Shivani Ramesh

Durham University | shivani.ramesh@durham.ac.uk | +44 7470577450

Education

MPhys (Hons) Physics and Astronomy, Van Mildert College, Durham University (2021–2025)

4th year Relevant Courses: General relativity; Electrodynamics; Theoretical astrophysics; Observational Astronomy.

3rd year Relevant Courses: Planets and Cosmology; Quantum Mechanics; Nuclear Physics; Condensed Matter Physics; Statistical Physics; Modern Atomic and Optical Physics.

3rd year Grade - 2:1 (68%)

2nd year Relevant Courses: Stars and Galaxies; Quantum Mechanics; Electromagnetism; Condensed Matter Physics; Thermodynamics; Theoretical Physics; Mathematical Methods in Physics.

2nd year Grade - 2:1 (69%)

International Foundation Year in Science and Engineering, Durham University (2020–2021)

Courses: Advanced Physics; Pure Mathematics and Mechanics; Extended Research Project

Grade - 84% (First Class)

Research Experience

Master's thesis: Repopulating N-body Simulations Below the Resolution Limit, Durham University (October 2024 – June 2025)

Supervisors: Dr. Sownak Bose, Dr. Alejandra Aguirre-Santaella

- **Enhancing cosmological N-body simulations** by integrating unresolved lower-mass dark matter subhaloes, improving resolution for more accurate predictions of gamma-ray annihilation signals.
- **Analysing Milky Way-like dark matter haloes** using COCO simulation data to extend the subhalo mass function below resolution limits, down to ~10^2 $M_\odot$, to understand galactic structures.
- **Modelling subhaloes with Navarro-Frenk-White density profiles** and accounting for tidal effects to calculate annihilation J-factors, exploring how unresolved subhaloes might significantly boost the gamma-ray signal for indirect dark matter detection.

Research project: Dynamics of Galaxy Formation: Investigating Angular Momentum in Warm and Cold Dark Matter Paradigms, Durham University (July 2024 – July 2025)

Supervisor: Dr. Sownak Bose

- **Conducting N-body simulations of Cold and Warm Dark Matter Universe models** to investigate the formation of **ultra-diffuse galaxies**, enhancing proficiency in simulation software and understanding dark matter's influence on galaxy morphology.
- **Exploring the role of angular momentum in dark matter haloes** on the formation of ultra-diffuse galaxies, developing analytical skills and deepening knowledge of cosmological processes.
- **Utilising advanced simulation tools and performing comprehensive literature reviews** to compare simulation results with observational data, improving research methodology and data synthesis abilities.
- Developing critical insights into how Warm and Cold Dark Matter models differently impact galaxy structure, aiming to advance theoretical astrophysics comprehension.

Research Projects

Astro-Lab: Determining Orbits of Asteroids, Durham University (October 2023 - January 2024)

Under the guidance of Dr Mark Swinbank and Dr Alistair Edge at Durham University, my research partner and I explored the orbital dynamics of the Main Belt and Trojan asteroids. Utilising the observatory facilities of the Department of Physics, we collected comprehensive astrometric data, analysed using the Gaia database. We employed Monte Carlo simulations to enhance our predictions of asteroid orbits and applied parallax techniques to accurately determine their distances. By refining these orbital paths through advanced data processing and statistical methodologies, we not only increased the precision of our measurements but also significantly improved the reliability of our predictive models. This project demonstrated the effectiveness of advanced astrometric tools for future space missions, such as asteroid mining and navigational planning.

Individual Computing Project: Supernova Cosmology, Durham University (October 2023 - March 2024)

During my research project under the guidance of Dr. Dimitri Gadotti at Durham University, I developed a comprehensive understanding of cosmological models with a specific focus on the role of dark energy in the expansion of the universe. I analysed Type IA supernovae data using advanced statistical methods involving Markov Chain Monte Carlo techniques. This work significantly enhanced my skills in data interpretation and model fitting. Additionally, I deepened my knowledge of numerical methods and computational tools to address complex astrophysical challenges, particularly exploring the effects of non-flat geometries on dark energy evolution. I refined my understanding of the universe's expansion dynamics by integrating time-varying dark energy parameters into cosmological models. I developed problem-solving skills by adapting models to include curvature and dynamic state parameters. The project broadened my knowledge of cosmology and showcased innovative approaches to interpreting cosmological observations.

Research-led Investigation: Unveiling the Formation of Galaxies, Durham University (January 2023 - March 2023)

My partner and I conducted a research project at Durham University under the guidance of Dr. Dimitri Gadotti, focusing on the formation of the M81 and NGC 1530 galaxies. To analyse their Sersic indices, we employed SAO DS9 software alongside theoretical modelling, enhancing our proficiency in image analysis and model application. We applied chi-square statistical methods to validate the brightness profiles of these galaxies, which enhanced our skills in statistical analysis and data interpretation. The confirmation of our models through this project solidified our understanding of galactic structures and significantly improved our analytical techniques.

Programming Skills

- **Linux:** Knowledge of the Linux operating system.
- **Python:** Experience using Python for astrophysical data analysis and scientific computing. Knowledgeable in applying Python for Bayesian statistics, data modelling, and visualisation using libraries such as NumPy, SciPy, Pandas, and Matplotlib.
- **Supercomputing:** Experienced with leveraging supercomputing resources for complex simulations and data-intensive tasks in cosmology. My focus is on enhancing computational efficiency through parallelisation techniques, which are essential for optimising processing times and scaling up analyses.
- **Cosmology-Specific Software:** Proficient in using DS9 and Gaia for astronomical data visualisation for theoretical modelling and analysis.
- **Microsoft Excel:** Advanced user of Excel for statistical analysis and analysis of extensive data sets effectively.

Skills and interests

Skills:
- Research skills in Theoretical astrophysics.
- Experimental and applied physics skills.
- Professional report writing skills.

Languages:
- English (Proficient)
- Tamil (Native)
- Hindi (Intermediate),
- Arabic (Beginner)

Volunteering:
- Interest in engaging and educating diverse student groups.
- Climate awareness and tree-planting initiatives.

Interests:
- Running – participated as a sprinter.
- Swimming – acquired proficiency in swimming, developing both technique and endurance.
- Badminton (Beginner)

Societies:
- Physics Society, Durham University
- Astronomy Society, Durham University.
- Women in STEM Society, Durham University

Conferences:
- Small Galaxies, Cosmic Questions – II, Durham University