

# SNEH PANDYA

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## SUMMARY

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I am a fifth-year Ph.D. candidate in the Department of Physics at Northeastern University and a junior researcher at the NSF Institute for Artificial Intelligence and Fundamental Interactions (IAIFI). My research lies at the intersection of machine learning and cosmology, with a particular emphasis on particle cosmology and weak gravitational lensing. I also maintain broader interests in artificial intelligence, especially concerning the generalization properties of neural networks. My work draws on differentiable programming and simulations, Bayesian inference, optimal transport theory, and equivariance. Prior to beginning my Ph.D., I worked in AI and computational astrophysics.

## EDUCATION

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<b>Northeastern University</b> Ph.D., Physics <i>Advisors: Jim Halverson &amp; Jonathan Blazek</i> <i>Expected Graduation: May 2026</i>	<i>2021-Present</i>
<b>University of Illinois at Urbana-Champaign</b> B.S., Physics, Minors in Mathematics & Astronomy <i>Treasurer of Sigma Nu Fraternity</i>	2017-2021 <i>GPA: 3.79/4.00</i>

## PAPERS

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- S. Pandya**, Y. Yang, N. V. Alfén, J. Blazek, R. Walters. A Diffusion Generative Model for Galaxy Intrinsic Alignments. *In Progress*.
- S. Pandya**, J. Halverson. Differentially Learning Probabilities in the Inflationary Multiverse. *In Progress*.
- S. Pandya**, Y. Yang, N. V. Alfén, J. Blazek, R. Walters. **IAEmu**: Learning Galaxy Intrinsic Alignment Correlations. *Under Review at Open Journal of Astrophysics, 2025*. arXiv:2504.05235
- E. Berman, **S. Pandya**, J. McCleary, et al. On Soft Clustering for Correlation Estimators. *Open J. Astrophys. 8 144313 (2025)* arXiv: 2504.06174
- S. Pandya**, P. Patel, M. Walmsley, B. Nord, A. Ciprijanovic. **SIDDA**: Sinkhorn Dynamic Domain Adaptation for Image Classification with Equivariant Neural Networks. *Mach. Learn.: Sci. Technol. 6 035032 (2025)*. arXiv:2501.14048
- S. Pandya**, J. Halverson. On the Generality and Persistence of Cosmological Stasis. *Phys. Rev. D 110, 075041 (2024)*. arXiv:2408.00835.
- S. Pandya**, Y. Yang, N. V. Alfén, J. Blazek, R. Walters. Learning Galaxy Intrinsic Alignment Correlations. *ICLR Data-centric Machine Learning Research (2024)*. arXiv:2404.13702.
- S. Pandya\***, P. Patel\*, F. O., J. Blazek. E(2) Equivariant Neural Networks for Robust Galaxy Morphology Classification. *NeurIPS Machine Learning for the Physical Sciences (2023)*. arXiv:2311.01500.
- S. Pandya\***, J. Lin\*, D. Pratap, X. Liu, M. Kind, V. Kindratenko. AGNet: Weighing Black Holes with Deep Learning. *MNRAS, 518, 4921 (2023)*. arXiv:2108.07749
- S. Pandya\***, J. Lin\*, D. Pratap, X. Liu, M. Kind. AGNet: Weighing Black Holes with Machine Learning. *NeurIPS Machine Learning for the Physical Sciences (2020)*. arXiv:2011.15095

## PUBLICLY AVAILABLE CODE

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**diff-halotools-IA:** Differentiable implementation of the galaxy intrinsic alignment (IA) halo-occupation distribution (HOD) model introduced in arXiv:2311.07374. Differentiably paints galaxies with various alignment models on  $N$ -body dark matter simulations. 

**SIDDA:** Codebase accompanying arXiv:2501.14048. Constructs a novel, semi-automatic, dataset-agnostic domain adaptation (DA) method leveraging the Sinkhorn divergence and optimal transport distances, designed to increase generalization performance across diverse datasets. 

**IAEmu:** Codebase accompanying arXiv:2504.05235. Implements a NN-based emulator for learning intrinsic alignment correlation functions from halo-occupation distribution simulations. The framework also incorporates Hamiltonian Monte Carlo for differentiable sampling with the neural network. 

**diff-stasis:** Codebase accompanying arXiv:2408.00835. Implements an end-to-end differentiable pipeline for simulating early universe dynamics. Utilizes `diffraex` for differentiable ODE solving and integrates with `numpyro` to enable differentiable sampling within the simulation framework. 

**GCNNMorphology:** Codebase accompanying arXiv:2311.01500. Implements a suite of  $E(2)$ -equivariant CNNs for galaxy morphology classification using the Galaxy Zoo DECal dataset, aimed at exploring the generalization properties of equivariant models. The repository also includes tools for analyzing NN latent spaces and implementing differentiable genetic algorithms for adversarial attacks. 

**AGNet:** Codebase accompanying arXiv:2011.15095 and arXiv:2108.07749. Implements a CNN-based modeling pipeline for predicting the spectroscopic redshift and mass of supermassive black holes. 

## WORK

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### Department of Energy SCGSR Fellow

*Fermilab*

August 2024 - February 2025

*Batavia, IL*

- Studying generalization of neural networks, at an architectural (equivariance) level and in the training of NNs (domain adaptation).

### SPIN Intern & NSF REU Fellow

*National Center for Supercomputing Applications*

August 2019 - May 2021

*Urbana, IL*

- Utilized HAL supercomputing cluster to accelerate neural network training time, execute data simulation pipeline to expand training data set, and create informative visualizations for a general audience.

## CONFERENCES & PRESENTATIONS

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NSF-Simons SkAI Institute, <i>Chalk Talk</i> .....	2025
AstroAI @ Harvard Center for Astrophysics, <i>Oral Presentation</i> .....	2025
Summit for AI Institutes Leadership (SAIL), <i>IAIFI Representative, Poster</i> .....	2025
FirstPrinciples, <i>Oral Presentation</i> .....	2025
NSF-Simons Open SkAI Conference, <i>Poster</i> .....	2025
IAIFI Workshop, <i>Oral Presentation</i> .....	2025
IAIFI Summer School, <i>Tutorial Lead</i> .....	2025
NSF-Simons SkAI Institute Undergraduate Symposium, <i>Lightning Talk</i> .....	2025
DESC Intrinsic Alignment Telecon, <i>Oral Presentation</i> .....	2025
NSF-Simons SkAI Institute, <i>Oral Presentation</i> .....	2025
Institute of Astrophysics of the Canary Islands, <i>Oral Presentation (Virtual)</i> .....	2025
Fermilab AI Meeting, <i>Oral Presentation</i> .....	2025
Cosmology & Galaxy Astrophysics w/ Simulations & ML 2024 @ Flatiron, <i>Oral Presentation</i> .....	2024
echoIA LILAC Workshop @ Harvard, <i>Lightning Talk</i> .....	2024
IAIFI Workshop @ MIT, <i>Poster</i> .....	2024

Tufts University, <i>Oral Presentation</i> .....	2024
Fermilab Surveys Meeting, <i>Oral Presentation</i> .....	2024
Neural Information Processing Systems (NeurIPS) Workshop, <i>Poster</i> .....	2023
Mathematical Physics Days, <i>Oral Presentation</i> (Video).....	2021
Illinois Astrofest, <i>Poster (1st Place)</i> .....	2021
Neural Information Processing Systems (NeurIPS) Workshop, <i>Poster</i> (Video, Poster).....	2020
Illinois Undergraduate Research Symposium, <i>Poster</i> (Video, Poster, Press) .....	2020

## SCHOOLS & WORKSHOPS

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IAIFI PhD Summer School and Workshop ( <b>Organizer, Presenter</b> ) .....	August 2025
IAIFI PhD Summer School and Workshop ( <b>Organizer</b> ).....	August 2024
IAIFI PhD Summer School and Workshop ( <b>Organizer</b> ).....	August 2023
IAIFI PhD Summer School and Workshop .....	August 2022
Princeton Deep Learning Theory Summer School .....	July 2021

## OUTREACH

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Northeastern HET Journal Club, <i>Lecture</i> , “Bayesian Inference for Smarties” .....	2025
John Hersey High School, <i>Lecture</i> , “Synergies Between AI & Physics” .....	2025
Northeastern University, <i>Seminar</i> , “Machine Learning, Neural Networks, & All That” .....	2022
Urbana High School, <i>Lecture</i> , “Black Holes & AI” .....	2020
John Hersey High School, <i>Lecture</i> , “Black Holes & AI” .....	2020

## AWARDS & RECOGNITION

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<b>Fiddler Innovation Undergraduate Fellowship Award</b>	2021
<i>National Center for Supercomputing Applications</i>	<i>Urbana, IL</i>
· \$1500 awarded to undergraduate students showing outstanding contributions during the Summer 2020 REU Inclusion program. The Fiddler Fellowship award is part of a \$2 million-dollar endowment from Jerry Fiddler and Melissa Alden to the University of Illinois in support of student interdisciplinary research initiatives through the Illinois eDream Institute at NCSA.	

## SERVICE & TEACHING

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<b>IAIFI PhD Summer School Tutorial</b>	2025
Constructed a code tutorial outlining distance based and adversarial domain adaptation methods, presented to 200+ students. Code is publicly available. 	
<b>International Conference on Machine Learning (ICML)</b> 2022, 2025	
Reviewer for the GenBio workshop, ML4Astro workshop, and AI4Science workshop	
<b>International Conference on Learning Representations (ICLR)</b> 2023	
Reviewer for the ICLR-DMLR workshop	
<b>Conference on Neural Information Processing Systems (NeurIPS)</b> 2022, 2023	
Reviewer for NeurIPS-AI4Science workshop	
<b>Department of Physics</b>	2021-2023
<i>Northeastern University</i>	<i>Boston, MA</i>
Teaching Assistant: (Under)graduate Computational physics, Engineering & Life Sciences Physics Lab	

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**Programming:** Python, scientific computing, differentiable programming, probabilistic programming  
**Other:** rock-climber, lifter, photographer, concert-goer, washed-up tennis player, record-collector