Cooper Niu

Website: cooperniu.com
Email: cooper_niu@brown.edu
Phone: (757) 968-0603

Department of Physics
Brown University
184 Hope Street
Providence, RI 02912 USA

SUMMARY

PhD researcher with a strong background in theoretical physics and machine learning, specializing in large language models, symbolic AI, and high-performance computing. Experienced in training LLMs with reinforcement learning, developing scalable algorithms for complex datasets, and optimizing simulations of nonlinear systems. Proven ability to tackle abstract, frontier problems with rigor and creativity, and now seeking to apply these skills to real-world AI challenges.

EDUCATION

Brown University, Providence, Rhode Island — 2022-2027 (expected)
Ph.D. in Theoretical and Computational Physics

William & Mary, Williamsburg, Virgina — 2018-2022
B.S. with honor in Physics and Philosophy, *Summa Cum Laude*, Phi Beta Kappa

RESEARCH & PROJECTS

AI for Theoretical Physics

- **LLM Architecture Design**
  - Proposed a novel foundation-model framework for theoretical physics that enables LLMs to autonomously propose new physics theories and test them against experimental data using reinforcement learning with verifiable rewards (RLVR).
  - Built a hierarchical RL environment integrating symbolic algebra (`Mathematica/SymPy`), numerical solvers, and Bayesian inference; implemented per-token rewards based on first principles and experimental agreement.
  - Developed a rule-based grammar encoding symmetry groups, differential geometry, quantum numbers, and spacetime curvature, enabling LLMs to reason through transparent, step-by-step scientific logic.
  - Streamlined the computation pipeline from theory to observables, reducing a process that previously took months of human effort to 3 minutes on a single CPU core, enabling rapid closed-loop RL training over thousands of candidate theories.
- **Applications to Particle Physics and Cosmology**
  - Automated particle physics theory discovery: evaluated **10, 000+ dark matter models**, calculated scattering cross-sections and relic densities, and validated predictions with LHC and LEP collider data.
  - Extended the framework to cosmology: generated novel **modified theories of General Relativity** explaining cosmic acceleration and evaluated predictions against DESI redshift-survey data.

Theoretical Cosmology and Astrophysics

- Explored helicity asymmetry in massive dark-photon halos as a potential explanation for JWST's discovery of unusually massive early galaxies; performed lattice simulations of axion-dark-photon systems with parity-violating interactions on an HPC cluster
- Proposed a parity-violating vacuum-amplification mechanism for NANOGrav's gravitational-wave data; applied Green's functions and Floquet analysis to compute graviton production and built numerical ODE solvers to execute the calculations
- Developed a Pseudo-Nambu-Goldstone (pNG) Higgs inflation model; performed linear perturbation analysis and implemented numerical solvers for stiff ODE systems that describe scalar, vector, and tensor cosmological perturbations

ACTIVITIES & LEADERSHIP

- **Winner of 2025 Brown–IBM Quantum Hackathon** by building an interactive visualizer for quantum computing algorithms that explicitly displays algorithm topology and qubit entanglements, completed in just 10 hours.
- **Organizer** of weekly student-led seminars Quantum Tea Time at Brown Center for Theoretical Physics and Innovation (BCTPI).
- **Research Mentor** for 3 junior graduate students and 1 undergraduate student (including a computer science senior thesis).
- **Teaching assistant** for 6 physics courses (5 undergraduate, 1 graduate), supporting instruction and mentoring students.

PUBLICATIONS

- **Perturbations in psuedo-Nambu-Goldstone Higgs Inflation**
  Stephon Alexander, Humberto Gilmer, and **Cooper Niu*** (2025), *Journal of Cosmology and Astroparticle*
- **Vacuum Amplification of Chiral Gravitational Waves and the Stochastic Gravitational Wave Background**
  Stephon Alexander, Heliudson Bernardo, Yiya Selina Li, and **Cooper Niu*** (2024), *Physics Review D*
- **Exploring Beyond-the-Standard-Model Theory Space with Reinforcement Learning and Transformer**
  Loukas Gouskos, Benjamin Bradley, **Cooper Niu*** (2025), *under preparation*
- **Parity-Violating Mini-Halo**, Stephon Alexander, Lawrence Edmond IV, **Cooper Niu*** (2025), *under preparation*

SKILLS & LANGUAGE

Programming and Software: Python, Pytorch, CUDA, Julia, Fortran, C/C++, Mathematica, LaTeX, HTML, JavaScript, CSS
Language: English (Near-native Proficiency), Mandarin Chinese (Native)