

Research interests

Theoretical Cosmology, Astrophysics and Gravitation

Education

Indian Institute of Technology Bombay

[Nov 2021 - Present]

- **Major degree (with Honors):** Bachelor of Technology in Engineering Physics; Current CPI: **9.81/10**
- **Minor degree:** Department of Mathematics; Minor CPI: **10/10**

Publications

Navdha, P. Busch, S. D. M. White, *The relation of galaxies and dark matter haloes to the filamentary Cosmic Web*. <https://arxiv.org/abs/2412.03438>. Accepted in the Monthly Notices of the Royal Astronomical Society (MNRAS).

T. Roychowdhury, **Navdha**, H. Rathore. *Anomalous proper motions of six LMC clusters*. <https://arxiv.org/abs/2309.02298>. In preparation.

Seminar Presentations and Posters

Invited Talk (November 2024): University of Arizona, Galaxy Theory Group Meeting, Steward Observatory, presented original work on *Anomalous proper motions of six LMC clusters* in collaboration with Himansh Rathore (U. Arizona), Dr. Knut Olsen and Dr. Yumi Choi (NOIRLab)

Poster presentation (January 2024): ResCon 2024, IIT Bombay. Selected among 10/100 finalists from the country to present original work on LMC globular clusters and their possible extragalactic origins.

Talk (October 2024): Tata Institute for Fundamental Research, Mumbai, Dept. of Astronomy and Astrophysics, Group meeting. Presented work by Busch & White (2020): The Tessellation-Level-Tree: characterizing the nested hierarchy of density peaks and their spatial distribution in cosmological N-body simulations

Research and Academic Experience

Relation of galaxies and dark matter haloes to the Cosmic Web

https://navdhabh.github.io/cosmic_web/

[Summer '24]

Guide: Prof. Dr. Simon White | Max Planck Institute of Astrophysics, Garching

- Analyzed the systematic dependence of galaxy & halo properties on their environment (Cosmic Web); efficiently handled large datasets (10^{10} particles in Millennium Simulation) using computer cluster Freya
- Studied the mass dependence of web fractions, dependence on distance distributions, and specific star formation rate dependence using computational geometry techniques to categorize in-web and out-web galaxies.

Quantum Cosmology and Eternal Inflation

<https://github.com/navdhabh/qc/tree/main>

[Jul '23 - Nov '23]

Supervisor: Prof. Vikram Rantala | Department of Physics, IIT Bombay

- Studied the theory of **Inflation** including **power spectrum of scalar & tensor perturbations** at horizon re-entry & re-derived results from the **T.A.S.I.** lectures on Cosmology by Daniel Baumann (2009)
- Studied quantum cosmology with an emphasis on the **Hartle-Hawking wavefunction** of the universe, also studied the theory of Eternal Inflation by Alan Guth in the context of Quantum Cosmology

Inferring delayed time distributions of BBHs as a function of their masses

[August '24 - present]

Guide: Prof. Suvodip Mukherjee | Dept. of Astronomy & Astrophysics, TIFR | Bachelor Thesis Project

- Extensively studied the tools and techniques used in gravitational wave (GW) research, including GW theory and simulations, and the work on inferring Binary Black Hole (BBH) source parameter populations

- Constructed multiple toy models to infer a mass-dependent delay-time distribution both parametrically and non-parametrically; applying the methods on the Gravitational Wave Transient Catalogue 3 (GWTC-3) data

Optimal Parameter Constraints for Dark Energy Models |

<https://github.com/navdhabh/paramconstraints/tree/main>

[May '23 - May '24]

Guide: Prof. Bharat Ratra | Kansas State University

- Applied MCMC parameter estimation simulations to constrain model parameters Ω and H_0 for Λ CDM, XCDM and ϕ CDM models using the Hubble parameter ($H(z)$) & Baryon Acoustic Oscillations (BAO) data
- Studied cosmological tests from General Relativity and Cosmology by Jim Peebles including Gravitational Lensing, Bolometric Distance Modulus, Galaxy Count and density fluctuations in linear perturbation theory

Gaia Data Analysis

[Jul '22 - Sep '22]

Krttika Summer Projects | Krttika - The Astronomy Club, IIT Bombay

- Worked in a group of 7 to extract Gaia Data from European Space Agency's Gaia Archive using ADQL queries for specific classes of stars including the Large Magellanic Cloud (LMC) and the Galactic Centre
- Used HR diagrams to arrive at qualitative results including the presence of older red giants in the Large Magellanic Cloud; also studied the LMC's proper motion distribution to calculate its tangential velocity

Impact of longitudinal phase-matching variations on three-wave nonlinear interactions [Aug '23 - Nov '23]

Course Project | Supervisor: Prof. Anshuman Kumar | Department of Physics, IIT Bombay |

<https://github.com/navdhabh/PH421---project-report>

- Undertook a comprehensive analysis of three-wave nonlinear mixing amidst longitudinal discrepancies in phase-matching conditions following a study by Dorrer (2023); winner of the Best Project Award
- Quantified the performance of second-harmonic generation through the application of polynomial representation of wave-vector and verified this for empirical data for five partially deuterated DKDP crystals

Analysis of net charge in p-p collisions AT 13 TeV with PYTHIA 8

[Oct '22 - Nov '22]

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

- Conducted the first of its kind comprehensive analysis of variations in kinematic variable and multiplicity distributions with charge asymmetry by obtaining and analyzing distributions of transverse momentum, azimuthal angle, and pseudorapidity in p-p collisions at 13TeV using ROOT library in C

Cosmology and Dark Matter

[Summer '22]

Summer of Science | Maths and Physics Club, IIT Bombay

- Studied Newtonian cosmology with emphasis on cosmological models and cosmic dynamics following lectures by Prof. Leonard Susskind

Scholastic Achievements

- Ranked 2nd out of 62 students in IIT Bombay's Engineering Physics batch of 2025 [Present]
- Awarded DAAD-WISE Scholarship for research at Max Planck Institute for Astrophysics Germany [Summer '24]
- Among the only 2 students in the institute selected for Asian Universities Alliance Entrepreneurship Bootcamp at Hong Kong University of Science and Technology as a part of the AUA Overseas Study Program ['23]
- Recipient of the Institute Academic Prize for exemplary academic performance in 2nd & 3rd year ['23]
- Secured Academic Proficiency (AP) grade given to top 1.5% in 5 courses for exceptional academic performance
- Secured 99.69%ile in JEE Main '21 (1.1mn+ candidates) & 98.49%ile in JEE Advanced (0.15mn+ candidates)
- Bagged the Student-preneur Award (ATL Girl) by NITI Aayog under the Atal Innovation Mission ['18]

Technical Experience

Demonstrating Transit Method for Exoplanet Detection using Arduino

<https://github.com/navdhabh/PH435>

[Fall '23]

Course Project | Supervisor: Prof. Pramod Kumar | Department of Physics, IIT Bombay

- Built a star-planet model aligned edge-on with a light sensor to replicate light-curves for exoplanet detection
- Analyzed the obtained light-curves in Arduino IDE to obtain and verify the system parameters

Conway's Game of Life using Logic Gates

[Spring '23]

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

- Ideated and built a **hardware simulation** of Conway's Game of Life on a **4×4 LED matrix** using digital logic
- Used DE0-nano board featuring Altera Cyclone IV FPGA and a built-in USB-Blaster for FPGA programming to implement the rules of Life written in **Verilog-HDL** code documented in Quartus Prime

Junior Design Engineer, Mars Rover Team, IIT Bombay

[Feb'22 - Mar '23]

MRT won Best Navigation Task award (remote category) in the European Rover Challenge (ERC) '22

- Worked on obstacle detection & **path planning** of a prospective Mars rover in the **autonomous subdivision**
- Presented a detailed study on **power supply & communication** of the rover using Advanced Stirling Radioisotope Generator and Multi-mission Radioisotope Thermoelectric Generator for the final report of **IRDC 2022** (MRT stood 5th worldwide in International Rover Design Challenge (IRDC) '22 out of **37+ teams**)

Teaching Experience

Undergraduate Teaching Assistant

[Dec '22 - Present]

MA106 (Lin. Algebra), MA105 (Calc-I), MA108 (ODEs), PH112 (Quantum Physics - Intro), PH221 (Analog Electronics - Theory + Lab), PH110 (Intro. to Classical & Quantum Phy.), CH107 (Quantum Chemistry)

- Conducted weekly problem-solving **tutorial sessions** and doubt-clearing sessions for a batch of **40** students
- Assisted with **handling logistics** of the course; also involved in **invigilation** and **grading** of quizzes and exams

Mentor, Gaia Data Analysis | Krittika Summer Projects

[Summer '23]

Krittika - The Astronomy Club, IIT Bombay

- Conducted weekly sessions for **7** students ranging from **UG to M.Tech.** explaining concepts of stellar evolution using HR diagrams; instructed the mentees to successfully be able to retrieve Gaia data, analyze the properties of the given class of stars using simple cuts; also explained how to analyze the MCs and the Magellanic bridge

Leadership and Organisational Experience

Volunteer | Krittika - The Astronomy Club, IIT Bombay

[May '22 - May '23]

- Worked in a team of 16 responsible for organizing institute-wide events including conducting regular **stargazing sessions**, designing & assessing **problem statements** & assignments for various Institute Technical Competitions including the club's flagship **Astromania** and **General Championships**

Department Academic Mentor | Department of Physics, IIT Bombay

[May '23 - May '24]

- Co-mentored a group of **6** sophomores by providing **academic guidance** and **general counselling**
- Responsible for conducting information sessions, dissemination of resources, & bridging the student-faculty gap

Volunteer | Educational Outreach - National Service Scheme, IIT Bombay

[Dec '21 - Jul '22]

- Contributed 100+ hours of volunteering in the Prayog and Open Learning Initiatives, teaching underprivileged kids on campus

Extra-Curriculars

Writing & Journalism

- Among the only **6** out of **350+** participants from the city to win at **Inter School Creative Writing Competition** on Fight Against Counterfeiting and Smuggling organised by FICCI CASCADE [19]
- Worked with the **National Editorial Team** of the Times of India NIE in an eight-day Training Programme [18]
- Published **15+** poems and articles in **The Times of India NIE** and **The Curious Times Blogs** [18-'20]
- Shortlisted for the **Popular Choice Award** for the **Lockdown Diaries** contest by ReachIvy.com [20]

STEM and miscellaneous

- Stood **4th** in the **Annual Mathematics Olympiad** organized by **BITS Pilani** out of **100+** participants [21]
- Stood **4th** in the **Bennett Hatchery Innovation Launchpad** out of **80+** teams from around the country [18]
- Secured merit certificate for outstanding performance in **National Financial Literacy Assessment Test** [17]
- Secured an **international rank** of **100** and **gold medal** in National Science Olympiad organised by SOF [21]

References

Prof. Dr. Simon White

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