Akhil Premkumar

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Postdoctoral researcher working at the intersection of physics and machine learning, with sole-authored papers in Physical Review D, NeurIPS, and ICML. My research applies principles from statistical physics and information theory to diffusion models, and turns them into measurement tools for physics. Previously completed my Ph.D. studying quantum field theory in expanding spacetimes.

Education

University of California San Diego — **San Diego, CA**
Ph.D. in Physics — *2017–2022*
- Advisor: Daniel R. Green
- Thesis: *Loop effects in de Sitter spacetime*

Indian Institute of Technology - Bombay — **Mumbai, India**
M.Sc. in Physics — *2015–2017*
- Advisor: Pradeep Sarin
- Thesis: *A silicon detector test bench using the Beetle ASIC*

College of Engineering, Trivandrum — **Kerala, India**
B.Tech. in Applied Electronics and Instrumentation — *2007–2011*

Research Experience

Department of Physics — **University of California San Diego**
Postdoctoral Scholar, San Diego, CA — *2026–Present*

Department of Applied Physics — **Yale University**
Postdoctoral Associate, New Haven, CT — *2025–2026*

Kavli Institute of Cosmological Physics — **University of Chicago**
Associate Fellow, Chicago, IL — *2022–2025*

Work Experience

University of California San Diego — **San Diego, CA**
Lecturer — *Summer 2020*
Course: Fluids, Waves, Optics and Thermodynamics

University of California San Diego — **San Diego, CA**
Research Assistant — *2017–2022*

University of California San Diego — **San Diego, CA**
Graduate Teaching Assistant — *2017–2022*
Courses: (undergrad+grad) Classical Mechanics, Electromagnetism, Quantum Mechanics, (undergrad) General Relativity, Mathematical Physics, Thermodynamics.

Hewlett-Packard — **Bangalore/San Diego**
Systems Engineer — *2011–2014*
Worked on image processing software for inkjet pen characterization

Honors and Awards

- NeurIPS 2025 Spotlight for my sole-authored paper "Neural Entropy"
- Chancellor's Dissertation Medal for the School of Physical Sciences, UC San Diego, 2023

- Institute Silver Medal, IIT Bombay (equivalent to graduating summa cum laude), 2017
- R.P. Singh Memorial Award for overall academic performance from the Department of Physics, IIT Bombay, 2017

Publications

D. Green, K. Gupta, and A. Premkumar, "The Quantum Mechanics of Rare Events: From Quantum Walks to Stochastic Inflation," arXiv:2608.06319 [hep-th].

A. Premkumar and S. Lucioni, "The Diffusion Encoder," arXiv:2605.13399 [cs.LG].

A. Premkumar, "On the Separability of Information in Diffusion Models," *Proceedings of the 43rd International Conference on Machine Learning* (2026) , arXiv:2509.23937 [cs.LG].

A. Premkumar, "Diffusion Density Estimators," arXiv:2410.06986 [cs.LG].

A. Premkumar, "Neural Entropy," *Advances in Neural Information Processing Systems 2025* (2024) , arXiv:2409.03817 [cs.LG].

A. Premkumar, "Generative Diffusion From An Action Principle," arXiv:2310.04490 [cs.LG].

A. Premkumar, "Regulating loops in de Sitter spacetime," *Phys. Rev. D* **109** no. 4, (2024) 045003, arXiv:2110.12504 [hep-th].

T. Cohen, D. Green, and A. Premkumar, "Large Deviations in the Early Universe," *Phys. Rev. D* **107** no. 8, (2023) 083501, arXiv:2212.02535 [hep-th].

T. Cohen, D. Green, and A. Premkumar, "A Tail of Eternal Inflation," *SciPost Phys.* **14** no. 5, (2023) 109, arXiv:2111.09332 [hep-th].

T. Cohen, D. Green, A. Premkumar, and A. Ridgway, "Stochastic Inflation at NNLO," *JHEP* **09** (2021) 159, arXiv:2106.09728 [hep-th].

D. Green and A. Premkumar, "Dynamical RG and Critical Phenomena in de Sitter Space," *JHEP* **04** (2020) 064, arXiv:2001.05974 [hep-th].

Selected Talks

- University of Michigan, Leinweber Institute for Theoretical Physics 11^{th} Spring Symposium – *"On the Separability of Information in Diffusion Models"*
- Aspen Center for Physics, Theoretical Physics in AI – *"The Diffusion Gambler"*
- Radboud Universiteit, Generative Memory Lab – *"Information Theory x Machine Learning"* (video)
- CUNY – *"Neural Entropy"*
- Jump Trading, NY – *"Information Theory x Machine Learning"*
- Yale, Foundations of Data Science Seminar – *"Information Theory x Machine Learning"*
- MIT, Learning on Graphs and Geometry – *"Neural Entropy"* (video)
- Jump Trading, Chicago – *"An Entropic View of Machine Learning"*
- Caltech, Information, Geometry, and Physics seminar – *"An Entropic View of Machine Learning"*
- Loyola University, Colloquium – *"Diffusion Models: An Entropic Perspective"*
- MIT, IAIFI Summer Workshop 2024 Contributed Talk – *"Neural Entropy"*
- University of Wisconsin-Madison, Physics ∩ ML seminar – *"Diffusion Models: A Thermodynamic Perspective"*
- Aspen Center for Physics, Conference on Fields, Strings, and Deep Learning – *"Diffusion Models: A Thermodynamic Perspective"*

- University of Chicago, Particle Theory Seminar – *"Large Deviations in the Early Universe"*
- Lawrence Berkeley Laboratory, High Energy Seminar – *"A Tail of Eternal Inflation"*
- Perimeter Institute, Seminar for the Cosmology group – *"Regulating Loops in de Sitter"*
- Cambridge, Talk for Enrico Pajer's group at DAMTP – *"Regulating Loops in de Sitter"*
- Caltech, High Energy Seminar – *"Regulating Loops in de Sitter"*

Technical Skills

Programming: Python/JAX (current focus), C++ and C# (prior experience)
Specializations: Deep learning, diffusion models, information theory, statistical physics