Subhajit Dandapat, Ph.D.

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Professional Summary

- AI-driven computational astrophysicist with deep expertise in large-scale data analysis, Bayesian inference, and stochastic modeling for weak-signal detection in high-dimensional, noise-dominated time-series data; built GPU-accelerated Bayesian inference systems for efficient search of extremely high-dimensional parameter spaces, reducing probabilistic inference from days to hours.
- Designs and deploys scalable deep learning and ML-based inference systems, including transformers, generative models (normalizing flows, diffusion), and physics-informed architectures across scientific and quantitative domains.
- Proven technical leader in major international collaborations, including International PTA, ESA/NASA-funded LISA, and LIGO, with hands-on experience supervising researchers and driving cross-team inference workflows.
- Demonstrated compute and funding leadership, securing large-scale GPU/HPC resources and AI-focused research grants.

AI Grants and Compute Leadership

- **Principal Author**, *CFP03 HPC Project Resource Allocation Award (NUS HPC, 9 Oct 2025 – Oct 2026)* — **Approved** computing allocation of **30K NVIDIA H100 GPU-hours**, **2K NVIDIA A40 GPU-hours**, and **200K CPU-hours** for the project *"AI- and GPU-Accelerated Search for Gravitational Waves in PTAs."*
- Co-authored **NRF Singapore AI-for-Science (AI4S) Catalytic Grant** – *"Unified AI Solutions to Enable Scientific Inference for Next-Generation Gravitational-Wave Astronomy"*. 05 September 2025, **1.5M SGD**, Singapore National Research Foundation.
- Contributed to **NAII Seed Grant** – *"Using Artificial Intelligence to Enhance Bayesian Inference in Gravitational-Wave Astronomy"*. 15 April 2025, **250k SGD**, NUS Artificial Intelligence Institute FY2025 H1 Seed Grant Call.

Work Experience

Postdoctoral Research Fellow, National University of Singapore 2024 – Present

- **Physics-Informed Transformer Architectures (External Attention):** Designed and implemented a novel external-attention transformer with physics-informed positional encoding in PyTorch for multimodal PTA datasets. Achieved ∼**50% reduction in training epochs** and **an order-of-magnitude reduction in posterior uncertainty** compared to standard positional encodings.
- **Amortized Bayesian Inference with Generative Models:** Developed neural posterior estimators using continuous normalizing flows and diffusion models to approximate high-dimensional Bayesian posteriors.
- **Inference Scalability & Efficiency Gains:** Reduced inference time from days to hours and significantly decreased reliance on computationally expensive Markov Chain Monte Carlo (MCMC) Bayesian pipelines through amortized neural inference.
- **PINN-Accelerated Likelihood Evaluation:** Applied Physics-Informed Neural Networks (PINNs) to replace ODE/PDE-based likelihood evaluations, enabling GPU-accelerated scalable Bayesian inference.

IBM Research Collaborator 2026 – Present

Contributing to the development of a unified **foundation model** for scalable physics-informed machine learning, focused on scalable noise characterization, signal classification, and simulation-based Bayesian inference across diverse astrophysical systems.

Technical Skills

- **Mathematics & Statistics:** Calculus, Probability, stochastic processes, large-scale Bayesian inference, time-series analysis, linear algebra, Model Validation.
- **Machine Learning & AI:** Deep Learning, Transformers & Attention Architectures, Large Language Models (LLMs), Foundation Models, Generative Modeling (Normalizing Flows, Diffusion Models), Probabilistic Machine Learning, Uncertainty Quantification, Physics-Informed Neural Networks (PINNs), Simulation-Based Inference.
- **Programming & Tools:** Python (NumPy, SciPy, Pandas, PyTorch, Scikit-learn), Mathematica, Maple, C, Bash, LINUX/UNIX, LaTeX, HPC/GPU computing.
- **Numerical Methods:** Differential equations, Monte Carlo methods, regression, interpolation.

- **Research & Leadership**: Technical Leadership in Global Teams, Research Supervision & Mentorship, AI & Compute Grant Writing, Numerical & Quantitative Methods.

Education

Ph.D. in Astrophysics, Tata Institute of Fundamental Research, Mumbai 2019–2024
Thesis: *Modeling Nano and Hecto Hertz Gravitational Wave sources and their observational implications*

- **Large-Scale Bayesian Inference (MCMC)** – Applied high-dimensional Bayesian inference using **large-scale MCMC** (hundreds of parameters) to extract weak gravitational-wave signals from heterogeneous, noise-dominated PTA datasets, enabling detection and characterization of SMBHBs from real observational data.
- **Cross-Collaboration Posterior Analysis & Validation** – Led rigorous **posterior comparison studies** across multiple international PTA collaborations, introducing **distribution-level comparison frameworks** that go beyond traditional point-estimate metrics (e.g., Mahalanobis distance) to assess model agreement and uncertainty.
- **Burst-with-Memory (BWM) Signal Search Leadership** – Spearheaded the **international search for gravitational-wave burst-with-memory signals**, coordinating end-to-end data analysis pipelines, large-scale computational workflows, and cross-team validation across global research groups.

BS–MS Dual Degree in Physics, IISER Bhopal *2014–2019*
MS Thesis: Chiral Anomalies in Quantum Field Theory **CGPA:** 8.89/10

- Built a strong foundation in theoretical physics, applied mathematics, and computational problem solving.

Research Leadership and Collaboration

- Supervised graduate and doctoral researchers across multiple international institutions on **AI-driven inference, probabilistic modeling, and large-scale Bayesian time-series analysis**.
- Co-led the burst-with-memory signals search within **International PTA Data Release 3**.
- Co-led **posterior comparison studies** across three major global collaborations.
- Served as **Deputy Managing Leader (DML)** for the Indian Pulsar Timing Array, overseeing **data reduction workflows, system reliability, and long-term dataset management**.

Communication and Visibility

- Delivered invited and contributed talks at leading institutions across the US (including **Caltech**) and Europe, translating advanced ML and probabilistic inference concepts for interdisciplinary audiences.
- Featured in a Times of India press release ([link]) highlighting Indian-led contributions to the first compelling evidence of nanohertz gravitational waves.
- Regular presenter at major international conferences, communicating complex inference methodologies to technical and non-technical stakeholders.

Selected Publications

🎓 **Google Scholar:** 2470+ citations — h-index: 14 — i10-index: 14 — 24 total publications

- Dandapat, S., Chua, A. J. (2026). *Transformers with physics-informed encodings and simulation-based inference for robust gravitational-wave detection in PTA data*. AI4X – Accelerate Conference 2026. [OpenReview]. [PDF].
- Dandapat, S. et al. (2024). *Efficient prescription to search for linear gravitational wave memory from hyperbolic black hole encounters and its application to the NANOGrav 12.5-year dataset*. Phys. Rev. D 109, 103018. arXiv:2402.03472.
- Agazie, G., Dandapat, S., et al. (2024). *Comparing recent PTA results on the nanohertz stochastic GW background*. Astrophys. J. 966, 105. arXiv:2309.00693.
- Dandapat, S. et al. (2023). *Gravitational waves from black-hole encounters: Prospects for ground and galaxy-based observatories*. Phys. Rev. D 108, 024013. arXiv:2305.19318.
- Cho, G., Dandapat, S., & Gopakumar, A. (2022). *Third order post-Newtonian gravitational radiation from two-body scattering*. Phys. Rev. D 105, 084018. arXiv:2111.00818.