Nihar Gupte

Email: Nihar.Gupte@aei.mpg.de
Github: github.com/nihargupte-ph
Website: nihargupte.com

Letters of recommendation: Prof. Alessandra Buonanno, Prof. Jonathan Gair, Dr. Stephen R. Green

Education

- **Ph.D. in Physics** 2021–

  Max Planck Institute for Gravitational Physics (Albert Einstein Institute, AEI), Potsdam, Germany; Department of Physics, University of Maryland, College Park, MD, USA

  Advisor: Prof. Alessandra Buonanno; Co-advisor: Prof. Jonathan Gair

- **B.S. in Physics and Mathematics** 2017–2021

  University of Florida, Gainesville, FL, USA

  Research advisors: Prof. Imre Bartos, Prof. Stephen Hagen

Research Experience

- **Graduate Researcher** Fall 2021–

  Max Planck Institute for Gravitational Physics (Albert Einstein Institute, AEI), Potsdam, Germany; Department of Physics, University of Maryland, College Park, MD, USA

  - **Core developer,** `DINGO`: `DINGO` (Deep INference for Gravitational-wave Observations) is a machine-learning code that performs simulation-based inference to obtain posterior distributions for gravitational-wave events. The current architecture is a transformer encoder coupled with a normalizing flow, trained across multiple graphics processing units (GPUs), optionally with flow matching. The code has been adopted by independent research groups worldwide and by the LIGO-Virgo-KAGRA (LVK) Collaboration to produce gravitational-wave catalogs. Currently working on a project using mixture-of-experts and distillation to improve performance at high eccentricity and high signal-to-noise ratio.
  - **Eccentricity in the population of binary black holes**: Performed eccentric binary black hole parameter inference across 150 gravitational-wave events from the first three LVK observing runs and the first part of the fourth. Found that GW200129 shows a strong preference for eccentricity, revising its earlier interpretation as a quasi-circular, spin-precessing binary with a large recoil. Assessed the effect of non-Gaussian noise and waveform systematics when doing eccentric analyses. The trained networks and results were released publicly and are used regularly by other researchers with 700+ downloads.
  - **Population inference for eccentric binaries**: Produced the first hierarchical population analysis of eccentric binary black holes that includes selection effects. Separately, developed a statistical framework for the probability that a given event is eccentric. This is a general construction that applies equally to tests of general relativity and lensing. Implemented a black hole capture model to constrain the fraction of binaries formed by gravitational-wave capture in nuclear star clusters.

- **Undergraduate Researcher** Fall 2017 – Spring 2021

  University of Florida, Gainesville, FL, USA

  - **Multi-messenger astrophysics**: Developed genetic-algorithm tiling strategies for covering LIGO localization maps with telescope fields of view. Ran Monte Carlo studies to estimate joint gamma-ray burst–gravitational-wave detection rates.
  - **Experimental biophysics**: Imaged amyloid formation in *S. mutans* biofilms by optical microscopy under media flow.

Engineering Experience

- **Co-founder and Machine-Learning Lead** Spring 2020 – Spring 2021

  Fire Neural Network, Gainesville, FL, USA

  - **Detecting fires from satellite data using neural networks and cross referencing with lightning databases**: One of three founders of a startup to predict where fires will occur in California. We worked with time-series infrared data to extract potential hotspots. I wrote the machine-learning algorithm for the detection and the first iteration of the real-time inference website with Django. www.fireneuralnetwork.com

- **Space Systems Design Club President/Treasurer** Fall 2017 – Spring 2021

  Space Systems Design Club, University of Florida

  - **Space systems engineering projects**: Competed three years in the NASA Micro-g Challenge (hull-breach plugging tool 2017; software lead for a drone-deployable autonomous boat 2019; team lead for an Artemis bag dispenser 2020).
  - **Teaching and funding**: Taught a Python-for-research workshop; wrote the club's funding applications.

- **Programming languages and frameworks:** Python, PyTorch, JAX

Publications

[1] **Eccentricity constraints disfavor single-single capture in nuclear star clusters as the origin of all LIGO-Virgo-KAGRA binary black holes**
N. Gupte et al., Astrophys. J. **1009**, 90 (2026), arXiv:2603.29019.

[2] **Accurate and efficient simulation-based inference for massive black-hole binaries with LISA**
A. Spadaro, J. Gair, D. Gerosa, S. R. Green, R. Buscicchio**, N. Gupte**, R. Tenorio, S. Clyne, M. Pürrer, and N. Korsakova, Phys. Rev. D **114**, 023038 (2026), arXiv:2603.20431.

[3] **Flexible Gravitational-Wave Parameter Estimation with Transformers**
A. Kofler, M. Dax, S. R. Green, J. Wildberger**, N. Gupte**, J. H. Macke, J. Gair, A. Buonanno, and B. Schölkopf, Phys. Rev. Lett. **136**, 251401 (2025), arXiv:2512.02968.

[4] **Accelerated inference of microlensed gravitational waves with machine learning**
M. Caldarola, S. Goyal**, N. Gupte**, S. R. Green, and M. Zumalacárregui, Phys. Rev. D **113**, 104073 (2025), arXiv:2511.08486.

[5] **GW200208_222617 as an eccentric black-hole binary merger: Properties and astrophysical implications**
I. Romero-Shaw, J. Stegmann, H. Tagawa, D. Gerosa, J. Samsing**, N. Gupte**, and S. R. Green, Phys. Rev. D **112**, 063052 (2025), arXiv:2506.17105.

[6] **Fast and accurate parameter estimation of high-redshift sources with the Einstein Telescope**
F. Santoliquido et al., Phys. Rev. D **112**, 103015 (2025), arXiv:2504.21087.

[7] **Real-time inference for binary neutron star mergers using machine learning**
M. Dax, S. R. Green, J. Gair**, N. Gupte**, M. Pürrer, V. Raymond, J. Wildberger, J. H. Macke, A. Buonanno, and B. Schölkopf, Nature **639**, 49–53 (2025), arXiv:2407.09602.

[8] **Evidence for eccentricity in the population of binary black holes observed by LIGO-Virgo-KAGRA**
N. Gupte et al., Phys. Rev. D **112**, 104045 (2025), arXiv:2404.14286.

[9] **EinsteinPy: A Community Python Package for General Relativity**
S. Bapat et al. (2020), arXiv:2005.11288.

[10] **Optimal Gravitational-wave Follow-up Tiling Strategies Using a Genetic Algorithm**
N. Gupte and I. Bartos, Phys. Rev. D **101**, 123008 (2020), arXiv:2003.04839.

[11] **Gravitational-wave follow-up with CTA after the detection of GRBs in the TeV energy domain**
I. Bartos, K. R. Corley**, N. Gupte**, N. Ash, Z. Márka, and S. Márka, Mon. Not. Roy. Astron. Soc. **490**, 3476–3482 (2019), arXiv:1908.09832.

[12] **How would a nearby kilonova look on camera?**
N. Gupte and I. Bartos, Am. J. Phys. **88**, 568 (2020), arXiv:1905.01594.

[13] **Observational consequences of structured jets from neutron star mergers in the local Universe**
N. Gupte and I. Bartos (2018), arXiv:1808.06238.

Selected Collaboration Publications

[14] **GWTC-5.0: Observations from the Second Part of the Fourth LIGO-Virgo-KAGRA Observing Run and Updates to the Gravitational-Wave Transient Catalog**
LIGO-Virgo-KAGRA Collaboration (2026), arXiv:2605.27225.

Papers in Preparation

[15] **GWTC-6.0E: Population Properties of Eccentric Merging Compact Binaries**
LIGO-Virgo-KAGRA Collaboration, in preparation (2026).

[16] **Mixture-of-experts and distillation improve training inefficiency in simulation-based inference**
N. Gupte et al., in preparation (2026).

[17] **Improving the accuracy and speed of effective-one-body waveform models using GPU acceleration**
C. Ewan et al., in preparation (2026).

[18] **Mapping systematic biases in gravitational-wave parameter estimation: a high-dimensional approach using the Mahalanobis distance**
S. Clyne et al., in preparation (2026).

[19] **Glitch mitigation and the robustness of eccentricity in GW200129**
L. Pompili et al., in preparation (2026).

Collaboration Contributions

- **Member, LIGO-Virgo-KAGRA (LVK) Collaboration** 2022–
  - `DINGO` **review lead — fourth and upcoming LVK observing runs**: Led the LVK reviews that qualified `DINGO` for collaboration use in the second and third parts of the fourth observing run and in the upcoming observing run, and was heavily involved in the review for the first part. Review involves strict criteria and is a precursor to the collaboration accepting scientific results; `DINGO` is now used routinely in LVK catalogs.
  - **GWTC-5.0 catalog pipeline lead**: Produced the `DINGO` portion of the fifth Gravitational-Wave Transient Catalog (GWTC-5.0), analyzing 60 gravitational-wave events.
  - **Online analyst, fourth observing run**: Ran independent real-time parameter estimation on 200+ gravitational-wave events to cross-check the online LVK results with a more accurate but expensive waveform model. Released the trained models publicly.
  - **Leading eccentric binary black hole analyses**: Leading member of the LVK eccentric parameter-estimation effort: training collaboration members on parameter estimation, shaping the structure of the GWTC-6.0E eccentric population paper, and developing methods to reconcile differing eccentricity definitions.

Presentations

Invited Talks

"Machine-learning methods enable discovery of eccentric binary black holes" Seminar, Princeton University, Princeton, NJ, USA, *Nov. 2026*

"What does eccentricity tell us about formation channels?" Seminar, Niels Bohr Institute, Copenhagen, Denmark, *Oct. 2026*

"Detecting eccentricity: what are our current prospects?" Plenary, *Binary compact objects on eccentric orbits and their gravitational-wave signatures*, Corfu, Greece, *Sep. 2026*

"Machine-learning methods in the era of gravitational-wave astronomy" Seminar, Sun Yat-sen University, Zhuhai, China (online), *Mar. 2025*

"Gravitational-wave analysis in the era of machine learning" Panelist, Royal Astronomical Society Specialist Discussion Meeting, London, UK, *Jan. 2025*

"Evidence for eccentricity in binary black holes" Seminar, Korean Gravitational-Wave Group, South Korea (online), *Jul. 2024*

"Evidence for eccentricity in binary black holes" Seminar, University of Nottingham, Nottingham, UK, *Apr. 2024*

Talks

"Population properties of eccentric binary black holes" Seminar, Inter-University Centre for Astronomy and Astrophysics, Pune, India, *Nov. 2025*

"10-year anniversary of GW150914" Long Night of Astronomy, Berlin, Germany, *Oct. 2025*

"Population properties of eccentric binary black holes" GR24–Amaldi16, Glasgow, UK, *Jul. 2025*

"Evidence for eccentricity in binary black holes" AIslands: Arran 2024, Brodick, Isle of Arran, UK, *Apr. 2024*

"Evidence for eccentricity in binary black holes" LVK Meeting, Louisiana State University, Baton Rouge, LA, USA, *Mar. 2024*

Posters

"Accurate parameter inference of binary neutron stars in one second" LVK Meeting, Barcelona, Spain, *Sep. 2024*

"Evidence for eccentricity in the binary black hole population" LVK Meeting, Baton Rouge, LA, USA, *Mar. 2024*

"Lightning data for real-time wildfire detection" American Geophysical Union Fall Meeting (online), *Dec. 2020*

"How would a nearby kilonova look on the sky?" American Association of Physics Teachers Winter Meeting, Orlando, FL, USA, *Jan. 2020*

"Neutron star mergers, gravitational waves, and the origin of heavy elements" University of Florida Physics Graduate Research Symposium, Gainesville, FL, USA, *Dec. 2019*

Teaching and Mentoring

- **Mentoring**: Trained Marienza Caldarola, Srashti Goyal and Alice Spadaro (PhD students and postdocs) in machine-learning methods for gravitational-wave data analysis, leading to publications on gravitational-wave lensing and simulation-based inference for the Laser Interferometer Space Antenna (LISA).
- **International Max Planck Research School lecture week**: tutorial on machine learning for gravitational-wave data analysis.
- **Teaching assistant**, General Physics, University of Maryland, Fall 2021 – Fall 2022.

Service and Outreach

- **Chair**, LIGO meetings at the AEI, Fall 2025–.
- **Organizer**, social committee of the Astrophysical and Cosmological Relativity division, AEI.
- **Space Systems Design Club**, University of Florida: ran meetings, speakers and outreach events; built and displayed exhibits to engage kids in space engineering research, Fall 2017 – Spring 2021.

Honors

- University of Maryland Graduate School Fellowship
- Goldwater Scholarship Nomination (University of Florida)
- Florida Bright Futures Scholarship (4-year merit-based full tuition)
- Wentworth Travel Scholarship; University of Florida Honors Program and Dean's List