

Department of Astrophysical and Planetary Sciences
University of Colorado Boulder

 [Personal website](#)
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Research Interests

I am broadly interested in using first-principles theoretical and computational approaches to understand relativistic plasma and fluid dynamics around compact objects, and to connect these dynamics to observable signatures in electromagnetic and gravitational-wave data.

UAT keywords: Black hole physics, Accretion, Magnetohydrodynamics, General relativity, Magnetohydrodynamical simulations

Education

- 08/2020 – **University of Colorado Boulder**, Dept. of Astrophysical and Planetary Sciences
Ph.D. thesis: *Investigating the Dynamics and Observational Signatures of Misaligned Accretion Disks Around Black Holes*
(working title, degree expected May 2026)
M.S. awarded December 2023: Shock-induced Partial Alignment in Geometrically Thick Tilted Accretion Disks Around Black Holes
Advisor: Jason Dexter
- 08/2015 – 05/2020 **Indian Institute of Science Education and Research (IISER)**, Kolkata, India
5-Yr BS-MS Dual Degree in Physical Sciences
M.S. awarded May 2020: *Solar wind interaction with a planetary off-center mini magnetosphere: A case study for Mars*
Advisor: Dibyendu Nandi

Publication List

- “Hot, Retrograde Tilted MADs: Misaligned, Precessing, and Shaped by Electromagnetic Torques”. **Gupta, S.** and Dexter, J. 2026, *arXiv e-prints*, [arXiv:2601.16370](#).
- “Tilted Semi-MAD Accretion Flows: Warp Damping, Slow Alignment, and a Change in Precession Sense”. **Gupta, S.** and Dexter, J. 2026. Manuscript in preparation, expected submission April 2026.
- “Shock-induced Partial Alignment in Geometrically Thick Tilted Accretion Disks Around Black Holes”. **Gupta, S.** and Dexter, J. 2024, *The Astrophysical Journal*, **974**, 209.
- “Yet another test of Radial Acceleration Relation for galaxy clusters”. Pradyumna, S., **Gupta, S.**, Seeram, S., and Desai, S. 2021, *Physics of the Dark Universe*, **31**, 100765.
- “Galaxy cluster hydrostatic masses using Tolman-Oppenheimer-Volkoff equation”. **Gupta, S.** and Desai, S. 2020, *Physics of the Dark Universe*, **28**, 100499.
- “Bound on the graviton mass from Chandra x-ray cluster sample”. **Gupta, S.** and Desai, S. 2019, *Classical and Quantum Gravity*, **36**, 105001.

- “Magnetar signature - the U curve”. Soni, V., Bhattacharya, D., Patel, S., **Gupta, S.**, and Bera, P. 2019, *Monthly Notices of the Royal Astronomical Society*, **482**, 5336–5348.
- “Limit on graviton mass using stacked galaxy cluster catalogs from SPT-SZ, Planck-SZ and SDSS-redMaPPer”. **Gupta, S.** and Desai, S. 2018, *Annals of Physics*, **399**, 85–92.

Research Experience

- 11/2024 – Present *Flux-regulated warp damping and precession reversals in tilted semi-MAD accretion flows* (Working title)
 Advisor: Jason Dexter (PhD projects)
 Running 3D global GRMHD simulations of tilted, hot thick disks at intermediate magnetic flux (semi-MAD) to bridge the SANE and MAD regimes. I am measuring steady-state tilt and precession and evaluating electromagnetic and hydrodynamic torque budgets to locate a spin- and tilt-dependent critical flux for alignment. Preliminary results indicate that increasing flux damps the warp and removes standing shocks, while some prograde semi-MADs show retrograde precession when hydrodynamic angular-momentum fluxes dominate as gravitational torques weaken during alignment.
- 12/2022 – 11/2025 *Hot, Retrograde Tilted MADs: Misaligned, Precessing, and Shaped by Electromagnetic Torques*
 Advisor: Jason Dexter (PhD projects)
 Performed 3D global ideal GRMHD simulations of misaligned, magnetically arrested disks (MADs) across black-hole spins and tilt angles to study alignment and precession. Prograde MADs align with the black hole spin, while retrograde MADs remain persistently misaligned and undergo near solid-body precession. Derived torque equations in ideal GRMHD and showed electromagnetic torques always act to align the disk but are opposed by hydrodynamic angular-momentum fluxes in retrograde flows, motivating an empirical scaling model and implications for low-frequency QPOs.
- 02/2021 – 08/2024 *Shock-induced Partial Alignment in Geometrically Thick Tilted Accretion Disks Around Black Holes*
 Advisor: Jason Dexter (PhD projects)
 Conducted global ideal 3D GRMHD simulations of 24°-tilted, geometrically thick, weakly magnetized accretion flows around Kerr black holes with varying spin using **HARMPI**. Found that tilted disks develop a warped, twisted steady state and form standing spiral shocks near the black hole, which produces spin-dependent partial alignment of inner disk. Developed an orbit-crowding toy model that predicts shock locations in moderate-to-fast spin cases and provides a physical interpretation for shocks in misaligned accretion systems.
- 02/2019 – 08/2020 *Solar wind interaction with a planetary off-center mini magnetosphere: A case study for Mars*
 Advisor: Dibyendu Nandi

Performed 3D compressible MHD simulations of a Sun–Mars-like system using the [PLUTO](#)-based Star–Planet Interaction Module (SPIM) to study solar-wind interaction with Mars-like crustal fields. Modeled an off-centered southern dipole and compared no-field, southward-IMF, and northward-IMF cases, finding a localized mini-magnetosphere with reconnection-driven variability in wake currents and surface-reaching magnetic perturbations. The crustal mini-magnetosphere modestly reduced atmospheric mass loss relative to the no-field case, with higher loss for southward IMF than for northward IMF.

- 01/2019 – 04/2019 *Galaxy cluster hydrostatic masses using Tolman–Oppenheimer–Volkoff (TOV) equation*
 Computed hydrostatic masses of 12 relaxed galaxy clusters using the TOV equation (GR analog of spherical hydrostatic equilibrium) and the Newtonian formulation. Quantified fractional relative differences and showed the GR correction is negligible, $\mathcal{O}(10^{-5})$.
- 07/2018 – 02/2019 *Bound on the graviton mass from the Chandra X-ray cluster sample*
 Derived new constraints on the graviton Compton wavelength (and corresponding graviton mass) by modeling gravity with a Yukawa potential in 12 relaxed galaxy clusters with Chandra-derived temperature and gas-density profiles. Obtained a 90% confidence upper limit on m_g via χ^2 analysis.
- 05/2017 – 04/2018 *Dynamical Evolution of Magnetic Field in Magnetars*
 Analyzed proposed origins of magnetar magnetic fields by contrasting a standard dynamo mechanism with a dense-core phase-transition model that aligns neutron magnetic moments. Validated model predictions against observed period clustering and X-ray decline trends using the McGill Magnetar Catalog.

Awards

- 2015 – 2020 Awarded the Government of India DST INSPIRE Scholarship for Higher Education (top 1% nationwide; \$5,000).

Selected Presentations (*indicates invited)

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| 03/2025 | Magnetic Fields Around Compact Objects Workshop , <i>Organized by Perimeter Institute for Theoretical Physics</i>
Contributed talk: Hot, Retrograde Tilted MADs: Misaligned, Precessing, and Shaped by Electromagnetic Torques | Waterloo, Canada |
| 02/2020 | Conference on Plasma Simulation, <i>Organized by Institute for Plasma Research</i>
Poster Presented: Solar wind interaction with a planetary off-center mini magnetosphere: A case study for Mar | Gujrat, India |

01/2020	38th Annual Meeting of the Astronomical Society of India , <i>Organized by IISER</i> Contributed talk: Bounds on graviton mass from galaxy clusters	Tirupati, India
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Accepted Presentations (not presented)

07/2025	Vasto Accretion Meeting , <i>Organized by Durham University and INAF</i> Accepted contributed talk: “Hot, Retrograde Tilted MADs: Misaligned, Precessing, and Shaped by Electromagnetic Torques” (<i>unable to attend—visa</i>)	Vasto, Italy
12/2025	33rd Texas Symposium on Relativistic Astrophysics , <i>Arizona State University</i> Accepted contributed presentation: “Hot, Retrograde Tilted MADs: Misaligned, Precessing, and Shaped by Electromagnetic Torques” (<i>unable to attend—travel</i>)	Tempe, AZ, USA
10/2025	22nd Annual Meeting of the AAS High Energy Astrophysics Division (HEAD) Accepted poster (Program #109.07): “Hot, Retrograde Tilted MADs: Misaligned, Precessing, and Shaped by Electromagnetic Torques” (<i>unable to attend—travel</i>)	USA

Selected Teaching Experience

08/2020 – 12/2023	Graduate Teaching Assistant (5 semesters), CU Boulder Dept. of Astrophysical and Planetary Sciences Taught recitations/labs for both lower-division and upper-division courses, assisted with grading assignments/exams, and occasionally assisted in the development of class materials (like Jupyter notebook labs). Courses TA’d: ASTR 2000 (Ancient Astronomies of the World), ASTR 1010 (Intro Astronomy I; two times), ASTR 1200 (Stars & Galaxies), ASTR 1000 (The Solar System)
08/2019 & 05/2020	Teaching Assistant (2 semesters), IISER Kolkata, Dept. of Physics Taught recitations upper-division physics courses, and assisted with grading assignments/exams. Courses TA’d: Intermediate Electricity and Magnetism, and Relativistic Mechanics

Selected Service and Outreach

01/2018 – 05/2020	Volunteer Instructor , VIJYOSHI, National Science Camp Taught introductory science classes and delivered hands-on physics and chemistry activities for students with limited access to educational resources.
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- 08/2018 – **Founder & CEO**, Entrepreneurship Cell (E-Cell), IISER Kolkata
- 05/2019 Co-founded and led the institute entrepreneurship cell; organized short courses and workshops, hosted invited industry speakers, and ran hands-on activities on building a company with minimal capital (e.g., \$100).
- 08/2020 – **Graduate committee member**, CU Boulder
- Served on several department service committees with faculty and other graduate students, influencing departmental policies.