

Subhrat Prahara

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RESEARCH INTERESTS

- **Computational astrophysics** and **Astro-statistics**, with specific applications in high-energy astrophysics and astro-particle physics using large-scale GR-MHD and PIC simulations along with radiative transfer. Also interested in application and addition of Machine Learning methods to improve existing computational pipelines.

EDUCATION

Birla Institute of Technology and Science (BITS) - Pilani University <i>B.E. Mechanical Engg., M.Sc. in Mathematics - 8.1/10</i>	Hyderabad, Telangana Aug 2018 - July 2023
Birla Bharati <i>Science, CBSE Class 12 (AISSCE) - 90.25%</i>	Kolkata, West Bengal 2017-18

WORK AND RESEARCH EXPERIENCE

Research Assistant (Dr. Francisco Villaescusa-Navarro) <i>CCA, Flatiron Institute, Simons Foundation</i>	Oct 2022 – Present New York, USA
<ul style="list-style-type: none">• Using Graph Neural Networks to infer virial masses of galaxy clusters.• Using stellar masses, peculiar velocities, and comoving coordinates of individual galaxies as parameter space.• Making the model geometrically invariant to rotation and translation for robust training and predictions.• Working with the Uchuu simulation catalog to obtain the training data and the SDSS4 data releases for testing.• We compare the mass estimates obtained against those through virial methods, caustics, x-ray profiles etc.	
Research Assistant (A/Prof Christoph Federrath, Dr. Amit Seta) <i>Mount Stromlo Observatory, RSAA, ANU</i>	July 2022 – Aug 2023 Canberra, Australia
<ul style="list-style-type: none">• Studying role of driven turbulence on MeV-GeV CR transport in turbulent ISM using MHD-PIC simulations• Studying effect of Alfvénic and sonic Mach numbers on Larmor radius normalised against driving scales• Calculating diffusion coefficients from temporal evolution of separation and fitting PDFs to separation distribution• Interpreting dependence of test particle propagation on driving modes in terms of the field structure evolution• Investigating existence of super-diffusion for given regime and possible dependence on turbulence driving modes	
Summer Research Intern (Dr. Iair Arcavi) <i>Wise Observatory, RBSSPA, TAU</i>	May 2022 – August 2022 Tel Aviv, Israel
<ul style="list-style-type: none">• Quantification of Humphreys-Davidson limit using synthetic stellar populations and observed population data• Generated CSPs with informed assumptions on star formation history, multiplicity and mixing• Evolved multiple stellar evolution tracks based on observed Milky Way, SMC, and LMC compositions• Inferred implications of massive star evolution around HD limit on high-energy transients and GW events• Compared synthetic stellar populations with observed data to reconcile the empirical HD limit with theory	
Research Assistant (Dr. Sayantan Auddy) <i>Jet Propulsion Laboratory, NASA</i>	Oct 2021 – Oct 2022 California, USA
<ul style="list-style-type: none">• Used Pruned Convolutional Neural Networks to interpret planet properties in extrasolar protoplanetary disks• RT-HD physics-informed generation of synthetic data to directly apply the architecture to observational images• Used massively parallel, GPU-driven code FARGO3D for orbital advection modeling of Hydrodynamic calculations• Used RADMC-3D for observation-mimicking images and spectra from FARGO3D output using radiative transfer• Co-developed Bayesially tuned classification-regression co-network predicting number of planets and their masses	

TECHNICAL SKILLS

Languages: Python, C/C++, MATLAB, Fortran

Software: OpenFOAM, Gmsh, Paraview, FEniCS, Tecplot, LaTeX, Fargo3D, Radmc, Flash4

Developer Tools: Docker, OpenMP, PyCharm, Jupyter, Visual Studio Code, Sublime, Vim (wsl2 - Ubuntu)

Libraries: pandas, NumPy, Matplotlib, Scikit-learn, TensorFlow, PyTorch, Seaborn, bilby

RELEVANT PROJECTS - PHYSICS AND ASTRONOMY FOCUSED

- Evolution of Large Scale Structure in $F(Q)$ gravity** | *Gadget3, Simp2LPTic* Aug 2022 – Oct 2022
- Investigated anisotropic stellar solutions admitting Finch-Skea symmetry in presence of exotic matter fields
 - Specifically focused on Bose-Einstein Condensate Dark Matter, Kalb-Raymond, and $U(1)$ symmetric Gauge fields
 - Used MCMC fitting techniques to constrain our modified gravity model against Pantheon, Hubble, and BAO data
 - Used N-body simulations to model structure evolution Dark and Baryonic Matter+DE scenarios in obtained model
- Accretion around models of exotic wormholes** | *Gyoto, Mathematica* April 2022 – July 2022
- Studied spherically symmetrical wormhole solutions probing accretion dynamics around special WH models
 - Studied specific cases of Schwarzschild, Reissner-Nördstrom, and Damour-Solodukhin (DS) wormholes
 - Obtained test-particle orbital solutions using normalisation by \mathcal{L}^2 effective potential to model accretion disks
 - Performed ray-tracing to obtain synthetic images analysing the photon sphere for both thin and thick disk cases
 - Analysed accretion jet properties and microlensing of the radiative fluid sphere due to wormhole curvature
- Dense Matter EoS in Neutron Stars using Bayesian Analysis** | *Python* Jan 2022 – May 2022
- Studied about the development of states with depth inside a Neutron Star from a Quantum Mechanical perspective
 - Studied Bayesian Statistical techniques along with associated practices such as Nuisance Parameter classification.
 - Applied bayesian techniques to infer radius and tidal deformability (TD) of PSR J0740+6620 using NICER data
 - Employed parabolic expansion-based parametrization around piece-wise polytrope for nuclear saturation density
 - Compared radius and dimensionless TD from above against a that predicted by symbolic regression inferred model
- Accelerated expansion of the universe in modified gravity** | *Mathematica* Jan 2022 – May 2022
- Took given metrics such as FLRW to obtain Christoffel symbols and the Ricci tensor
 - Obtained non-metricity and superpotential tensor for each metric case
 - Found the energy-momentum tensor for the selected combination of perfect fluid and metric tensor model
 - Explored and reviewed non-ideal effects such as Anisotropy and Chaotic Behaviour in $f(R,T)$ and $f(Q)$ gravities
- Mechanical study of waves in heterogeneous medium** | *MATLAB, Mathematica* Apr 2021 – Dec 2021
- Studied the impact of inhomogeneity associated with the medium on the propagation of torsional waves
 - Modelled torsional wave propagation, specifically phase velocities under impact of initial stress
 - Deduced displacements in a multi-material medium and found the closed form dispersion relation using BVPs
 - Studied the effect of imperfections between interfaces of two distinct materials on phase and group velocity

PEER-REVIEWED PUBLICATIONS

- O. Sokoliuk, S. Arora, S. Praharaj, A. Baransky, P.K. Sahoo, **On the Impact of $F(Q)$ gravity on the Large-Scale Structure**, Monthly Notices of the Royal Astronomical Society, Volume 522, Issue 1, June 2023, Pages 252–267 (2023)
- O. Sokoliuk, S. Praharaj, A. Baransky, P.K. Sahoo, **Accretion flows around exotic tidal wormholes. I. Ray-tracing**, Astronomy & Astrophysics (A&A), 665 (2022) A139, (Impact factor 6.240), EDP
- S. Kumawat, S. Praharaj & S.K. Vishwakarma, **Dispersion of torsional surface waves in a threefold concentric compounded cylinder with imperfect interface**, Waves in Random and Complex Media (2022), Taylor & Francis
- Chaitanya Peshin and Subhrat Praharaj, **Design of powertrain of an off-road racing vehicle**, AIP Conference Proceedings 2358, 050026 (2021) - 2nd International Conference on Manufacturing, Material Science and Engineering

EXTRA-CURRICULARS WITH KEY ACHIEVEMENTS

- Spaceport America Cup - Vice Captain** 2019 – 2021
Experimental Sounding Rocket Association Las Cruces, NM
- Among only 4 Indian and 150 international teams to qualify for finals. Honourable mention for our science payload
- SAE BAJA India - Captain** 2019 – 2021
Society of Automotive Engineers Punjab, India
- First rank among new teams, 10th overall in the presentation round. Finished inside top 25%ile in the static round
- National Service Scheme** 2019 – 2020
Ministry of Youth Affairs and Sports BITS Pilani chapter
- Worked on events to generate awareness on poor living conditions in old-age homes and orphanages