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Current position

PhD student, Rice University

Domain of expertise

General Relativity, Quantum Field Theory, Mathematical Physics

Areas of interest

- Inflation: CMB observables, quasi-single-field models, production of particles and gravitational waves during inflation
- Dark matter: superheavy WIMPzilla, ultralight dark photon, axion-like particles, non-minimal coupling to gravity
- CMB probes of new physics: isocurvature, non-Gaussianity, cosmological collider
- Gravitational wave: stochastic background, deviations from GR
- Structure formation: deviations from Λ CDM, tests on dark matter models
- Soliton

Education

2014-2018 BSc in Mathematics, University of Chicago

2019-now PhD in Physics, Rice University, Department of Physics and Astronomy

Expected graduation date: May 2024

Thesis title: Testing gravitational production and cosmological evolution of dark matter

Advisor: Dr. Andrew J. Long

Specialized expertise

- Aptitude for C. Have written an Othello game with a very strong AI, which utilizes machine learning for midgame evaluation and ISA extensions to speed up game tree search. See [GitHub link](#).
- Familiarity with C++. Used libraries including Eigen, Boost (odeint, lockfree, math), CTPL. Used these libraries to write parallelized numerical code in for my paper on gravitational production of massive spin-2 field; see [GitHub link](#) for the codebase. Also did numerical relativity simulation of spherical dust collapse for a class project; see [GitHub link](#) for the codebase.
- Mastery for Mathematica. Used packages including xAct/xTensor, NCAlgebra in research projects for symbolic calculations.
- Mastery for Python. Used Numpy and Scipy. Have done independent projects on automating Factorio gameplay, utilizing mixed integer programming (with Gurobi optimizer) and simulated annealing. See [GitHub link](#).
- Experience on GPU computing with CUDA. Have been writing C++ CUDA code to solve PDEs for cosmological simulations in a current project. The code utilizes more than 80% of the memory bandwidth on a RTX 3060 Ti graphics card on a desktop computer, and is consequently more than 10 times faster than optimized CPU code.
- QFT in curved spacetime
- Exact WKB method, Borel resummation
- Finite element and finite difference method for boundary and initial value problems.

Publications & talks

JOURNAL ARTICLES

- 2023 H. Zhang and S. Ling, “Phenomenology of wavelike vector dark matter nonminimally coupled to gravity,” *JCAP* **07** (2023) 055 [[arXiv:2305.03841 \[astro-ph\]](#)].
- 2023 E. W. Kolb, S. Ling, A. J. Long and R. A. Rosen “Cosmological gravitational particle production of massive spin-2 particles,” *J. High Energ. Phys.* **2023**, 181 (2023) [[arXiv:2302.04390 \[astro-ph\]](#)].
- 2022 S. Hashiba, S. Ling and A. J. Long, “An analytic evaluation of gravitational particle production of fermions via Stokes phenomenon,” *J. High Energ. Phys.* **2022**, 216 (2022) [[arXiv:2206.14204 \[hep-th\]](#)].
- 2021 S. Ling and A. J. Long, “Superheavy scalar dark matter from gravitational particle production in α -attractor models of inflation,” *Phys. Rev. D* **103**, no.10, 103532 (2021) [[arXiv:2101.11621 \[astro-ph.CO\]](#)].

ONGOING WORK

- 2023 M. Amin and S. Ling, “Free streaming and self gravity of ultralight scalar dark matter”.
- 2023 S. Ling, A. J. Long, L-T. Wang and Y. Zhao, “Inflationary production of nanohertz gravitational wave in Chern-Simons gravity”.

TALKS

- 2023 Workshop at University of Florida (The Early Universe: A Window to New Physics) : “Cosmological gravitational particle production of massive spin-2 particles”, 6+2 min. [Link](#)
- 2023 Journal club at University of Chicago, Kavli Institute for Cosmological Physics: “Cosmological gravitational particle production of massive spin-2 particles”, 1 hr.
- 2023 Seminar at University of Wisconsin-Madison: “Cosmological gravitational particle production of massive spin-2 particles”, 1 hr. [Link](#)
- 2023 TACOS 2023 (Theoretical Astroparticle and Cosmology Symposium in Texas): “Cosmological gravitational particle production of massive spin-2 particles”, 15+5 min. [Link](#)
- 2023 Invited presentation at group meeting of University of Texas at San Antonio: “Nonminimal vector dark matter”, 25 min talk + discussion.
- 2023 PHENO 2023 (Phenomenology 2023 Symposium): “Cosmological gravitational particle production of massive spin-2 particles”, parallel talk (12+3 min). [Link](#)
- 2023 Astronomy seminar at Rice University: “Nonminimally coupled dark photon dark matter”, 20+5 min. [Link](#)
- 2022 TSAPS (Texas Section of American Physical Society): “Gravitational Production of Scalar Dark Matter in α -Attractor Models of Inflation”, parallel talk (12+3 min). [Link](#)
- 2022 TACOS 2022 (Theoretical Astroparticle and Cosmology Symposium in Texas): 2 day meeting, at Southern Methodist University, in Dallas Texas, gave a 2 min fireslide talk. [Link](#)
- 2022 Astronomy seminar at Rice University: “Gravitational fermion production by Stokes phenomenon”, 20+5 min. [Link](#)
- 2021 Astronomy seminar at Rice University: “Gravitational Particle Production of Scalar Dark Matter in Alpha-Attractor Models of Inflation”, 20+5 min. [Link](#)
- 2021 PHENO 2021 (Phenomenology 2021 Symposium): “Superheavy scalar dark matter from gravitational particle production in α -attractor models of inflation”, parallel talk (10+2 min). [Link](#)

EXPOSITORY ARTICLES

- 2017 “Maxwell Equations and Yang-Mills Theory”, for Mathematics REU at University of Chicago. [Link](#)
- 2018 “Knots and Feynman Diagrams”, for class presentation at University of Chicago. [Link](#)

Other activities

- 2023 Michigan Cosmology Summer School 2023: one week at University of Michigan at Ann Arbor. Learnt about weak lensing, modified gravity, particle cosmology, cosmic microwave background, machine learning, galaxy-halo connection. [Link](#)
- 2021 QFT study group with 3 peer graduate students at Rice. Used Weinberg’s “The Quantum Theory of Fields: Vol. I” and Srednicki’s “Quantum Field Theory” as textbooks.

[Link to our solution for selected problems in Weinberg's book](#)

Teaching experience

2022	Astrophysics II: Galaxies and Cosmology (ASTR 452): graded weekly homework
2021	Mechanics (PHYS 101): helped students run lab sessions, graded lab reports
2021	Computational Physics (PHYS 416/517): graded written and coded homework
2020	Quantum Field Theory (PHYS 622): graded biweekly homework
2020	Electricity and Magnetism (PHYS 102): helped students run lab sessions, graded lab reports

Relevant coursework

At University of Chicago:

- General Relativity (PHYS 36400)
- Analysis-2 (Functional analysis) (MATH 31300)
- Statistical Mechanics (PHYS 35200)
- Introduction To Cosmology (PHYS 37100)
- Quantum Field Theory-1/2/3 (PHYS 44300/44400/44500)
- Numerical Solutions To PDES (Finite element method) (CMSC 38300)
- Machine Learning (CMSC 25400)
- Operating Systems (CMSC 23000)
- Intro To Computer Systems (CMSC 15400)

At Rice University:

- Cosmological relics (PHYS 600)
- Quantum field theory (PHYS 622)
- Quantum mechanics I (PHYS 521)
- Classical electrodynamics (PHYS 532)
- Computational physics (PHYS 517)
- Statistical physics (PHYS 526)
- Classical dynamics (PHYS 515)
- Intro to nuclear and particle physics (PHYS 542)
- Physics of quarks and lepton (PHYS 543)
- Intro to plasma physics (PHYS 580)

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