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Research Interest and Experience

My academic focus centers on **Gravitation** and **Black Hole Physics**, with a strong foundation in General Relativity, Classical Mechanics, Quantum Field Theory, and Quantum Mechanics. Currently, my research is dedicated to Modified Gravity theories. Additionally, I possess a keen interest in **Computational Astrophysics** and boast proficiency in programming languages such as Python, C++, Fortran, Mathematica, and ROOT (CERN).

Education

Indian Institute of Technology Bombay Bachelor of Technology, Department Of Physics Majoring in Engineering Physics , while pursuing an Honors in Physics	GPA: 8.4/10 '21 – Present
Nirmala Memorial Foundation College of Science HSC Maharashtra State Board	95.50% '19 – '21
St. John's High School SSC Maharashtra State Board	90.20% '19

Scholastic Achievements

Attained an impressive 9.47 SPI out of 10 during the Spring semester of 2022-23 at IIT Bombay	('23)
Attained an exceptional 99.15 percentile ranking in the JEE - Main , surpassing over 1 million candidates	('21)
Secured a 98.11 percentile in the JEE - Advanced , standing out among 0.14 million+ candidates	('21)
Demonstrated excellence with a 99.86 percentile in the MHT CET , outshining 0.41 million+ candidates	('21)
Part of the IPHo 2023 Indian delegation's selection committee, achieved 3 gold and 2 silver medals	('23)

Key Projects

Quantization in $D \rightarrow 4$ Gauss-Bonnet Gravity Guide: Prof. Shankaranarayanan S, Department of Physics, IIT Bombay	Jan '23 – Present
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- Working on a **4D Gauss-Bonnet gravity action** obtained from **Kaluza Klein dimensional reduction**
- Learning to perform Relativistic and Field Theory related calculations in **xAct Mathematica** and **Cadabra 2**
- Searching for quantum corrections resulting from expansion about a background classical solution to the 4D field equations and examining the effect of the **quantum fluctuations** on the "physical" space-time
- Obtained field equations of **Boson Stars (Q-Balls)** in 4D EGB gravity based on Glavin and Lin's approach of rescaling the Gauss-Bonnet constant to study the dynamical effects on the Gauss-Bonnet term

3D Gravity and BTZ Blackholes Course Project, Guide: Prof. Vikram Rentala, Department of Physics, IIT Bombay	Aug '23 – Present
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- Engaging in a comprehensive review project focusing on **3 dimensional gravitational theories** and their implications, with a particular emphasis on the **BTZ black hole** in (2+1)-dimensional topological gravity
- Investigating the simplification of 3D gravity and exploring alternatives such as topologically massive gravity
- Analyzing various solutions within the realm of 3D gravity, including **static N-body solution**, and rotating source (**Kerr**) **solution**, and delve into the asymptotic structures inherent to these models
- Conducting a thorough review of the BTZ black hole solution in (2+1)-dimensional gravity with a negative cosmological constant, drawing comparisons to the well-known 4D Schwarzschild and Kerr black holes

Hands on Computational Physics : Raytracing in Curved Spacetime

June '23 – July '23

Season Of Code, Web and Coding Club(WnCC), IIT Bombay

[Source](#)

- Explored diverse numerical analysis methodologies for computational physics using **Python** and **Fortran**
- Executed projects encompassing the **visualization** of Poisson's equation solutions, Hydrogen atom eigenstate **wavefunctions** and eigenvalues, and resolution of **time-evolution systems** for non-linear oscillators
- Engineered a **C++ raytracer** tailored to simulate a curved spacetime environment which entailed the numerical solutions of geodesics encircling a **Schwarzschild black hole**, leading to visual depictions of phenomena such as **accretion disks** and gravitational lensing effects, including the formation of an **Einstein ring**

Exploring Hertzsprung-Russell Diagrams

Aug '22 – Nov '22

Computational Astronomy Bootcamp, Kritika: The Astronomy club of IIT Bombay

[Source](#)

- Engaged in a two-week virtual workshop on **computational astronomy**, hosted by Kritika Astronomy Club
- Focused intently on grasping the intricacies of **Stellar Evolution** and **Classification**, exploiting observational data using **data science modules** for array manipulation to statistically deduce outcomes and gain insights
- Spearheaded an intricate data analysis project centered around the NGC 2808 cluster, drawing from the extensive HST UV Globular Cluster Survey (**HUGS**) **dataset**, encompassing over **100 million** data points.
- Accomplishments included constructing the **Hertzsprung-Russell Diagram** of the cluster and producing an insightful visualization depicting **stellar positions** based on RA and Dec values from the dataset

Other Projects

Cosmology And Dark Matter

May '22 – July '22

Summer Of Science, Maths, And Physics (MnP) Club, IIT Bombay

[Report](#)

- Acquired a foundational understanding of Einstein's General Relativity through **Reimannian geometry** and **manifolds** and also through the application of the **variational principle** to the Einstein-Hilbert action
- Focused on its cosmological implications, particularly in relation to mathematical frameworks of the universe within the context of **FLRW cosmology**, like the Friedmann equations, Hubble's law, red-shift effects, etc.
- Engaged in theoretical exploration of the diverse epochs of the universe spanning from the Big Bang while investigating evidence and an array of potential **dark matter** candidates and **dark energy** models
- Developed an exhaustive LATEX report and an interactive presentation, intended as valuable introductory points of reference for others in the field of General Relativity, Cosmology, and dark matter

Non-Linear Dynamics in Biochemical Networks

Autumn '22

Course Project, Guide: Prof. Amitabha Nandi, Department of Physics, IIT Bombay

[Report](#) | [Source](#)

- Worked in a team of 4 on the basic building blocks of dynamic behavior in **non-linear control systems**
- Studied how simple signaling pathways can be embedded in networks using positive and negative feedback to generate **complex behaviors** like toggle switches and oscillators using **mathematical techniques**
- Reproduced graphs from a research paper about Sniffers, buzzers, toggles, and blinkers: dynamics of regulatory and signaling pathways in the cell by solving differential equations using **Runge-Kutta algorithms**

Underlying Events in Proton-Proton Collisions

Autumn '22

Course Project, Guide: Prof. Sadhana Dash, Department of Physics, IIT Bombay

[Report](#) | [Source](#)

- Engaged with an extensive dataset comprising **two million** events within **p-p collision** systems, which were generated through the utilization of Pythia 8, a Monte Carlo event generator
- Methodically analyzed the data across **six distinct multiplicity** categories, effectively categorizing particle distributions into **three distinct regions**. This classification was based on the azimuthal angle of the leading jet's direction, while concurrently investigating the distributions of **transverse momentum** and **rapidity**
- Leveraged the **ROOT** software to effectively generate Course Projects, thereby **plotting distributions** across varied regions and multiplicity classes and extracting and interpreting valuable trends from the data

Bubble Trouble Game

Course Project, Guide: Prof. Parag Kumar Chaudhari, Department of CSE, IIT Bombay

Autumn '21

[Source](#)

- Executed a series of feature implementations and performance enhancements within a captivating **bubble shooting game** by proficiently utilizing **C++** programming language in a simplified version of Code::Blocks
- Skillfully leveraged **Object-Oriented Programming** principles like classes and structures to streamline and enhance the game's intricacies, resulting in a more engaging and dynamic experience for the user
- Demonstrated a commitment to user satisfaction by integrating informative messages via strategically placed **conditional statements** and **looping structures** making the game more intuitive and enjoyable for players

High-Frequency LED Clock

Course Project, Guide: Prof. Pradeep Sarin, Department of Physics, IIT Bombay

Spring '22

[Report](#) | [Source](#)

- Developed a **highly accurate digital clock** utilizing an ,Field Programmable Gate Array, **FPGA board**, achieving precise timekeeping through the utilization of our meticulously designed **Verilog-HDL** code
- Incorporated counters and buttons for an **input mode**, empowering users to define their **desired time**
- Built a **LED display unit** for the clock using effectively linked separate 7-segment displays and interfaced it to showcase multiple modes on a **single screen**, thus enhancing the versatility and functionality of the clock

Teaching Assistantships and Mentorships

TA, PH111 : Classical Mechanics

Department of Physics, IIT Bombay

Spring '22

- Provided guidance and support to a cohort of **38 first-year students**, aiding them in resolving **tutorial problems** and addressing **general inquiries** while effectively tackled problem-solving tasks encompassing subjects like Newtonian Mechanics, Planetary Orbital Mechanics, and Special Theory of Relativity

TA, MA108 : Differential Equations

Department of Mathematics, IIT Bombay

Spring '22

- Provided guidance to a group of **40 freshmen** by aiding them in **solving tutorial problems** and addressing **general doubts** involving the resolution of Ordinary Differential Equations (ODEs) through techniques such as undetermined coefficients, variation of parameters, Laplace transforms, and convolutions

Mentor, Summer of Science : Cosmology and Dark Matter

Maths and Physics(MnP) Club, IIT Bombay

May '23 – July '23

- Mentored **3 freshers** to study Cosmology and Dark Matter as a part of the Summer Of Science project by providing them with materials to study **mathematical models of the universe** and **dark matter candidates**

Technical skills

Languages	C++, Fortran, Python (Numpy, Pandas, Scipy, Matplotlib, Astropy), HTML/CSS, Verilog-HDL
Softwares	Blender, \LaTeX , ROOT, LTSpice, AutoCAD, Gnuplot, Arduino IDE, Mathematica, CUDA Toolkit

Courses Undertaken

Physics	Special Relativity, Advanced General Relativity*, Classical Mechanics, Electromagnetism, Relativistic Quantum Mechanics & Quantum Field Theory*, Waves & Oscillations, Data Analysis & Interpretation, Non-Linear Dynamics, Thermal Physics, Photonics*
Mathematics	Linear Algebra, Complex Analysis, Differential Equations, Calculus, Numerical Analysis
Miscellaneous	Introduction to Electronics, Digital Systems, Electronics Lab(Analog, Op-amp, Digital and Microprocessor*), Computer Programming and Utilization

Extracurriculars

Mentored 4 freshers in a standup comedy competition Laughter Riots 3.0 by Comedy Cons, IIT Bombay	('23)
Awarded Student Of The Year by Times Of India NIE for securing first rank in the school	('19)
Appointed as the school Head Boy, St. John's High School , for three consecutive years	('17 - '19)
Placed 4th in Mumbai and was selected for State Level Suryanamsakar competition	('16)
Learned Drums through Introductory Music Learning Programme by IIT Bombay	('22)