Bhavya Gupta

Aspiring Astrophysicist

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I am an **A3D3 Post-Baccalaureate Fellow at MIT** and a recent graduate of UC San Diego with a B.S. in Physics (Specialization in Astrophysics). During my undergraduate studies, I developed skills in computational techniques and data analysis while investigating various astrophysical phenomena. My research projects have ranged from investigating the ionized gas in the interstellar medium of young, star-forming galaxies to modeling dark matter through stellar stream interactions and dynamics. My current work focuses on developing machine-learning methods for real-time gravitational-wave detection. I aim to **advance multi-messenger astrophysics by applying modern AI techniques** to uncover new physical insights from the rapidly growing volume of astronomical data as **I pursue a PhD**.

Education

Sep 2020 – Jun 2024 | **University of California, San Diego (Revelle College), La Jolla, CA**
B.S. in Physics with Specialization in Astrophysics

- *Department Honors: High Distinction* – GPA: 3.81/4.00
- Minor in Mathematics
- Honors Thesis: *Probing Dark Matter Subhalo Impacts on Stellar Streams with Graph Neural Networks and Normalizing Flows*

Research Experience

Massachusetts Institute of Technology, Cambridge, MA

July 2025 – Ongoing | *Accelerated AI Algorithms for Data Driven Discovery in Physics (A3D3) Post-baccalaureate Fellow*

- Working under Prof. Erik Katsavounidis, I am developing machine-learning frameworks to improve the low-latency detection and parameter estimation of binary neutron star (BNS) mergers in LIGO-Virgo gravitational-wave data.
- Extending the Aframe and AMPLFI pipelines to enhance sensitivity to low-SNR inspiral signals through domain-adaptive data augmentations, neural likelihood inference, and optimized architectures for lower-mass compact binaries.
- Strengthening expertise in time-domain astrophysics, real-time inference, and large-scale data processing, enabling earlier identification and sky localization of BNS mergers for multi-messenger astronomy.

University of California, San Diego, La Jolla, CA

Jan 2023 – June 2025 | *Streams* x *Machine Learning - Undergraduate Researcher*

- Worked under Prof. Javier Duarte and Prof. Tongyan Lin to model the gravitational interactions between dark matter (DM) subhalos and stellar streams, using perturbations such as gaps and spurs to infer subhalo dynamical properties and constrain the DM subhalo mass function.
- Adapted Erkal (2015)'s analytic framework for velocity perturbations to generate and evolve synthetic streams with `Gala` and `Galpy`, validating that simulated morphologies and kinematics reproduce analytic expectations.
- Developed a pipeline to recover stream–subhalo impact parameters (mass, velocity, time of encounter) using Markov Chain Monte Carlo (MCMC) for streams with tractable likelihoods.
- Extended this framework to complex, non-analytic cases using likelihood-free inference, implementing and training Graph Neural Networks (GNNs) and Normalizing Flows (nflows) on distributed CPU/GPU clusters at the San Diego Supercomputer Center.

- Compared traditional MCMC with Simulation-Based Inference (SBI), finding that MCMC achieved tighter posteriors, while ML-based methods offered faster, scalable inference across large simulated datasets, further highlighting how ML-driven inference can reveal faint DM substructure signatures in upcoming Rubin–LSST data.
- Awarded $7,500 in funding for the research work.
- Presented at *243rd American Astronomical Society Conference* in New Orleans, LA.

Sep 2022 – Dec 2022 | *Alison Coil Lab - Undergraduate Researcher*

- Worked with Professor Alison Coil to investigate the kinematic properties of outflows from accreting supermassive black holes (SMBHs) that drive galactic evolution.
- Conducted data modeling and spectral analysis using Python and IDL's IFSFIT software to perform a two-component Gaussian analysis of SMBH emission spectra, focusing on velocity dispersion in kinematic maps.
- Identified the need for a more accurate three-component model to better represent the complex outflow data from SMBHs, highlighting the limitations of the initial two-component approach.

Carnegie Observatories, Pasadena, CA

Jun 2022 – Aug 2022 | *Carnegie Astrophysics Summer Student Internship (CASSI) - Summer Intern*

- Worked with Carnegie Staff Astronomer Dr. Peter Senchyna to study metal-poor, star-forming dwarf galaxies ($z < 1$) as local analogs of high-redshift systems ($z > 6$), probing interstellar medium (ISM) conditions relevant to early galaxy formation.
- Investigated the distribution of highly ionized gas by analyzing [O III] and [C II] far-infrared emission lines from SOFIA spectroscopic data cubes using the SOSPEX package for flux extraction and line diagnostics.
- Compared [O III]/[C II] ratios and emission morphology with star formation and metallicity indicators, benchmarking results against the Dwarf Galaxy Survey (DGS) to assess ionized gas properties.
- Found that, unlike high-redshift systems observed with ALMA, local analogs show strong low-ionization [C II] emission from photodissociation regions (PDRs), indicating structural differences in the ISM.
- Received $6,000 stipend for the research work.
- Presented at *241st American Astronomical Society Conference* in Seattle, WA.

Center for Matter at Atomic Pressures (CMAP), University of Rochester, Rochester, NY (Remote)

Aug 2021 | *CMAP Undergraduate Summer School - Summer Student*

- Worked under Professor Pierre Gourdain and utilized scientific Python packages to analyze the collisions in plasma and investigate smooth particle hydrodynamics, magnetohydrodynamics, and single-particle motion.
- Analyzed simulations for building a two-layer planet to diagnose how density and particle size affect planet formation.
- Specialized in identifying the role of planetary characteristics in the evaporation rate for a planet's atmosphere.

Presentations and Publications

2026 | *247th American Astronomical Society Meeting Oral Presentation (Future Talk)*

- "Applying Machine Learning for Low-Latency Gravitational Waves Detection"

2025 | *NSF HDR Ecosystem Conference 2025*

- "Accelerating Gravitational Wave Astronomy with Machine Learning"

2024 | *243rd American Astronomical Society Meeting Poster Presentation*

- "Probing Dark Matter Subhalo Impacts on Stellar Streams with Graph Neural Networks"

2023 | *Undergraduate Summer Research Award Poster Presentation, UC San Diego*
- "Simulating the Effects of Dark Matter Subhalos on Stellar Streams"

2023 | *241st American Astronomical Society Meeting Poster Presentation*
- "Analyzing [O III] and [C II] Emission in Highly Ionized Local Systems"

2022 | *CASSI Summer Student Research Symposium*
- "Analyzing Far-IR [O III] and [C II] Emission Using SOFIA in Highly-Ionized Local Galaxies"

2022 | *CASSI Summer Student Research Poster Presentation*
- "Analyzing [O III] and [C II] Emission in Highly Ionized Local Systems"
- Won an award for the best poster presentation among the cohort.

Leadership & Clubs

Astronomy Club at UC San Diego, La Jolla, CA

Mar 2023 – Jun 2024 | *President*
- Executed the re-establishment and registration of the club (75 members), led a dedicated team of 8 board members, and secured funding of $1,500 from the Student Success Center.
- Organized 3 star-gazing events on campus, and 2 off-campus star-gazing events (Tierra Del Sol and Anza Borrego) to foster community building and increase participation. Hosted professor research talks to connect eager students with professors. Coordinated with the Department of Astronomy and Astrophysics to lead the 2024 solar eclipse viewing event with 100 students, multiple telescopes, and a live solar tracking screen.
- Mentored new board members in event organization and media management by contributing to long-term club sustainability.
- Astronomy Club at UC San Diego, ucsdastronomyclub

Society of Physics Students at UC San Diego, La Jolla, CA

Sep 2020 – Jun 2023 | *Media Chair and Website Designer*
- Led the media team of 4 members, utilizing a task matrix to delegate responsibilities and ensure timely project completion.
- Designed promotional posters for events across multiple platforms, spsucsd, SPS at UC San Diego, and managed the upkeep of the SPS website.
- Developed a professional website from scratch to enhance the club's online presence.
- Initiated and implemented in-person event promotion in both lower and upper-division physics and mathematics courses, increasing event attendance and awareness.

Teaching Experience

Unlimited Learning, La Jolla, CA

Sep 2024 – Dec 2024 | *Contract Tutor*
- Tutored college students in mathematics and physics, providing personalized instruction to enhance understanding of complex concepts and improve academic performance.
- Developed custom lesson plans, practice problems, and review materials to help students prepare for exams and reinforce key topics in vector calculus, linear algebra, and classical mechanics.

Teaching + Learning Commons at UC San Diego, La Jolla, CA

May 2022 – Dec 2022 | *Supplemental Instruction Leader*
- Facilitated student learning by organizing sessions that foster student-to-student problem-solving interaction (20 students in one session).
- Prepared weekly problem sets and reviewed the class content to better facilitate discussion.
- Courses – Math courses on Vector Calculus I and II (Math 20A, Math 20B, and Math 20C)

Honors and Awards

2025 | Accelerated AI Algorithms for Data Driven Discovery in Physics (A3D3) Post-baccalaureate Fellowship
- A one-year fully-funded research fellowship working at the intersection of AI/ML and Astrophysics.

2024 | UC San Diego Physical Sciences Dean's Undergraduate Award for Excellence
- Awarded to recognize students who have demonstrated academic excellence and promise as researchers in the school's three areas of study: Chemistry and Biochemistry, Mathematics, and Physics.
- Received $1,000 in recognition of this honor.

2020-24 | Revelle Provost Honors

2023 | School of Physical Sciences Undergraduate Summer Research Award (USRA)
- Awarded $7,500 summer research award to conduct a summer research project under the guidance of a UC San Diego faculty member.
- Worked on the Streams x ML research project.

2023 | Society of Physics Students Outstanding Chapter Award
- Awarded by SPS National Office for tireless efforts to enrich the physics community.

2022 | CASSI Summer Student Poster Presentation Award

2022 | Carnegie Astrophysics Summer Student Internship
- Received $6,000 summer research stipend to conduct observational astrophysics research on analyzing observations of nearby star-forming dwarf galaxies and using them to constrain models for metal-poor galaxies at high redshift.

2021 | NSF CMAP Summer School Award
- Awarded a stipend of $300 upon successful completion and the applicants were chosen on the following basis: top applicants—based on their resume or CV, transcript, personal statement, recommendation letters as well as their enrollment at a US college or university.

Grants

2023 | *Revelle Provost Academic Conference Support, Revelle College, UC San Diego*
- $300 grant to cover the costs of the 243rd American Astronomical Society Meeting in New Orleans, Louisiana.

Skills & Hobbies

Coding Languages	Python, MATLAB, Mathematica
Scientific Computation	Numpy, SciPy, Matplotlib, Numba, Astropy, Pandas, PyTorch, PyTorch Lightning, Keras, CUDA, Scikit-Learn
Softwares	Excel, Word, Office 365, Teams, Google Suites, LaTeX, Adobe Photoshop, Adobe Lightroom
Operating Systems	Linux, Unix, Kubernetes, Slurm
Languages	English (Native), Hindi (Native), Spanish (Intermediate), Thai (Beginner)
Hobbies	Photography, Painting, Badminton, Cricket, Biking

Memberships

2022 – Pres.	American Astronomical Society (AAS) Member
2020 – Pres.	American Physical Society (APS) Member

References

Contact for my work in Gravitational Wave Astrophysics, Machine Learning, and A3D3 Post-baccalaureate Fellowship

Erik Katsavounidis, PhD
- MIT Kavli Institute, MIT LIGO Lab
- Senior Research Scientist

kats@mit.edu

Contact for my work in Machine Learning and A3D3 Post-baccalaureate Fellowship

Javier Duarte, PhD
- UC San Diego Department of Physics
- Associate Professor

jduarte@physics.ucsd.edu

Contact for my work at Carnegie Observatories

Peter Senchyna, PhD
- Staff Astronomer at Carnegie Observatories
- CASSI Advisor

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Gwen Rudie, PhD
- Staff Scientist Carnegie Observatories
- Director of the CASSI Program

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Contact for my work in Dark Matter Research

Tongyan Lin, PhD
- UC San Diego Department of Physics
- Associate Professor
- Undergraduate Thesis Advisor

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Contact for my work in Astrophysics Research

Alison Coil, PhD
- UC San Diego Department of Astronomy and Astrophysics
- Department Chair, Professor

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Contact for my UC San Diego Academics

Oleg Shpyrko, PhD
- UC San Diego Department of Physics
- Department Chair, Professor
- Advisor

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Contact for my work in Astronomy Club at UC San Diego

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