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 computational techniques and data analysis skills 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*

- Under the supervision of Dr. Erik Katsavounidis, I'll work in the analysis of gravitational-wave data from the LIGO detectors to identify astrophysical sources and to improve the sensitivity of the searches via the use of Artificial Intelligence methods

University of California, San Diego, La Jolla, CA

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

- Worked with Professor Javier Duarte and Professor Tongyan Lin on modeling the interactions between dark matter (DM) subhalos and stellar streams, examining spurs and gaps to infer the dynamical properties of these subhalos and understand their distribution in the galaxy.
- Adapted Denise Erkal's analytic equations for modeling velocity perturbations in stellar streams due to DM subhalos flyby, using `Gala` and `Galpy` stream generation methods.
- Validated that synthetic streams closely match the analytic predictions and understood how the different DM subhalo properties affect stream morphology and kinematics, thereby helping us put constraints on these properties.
- Addressed the limitations of traditional Markov Chain Monte Carlo (MCMC) methods, which rely on tractable likelihood functions to recover DM subhalo parameters, by employing advanced Machine Learning (ML) techniques such as Graph Neural Networks (GNNs), Normalizing Flows (nflows), and Simulation-Based Inference (SBI) for scenarios where likelihoods are intractable.
- Modified GNN models and fine-tuned nflows architectures to analyze and model complex posterior distributions to recover the impact properties of DM subhalos from synthetic stellar streams.
- Evaluated and compared MCMC and SBI approaches for inferring DM subhalo parameters, revealing that SBI, despite its potential, did not achieve the expected efficiency and often produced broader posterior distributions compared to the narrower, more accurate posteriors from MCMC.

- 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*

- Coordinated 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 Peter Senchyna to investigate the young, star-forming galaxies in the local universe ($z < 1$) to understand the distribution of highly-ionized [C II] and [O III] gas, using local analogs to study early galactic formation due to the challenges involved in observing high-redshift galaxies.
- Probed the structure of the Interstellar Medium (ISM) in local analogs to see if they were elevated in [O III] emission in comparison to [C II] as observed in high-redshift systems ($z > 6$).
- Analyzed [O III] and [C II] emission lines from SOFIA data cubes using the SOSPEX package, focusing on flux extraction, and examining ionized gas properties by validating results through comparison with the Dwarf Galaxy Survey (DGS).
- Identified that [C II] is not suppressed; there is strong lower ionization emission in photodissociation regions of the highly-ionized local analogs in contrast with high-redshift systems observed with ALMA, suggesting differences in the ISM structure.
- 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*

- Coordinated with Professor Pierre Gourdain and utilized scientific Python packages to analyze the collisions in plasma and investigate smooth particle hydrodynamics, magneto-hydrodynamics, 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

psenchyna@carnegiescience.edu

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
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Contact for my work in Astronomy Club at UC San Diego

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