Pratyush Jha

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Google Scholar · LinkedIn · Portfolio Website

Research interests. Physics and machine learning: robust analysis and development of generative models using statistical physics, and the use of these models to capture physics faithfully.

Education

Indian Institute of Technology Roorkee — Nov 2020 – Jul 2024
B.Tech. in Engineering Physics — CGPA 9.117/10 · Department Rank 2

- **Thesis:** *Deep Learning Simulations for Phase Diagrams of Interacting Josephson Qubits*.
- **Physics coursework:** Nuclear Physics & Applications, Nuclear Astrophysics†, Nuclear Instrumentation†, Mechanics & Relativity, Electromagnetic Theory, Quantum Physics, Mathematical Physics, Thermal & Statistical Physics, Quantum Theory of Solids†, Numerical Analysis & Computational Physics, Quantum Computing.
- **Mathematics, statistics & ML coursework:** Statistical Inference†, Stochastic Processes†, Optimization Techniques, Machine Learning, Reinforcement Learning†.

†Postgraduate-level course.

Publications & Preprints

[1] **P. Jha***, B. Maji*, R. Pandit. *How well can Diffusion Models learn Lagrangian-Tracer Statistics in Non-reciprocal Turbulence?* Preprint, arXiv:2608.27378 (Aug 2026). **Equal contribution.*

[2] **P. Jha**. *Capturing the Topological Phase Transition and Thermodynamics of the 2D XY Model via Manifold-Aware Score-Based Generative Modeling.* Preprint, arXiv:2602.07548 (Feb 2026).

[3] **P. Jha**. *Coherence at the Financial Misinformation Detection Challenge Task: A Courtroom-Inspired Framework for Reference-Free Verification.* Workshop on Misinformation Detection in the Era of LLMs (MisD 2026), ICWSM 2026 (May 2026).
DOI: 10.36190/2026.40.

Research Experience

Indian Institute of Science, Bangalore — May 2026 – Present
Project Associate (Pre-doctoral Research) — Advisor: Prof. Rahul Pandit

Generative diffusion models for non-reciprocal turbulence [arXiv:2608.27378]

- Established, to our knowledge, **the first application of diffusion models to non-reciprocal binary-fluid systems**: synthesized Lagrangian-tracer trajectories in 2D non-reciprocal Cahn–Hilliard–Navier–Stokes (NRCHNS) turbulence and benchmarked them against direct numerical simulations.
- Presented a comprehensive statistical analysis of the generated trajectories: velocity and acceleration probability density functions, curvature statistics, Lagrangian velocity increments, structure functions, flatness, local scaling exponents, irreversibility and model transferability.
- Presented the sampler dependence of the results, testing DDIM as a sampling-acceleration technique: the accelerated **DDIM sampler loses accuracy below 100 steps** on some statistics in non-reciprocal turbulence, contrary to 3D fluid turbulence; found the **800-step DDPM sampler to be the most robust across all statistical benchmarks**.

Reducing sampler-induced errors in diffusion models [ongoing]

- Performing theoretical and computational analysis of sampler-induced errors that propagate into the samples, to develop new sampling techniques that isolate generated samples from such errors.
- Benchmarking the approach on physical systems with known statistical properties, to identify the different sources of error against ground truth and to assess its applicability to other data distributions.
- Benchmarked flow matching (Lee & Wang, 2026) against our manifold-aware diffusion model with MALA correction.

Independent Research — Jan 2026 – Apr 2026
Sole-author projects

Manifold-aware score-based generative modeling of the 2D XY model [arXiv:2602.07548]

- To my knowledge, **the first generative model trained on samples alone** (no Hamiltonian) to accurately reproduce second-moment quantities such as the heat capacity C_v of the 2D XY model, via manifold-aware training on $\mathbb{T}^{4096}$.
- Proposed the 2D XY model as a **non-trivial testbed for generative models**, showing the substantially higher accuracy of manifold-aware over manifold-agnostic training against the exact score of its Boltzmann distribution.
- Applied Metropolis-adjusted Langevin (MALA) steps driven by the learned score after ODE sampling (to my knowledge, the first such use), improving the accuracy of the heat capacity C_v computed from generated samples.

- Achieved **zero-shot generalization** to unseen lattice sizes without retraining, capturing the BKT transition.

Courtroom-inspired framework for financial misinformation detection [ICWSM 2026 workshop, DOI: 10.36190/2026.40]

- Proposed a **reference-free, courtroom-inspired framework** to counter the compliance bias of LLMs, which tend to accept mathematically coherent but contextually false financial claims.
- Formulated a dual-perspective adversarial generation technique: prompted DeepSeek-chat to construct prosecution (falsifying) and defense (justifying) arguments for each claim.
- Developed a **multi-channel classifier** with a frozen ModernBERT backbone, parallel BiGRU layers, and a context-based attention mechanism to weigh the two arguments.
- The method does not rely on dataset-specific perturbation details and is designed to generalize to other datasets for misinformation detection, with the aim of making **LLM agents robust** in such decision-making tasks.
- Achieved an **accuracy of 0.955** and F1 of 0.955 on the test dataset, **a 38.5% absolute improvement in accuracy over the 2-shot GPT-4.1 baseline** (accuracy 0.570).

Indian Institute of Technology Roorkee Aug 2023 – Apr 2024
Bachelor's Thesis Researcher Advisor: Prof. Peayush Choubey

- Classified the phases of Monte Carlo-sampled 2D Ising configurations with feed-forward and convolutional networks.
- Frustrated Josephson-junction arrays map to long-range Ising models. As a first step, **developed a transfer-learning approach**: pre-trained deep networks on nearest-neighbour (NN) Ising data and fine-tuned them on limited next-nearest-neighbour (NNN) data to predict phase transitions.
- Compared fine-tuning configurations across NN and NNN Ising models and demonstrated that the approach predicts NNN phase transitions efficiently from limited data; also carried out zero-shot NN→NNN transfer.
- Extended the analysis to the long-range Ising model (LRIM), sampling configurations with the **Fukui–Todo** $O(N)$ **cluster Monte Carlo** algorithm, and used transfer learning from CNN weights trained on NN Ising data to predict LRIM transition temperatures.

McGill University, Montreal May 2023 – Aug 2023
MITACS Globalink Research Intern Advisor: Prof. John Kildea

- Monte Carlo modelling of a radiator–degrader–detector setup for a CR-39 track-etch neutron detector using TOPAS and TOPAS-nBio, **calculating recoil-proton threshold energies** across nine aluminium degrader thicknesses.
- Modelled CR-39 detector configurations with and without a water phantom to compare the relative dose deposited by secondary charged particles from an isotropic monoenergetic neutron source.

Industry Experience

OLA Krutrim, Bangalore Jul 2024 – Dec 2025
SDE-1 (Research & Development)

- Built production AI services (a RAG platform; CCTV video analytics across 1000 service centres); benchmarked and deployed embedding and reranking models for low-latency RAG applications (**sub-200 ms latency**).
- Performed LoRA fine-tuning of LLaMA-3-8B-Instruct for code-repository understanding, using SimPO preference optimization to reduce hallucination (**+15%** accuracy on paraphrased questions).
- **Agentic AI**: worked on an AI assistant generating Krutrim Cloud SDK code; evaluated LLMs' reasoning capabilities.

Selected Projects

- **Feature-based dynamic pricing with adversarial contextual bandits** Feb 2024 – Mar 2024
  Reinforcement Learning course project, Prof. Manu Kumar Gupta
  Pricing with adversarially chosen product features and an unknown linear market value: implemented the ellipsoid-based pricing algorithm of Cohen *et al.* (2020) and EXP4, and compared their regret under changing distributions.
- **Monte Carlo simulation of magnetic skyrmions** Aug 2023 – Oct 2023
  Physics and Astronomy Club, IIT Roorkee
  Simulated topologically protected skyrmions on a 2D lattice using Metropolis sampling with simulated annealing.
- **Image colorization with conditional GANs** Mar 2023 – Apr 2023
  Machine Learning course project, Prof. Balasubramanian Raman
  Trained a conditional GAN for image-to-image translation in the Lab colour space on 8000+ COCO images.
- **Quantum Hadamard edge detection** Sep 2022 – Nov 2022
  Quantum image processing project, Prof. Peayush Choubey
  Implemented quantum Hadamard edge detection (QHED; Yao *et al.*, 2017): amplitude-encoded images on qubits and used a Hadamard gate on an auxiliary qubit to extract horizontal and vertical edges.
- **Deep Q-learning agent for pixel-based game control** Jun 2022 – Jul 2022
  Vision and Language Group, IIT Roorkee
  Trained a deep Q-network (DQN) with experience replay in PyTorch that learns from raw game frames through a convolutional network to progress through the first level of Super Mario Bros.
- **Geant4 simulation of a CsI(Tl) scintillation detector** May 2022 – Jul 2022

Department of Physics, IIT Roorkee
Coded the detector construction for a CsI(Tl) scintillator in Geant4 (C++) and counted the hits on the detector surface, which feed the detector's pulse-height spectrum.

Skills

Generative & surrogate models	Diffusion models (DDPM, DDIM, probability-flow ODE; manifold-aware training), flow matching, GANs, consistency models
Language models & agents	Encoder-only (BERT), decoder-only (LLaMA, Qwen), embedding and reranking models; LoRA, preference optimization (PPO, DPO, SimPO), RAG, agentic AI (LangGraph)
Reinforcement learning	Deep Q-learning (DQN), TD(λ); adversarial contextual bandits (EXP4, ellipsoid-based pricing); multi-armed bandits; policy gradient methods
Computational physics	MCMC (Metropolis, MALA), Langevin dynamics, simulated annealing; Geant4, TOPAS
Languages & tools	Python, C++; PyTorch, TensorFlow, SciPy; FastAPI, KServe, NVIDIA DeepStream; Git, LaTeX, Linux

Selected Awards

- GATE Data Science & AI: **All India Rank 117** of 69,242 candidates 2026
- 3rd place (as independent researcher), Reference-Free Financial Misinformation Detection Challenge 2026
- **Keynote Speaker**, NextGen Indian Leaders Program (DWDG): addressed 200+ attendees on GenAI 2024
- **MITACS Globalink Research Internship**, fully funded research at McGill University 2023
- **ENCORE Award for All-Round Excellence**, IIT Roorkee Alumni Awards (out of 1500 students, Class of 2024) 2022

Teaching & Service

- Student Mentor for **10+ first-year students**, IIT Roorkee 2022–2024
- Undergraduate Teaching Assistant for Mathematics-I (**70+ first-year students**), IIT Roorkee 2021
- Deputy Cell Secretary, NSS IIT Roorkee (education vertical): led 75 members; **'Best Cell Member' award** 2021–2022

Other Activities

- **CEEW & NSS:** report for the Bureau of Energy Efficiency on awareness of energy-efficiency star ratings
- **Enactus:** Project Anushruti, a sign-language translator for students of the Anushruti Academy for the Deaf
- **ShARE:** mentored a team of 5 students for a case-study competition