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# Siyang Ling

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## Current position

*Postdoc*, City University of Hong Kong

## 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 LambdaCDM, tests on dark matter models
- Soliton

## Education

2014-2018 BSc in Mathematics, University of Chicago

2019-2024 PhD in Physics, Rice University, Department of Physics and Astronomy
Graduation date: August 2024
Thesis title: Cosmological gravitational particle production of dark matter during inflation and beyond
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.

## Grants, honours & awards

2024 William and Elva Gordon Fellowship, Rice Space Institute

## Publications & talks

### Journal articles & preprints

2024 S. Ling and M. Amin, "Free Streaming in Warm Wave Dark Matter" [arXiv:2408.05591 [astro-ph]] .

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 $\alpha$-attractor models of inflation," Phys. Rev. D **103**, no.10, 103532 (2021) [arXiv:2101.11621 [astro-ph.CO]] .

## Ongoing work

2024 S. Ling, A. J. Long, L-T. Wang and Y. Zhao, "Inflationary production of nanohertz gravitational wave in Chern-Simons gravity" .

## Talks

2024 Workshop at MIAPbP (Quantum Aspects of Inflationary Cosmology) : "Cosmological gravitational particle production of massive spin-2 particles", 45 min. Link

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 $\alpha$-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 $\alpha$-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

2024 NVIDIA Deep Learning Institute: Fundamentals of Deep Learning (training workshop). Received training on deep learning. Obtained certificate of competency. Link to certificate

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

2024 Astrophysics II: Galaxies and Cosmology (ASTR 452): graded weekly homework

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)