analytics, just give it a shot; don't hesitate at all. Go deeper into it, that's what you're second year summer is for - to help you upskill for the 3rd year, even if you're not doing an internship over the second year. I didn't do an internship over the second-year summer. I did a project with a professor. If you're doing that and you kind of feel like you have the inclination towards quant, do something in your summer that can help you upskill on that and absolutely give it a shot, because in tech especially they value the test performance more than your actual resume. And never fear trying, because Fear closes the mind, but Curiosity keeps it open.

What are your future plans, What are you planning to pursue further?

At the moment I'm keeping all doors open. I do have a PPO, and would mostly be returning to the same team.   I can't predict for sure yet, but yeah, all options are open.

THE JOURNAL CLUB: RESEARCH PROMOTION WING OF PHYSICS DEPARTMENT

The Vision

The inclination of students towards non-core throughout the institute is inevitable. However, one of the few departments where the flame of core research still burns bright is the physics department. The passion of our students for physics makes them choose this stream over other options available during admission. To further develop research interest among students an initiative was launched in 2023 by OP-EP seniors Atharva Tambade, Kabir Bajaj and Rehmat Singh Chawla known as the Journal Club. It aimed at conducting sessions by students of the physics department on their research, giving juniors (especially freshies and sophomores) a glimpse of a variety of fields of research, so that they have prior knowledge and guidance before exploring projects under professors. It created a platform to ask questions, encourage group discussions and clear students' doubts related to different research domains. The talks helped juniors get the contacts of seniors working in various fields, under different professors. Research related discussions were now brought into informal domain, with jokes and chit-chats lightening the mood.

Their Motto is: Bridging the Gap Between Freshers and Research

Their main vision as stated by the Journal Club members is as follows:

"For many first-year Engineering Physics (EP) students, the idea of research is often unclear. Some may have joined the program driven by pop science interests, while others might not yet know if research is the right path for them. They must understand what research entails, and the Physics Journal Club seeks to address this need.

The club provides a platform for third and fourth-year students to showcase their work in various research fields, offering freshers and sophomores the chance to learn about the research problems others are tackling.

While students may find people working independently in their field of interest, the Physics Journal Club exposes them to a broader range of topics they may not have considered but might find fascinating. This exploration is essential in the program's early years to help students find what excites them the most.

Additionally, while graduate students have multiple opportunities to present their research at conferences, undergraduates rarely get such chances. The Journal Club provides this opportunity, helping them hone their presentation skills by showcasing their Bachelor's Thesis Project (BTP) or internship work in front of a diverse audience."

Currently the Club is spearheaded by Kabir Bajaj, Gopal and Mehul Goyal who are determined to take it to a next level

Structure of a Session

To get the best from a talk it is important to know how what all goes into the planning of a session and how it is structured. Let us go through what the members of the journal club have to say regarding it:

"We aim to feature at least one talk from each of the eight research groups every two semesters. To gauge the research interests of our third and fourth-year students, we circulated a Google form and received responses from people working in almost all fields. This overlap allows us to organize joint presentations where two speakers can present in one session.The preparation for each talk begins a week in advance, with a speaker chosen from those who expressed interest. We then coordinate a suitable time based on the availability of the speaker and the junior students. Invitations are sent out a few days before each talk, including details on the topic and timings.

The design secretary helps us create the poster which is circulated along with the invitation message. We always advise our speakers to tailor their content to be accessible to first-year students, although some material may still be challenging for everyone.

If a fresher is reading this, we advise that instead of focusing on just one area immediately, keeping your options open and soaking in as much as possible is better. It's advised that you attend all the sessions and explore the fields and get to know what people in the department as well as outside the department are interested in currently. At the end of your first year, you'll likely have a better idea of the fields you're most interested in, which you can dive into through programs like SoS, SoC, KSP, or SURP over the summer. One helpful thing, no matter which research path you choose, is to get comfortable with Python and the Linux command line.

These are essential tools in most fields, and having a good grasp on them will give you a head start.

Many sophomores might have already decided what field they want to work in, and it's the perfect time to reach out to professors, ask them about reading projects, and start getting involved with research groups. It's a great way to explore their interests more deeply and start contributing to the projects. The talks from their field of interest, along with enriching their knowledge, will also help them learn about the opportunities like professors from other universities, internship programs, etc., while other talks will help them explore other fields, which is essential if they are still undecided about what research field they want to choose.

We hope the IITB Physics Journal Club will serve as a dynamic space for knowledge sharing and skill development for all its members"

Sessions so Far

TThe Journal Club has covered topics from the domain of yocto to yotta involving different research areas of the department that include:

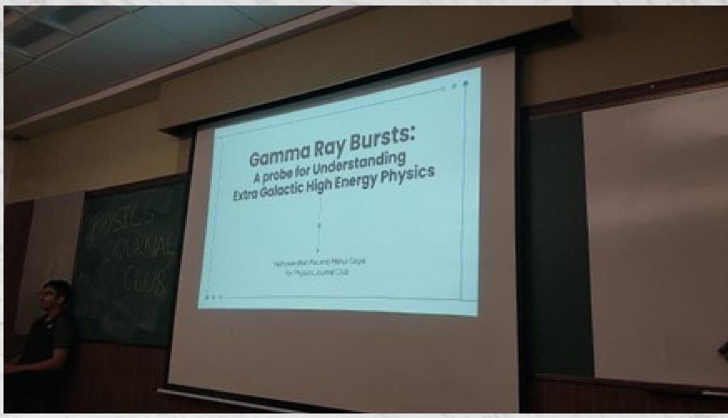
- High Energy Theory
- High Energy Experiments
- Condensed Matter Theory
- Condensed Matter Experiments
- Condensed Matter Theory
- Astronomy, Cosmology, and Gravity
- Quantum Information Theory

Here is a list of topics and their speakers on which talks were conducted :

Topic	Speakers
Quantum Computation: Experiments on Solid State Architectures	Devashish Shah, Aneesh Kamat
From Particle in a box to Feynman Diagrams	Rehmat Singh Chawla, Kabir Bajaj
Computation and Machine Learning	Kaustav Prasad, Mahesh Bhupati
A beginner's guide to General Relativity	Apurv Keer, Tarak
The Chaos inside us: Does the lack of order give rise to emergent phenomena?	Anurag Abhijeet Pendse
Atoms to processors: The World of Electronics	Paritosh Hegde, Mehul Vijay Chanda
Experimental Quantum Systems	Arnav Jain, Disha Zaveri
Gamma Ray Bursts: Exploring the Brightest Explosions	Yashowardhan Rai, Mehul Goyal
Dark Matter: What is it really?	Atharva Arora

This is just the beginning. As more and more students get into research and explore diverse fields, the list of topics will keep on expanding and the club will definitely bring glory to the Physics Department.

Special thanks to Gopal, Mehul Goyal and Kabir Bajaj from the Journal Club for helping to create this article



-Swayam Saroj Patel (B.Tech 3rd Year)

Guy wanna stay anonymous:

Valfie:-

You don't want this to end yet.
Do you?
You want someone to go there one more time.
You want to stand up and speak one last time.

There is so much to say, but not much time is left.
Still figuring out a way to avoid this theft.
Some things can't be said anyway.
They have to be felt only this hard way.

Maybe you'll never be able to figure out what this exactly is, but...
If you can smile with those eyes you are trying to avoid getting wet, you know it's something you'll never forget.
It's something that can't be taken away...
It's for you to keep forever.
It's something you have built in this short span of four years.
It might give you some tears.
Maybe not today... maybe not tomorrow...
but the day, the time has to borrow.

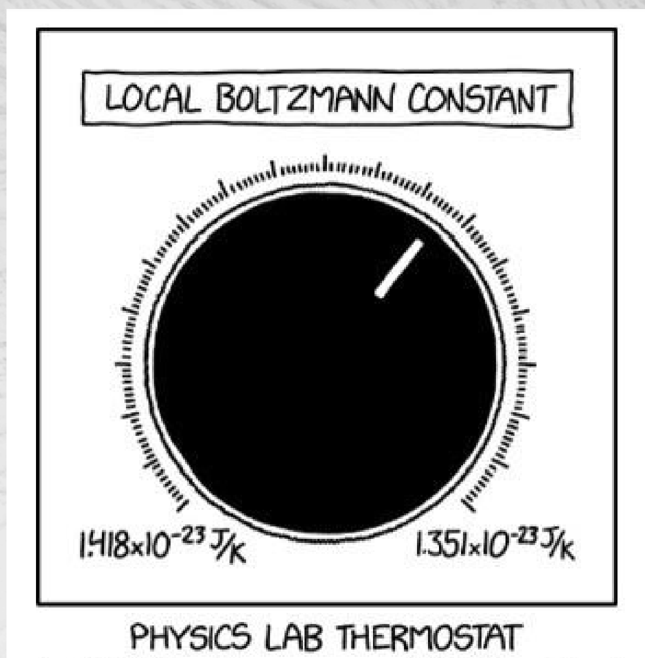
You know this day has to end like this piece...
Don't you?
I know it's not good to lie, but someday you will come back...
Won't you?

8th May, 2024
(Ah! It's already 9th)

फिर से हमें ये दावत-ए-मोहबबत कैसी
तबाह करने को छोड़ दी कोई कसर ऐसी,
हम जानते हैं तू वही है पहली थी जैसी,
दफा हो मेरी जिंदगी से जा तेरी ऐसी तैसी।

-Mohammad Hasan Iqbal

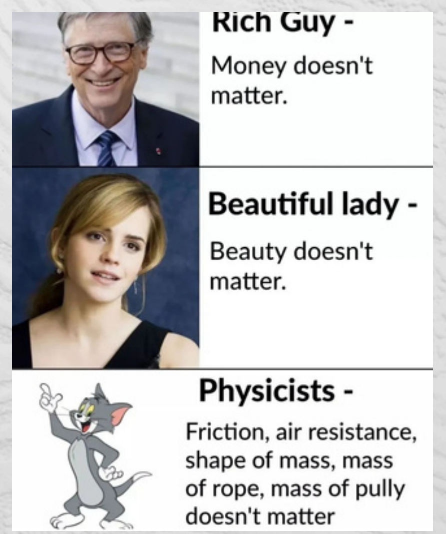
- **Soham Sahasrabuddhe**



Electric field to time independent magnetic field:

Har pal yaha,
Jee bhar jiyo,
Jo hai samaa,
Curl ho na ho!

- Yash Gupta



-Mohammad Hasan Iqbal

Chessling

Parent's Orientation

PG Night