

# Tianji Zhou

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## Education

### Haverford College

BS. Physics and Astronomy, Scientific Computing Concentration

Sep 2022 - Present

Haverford, PA

- **GPA:** 3.985/4.000
- **Advanced Coursework:** General Relativity (Haverford, ASTR H325), Cosmological Physics (Swarthmore, PHYS S137), Thermodynamics and the Introduction to Statistical Mechanics and Kinetic Theory (UPenn, PHYS P4401), Advanced Classical Mechanics (Bryn Mawr, PHYS B308), Advanced Electromagnetism (Haverford, PHYS H309), and Astroparticle Physics (Haverford, PHYS H356)
- **Graduate Level Topics Covered Under Research Credit/Independent Study:** The Expansion Rate and Growth of Structure Puzzles (Instructed by Prof. Bhuvnesh Jain, Supervised by Prof. Daniel Grin)

## Publications

### Uncertainty Quantification for the Relativistic Inverse Stellar Structure Problem, Oct 2024

Lindblom, Lee & Zhou, Tianji

Submitted to Physical Review D

### Chebyshev Based Spectral Representations of Neutron-Star Equations of State, Oct 2024

Lindblom, Lee & Zhou, Tianji

Physical Review D, 110(8), 083030

## Research Experience

### Undergraduate Researcher

Prof. Daniel Grin's Lab, Department of Physics and Astronomy, Haverford College

May 2023 - Present

Haverford, PA

### Model Independent Probes of Dark Sector Physics

- Developed a method to constrain dark matter models using principal component analysis (PCA) and the generalized dark matter (GDM) framework.
- Selected the Wess-Zumino Dark Radiation model and the Chameleon Early Dark Energy model as benchmarks, and derived expressions for the equations of state and effective sound speeds of dark sectors to constrain the GDM fluids.
- Computed the equations of state and effective sound speeds using the Cosmic Linear Anisotropy Solving System (CLASS) code.
- Projected the equation of state and effective sound speed onto the principal components of the cosmological dark fluid;
- Inferred model constraints via Fisher matrix analysis and PCA, and compared them against both the traditional Fisher inference ("fishchips") method and Markov Chain Monte Carlo (MCMC) approaches.

### Visiting Undergraduate Researcher

Dr. Lee Lindblom's Lab, Department of Physics, University of California at San Diego

Jun 2024 - Oct 2024

La Jolla, CA

### Chebyshev-Based Spectral Representations of Neutron-Star Equations of State

- Developed causal parametric representations of neutron-star equations of state using Chebyshev polynomial-based spectral expansions, including both pressure-based and enthalpy-based representations.
- Implemented enthalpy-based and pressure-based representations in Python to represent the equation of state.
- Optimized spectral parameters and calculated modeling errors using the Levenberg-Marquardt algorithm for first-order and second-order phase transition equations of state.
- Demonstrated that Chebyshev polynomial representations exhibit faster convergence in modeling errors compared to simple power-law representations.

## Uncertainty Quantification for the Relativistic Inverse Stellar Structure Problem

- Numerically solved the Oppenheimer–Volkoff equations to compute mass and radius data of neutron stars from a specified equation of state.
- Utilized the Levenberg–Marquardt algorithm to determine optimal Chebyshev-based spectral parameters and central pressures based on the generated data.
- Introduced 20%, 10%, 1% and 0.1% noise to the mass and radius data, recalculated the optimal spectral parameters and central pressure, and analyzed the resulting modeling errors.

## Conferences and Additional Education

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**Undergraduate Cosmology Workshop**, Massachusetts Institute of Technology, Jul 2024

- Presentation Titled: Model-independent Probes of Dark Sector Physics

**ACT + SPT CMB Analysis Summer School**, The University of Chicago, Jul 2024

**APS April Meeting**, American Physical Society, Apr 2024

- Poster Titled: Model-independent Probes of Dark Sector Physics

**Keck Northeast Astronomy Consortium**, Wesleyan University, Oct 2023

- Presentation Titled: The Behavior of The Equation of State and The Sound Speed for The Dark Matter Fluid of The Wess-Zumino Dark Radiation Model

**KINSC Undergraduate Science Research Symposium**, Haverford College, Sep 2023

- Poster Titled: The Behavior of The Equation of State and The Sound Speed for The Dark Matter Fluid of The Wess-Zumino Dark Radiation Model

**Keck Northeast Astronomy Consortium**, Wellesley College, Oct 2022

## Work Experience and Service

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### IDEA Seminar Student Organizer

Sep 2022 - Present

*Department of Physics and Astronomy, Haverford College*

Haverford, PA

- Organized student-led seminars, inviting speakers to raise awareness of Inclusion, Diversity, Equity, and Accessibility (IDEA) issues, reaching over 40 attendees in the department.
- Conducted a climate survey to identify potential IDEA issues within the department.
- Hosted a movie night for 10 physics students, fostering discussion around IDEA topics.
- Organized an art-expression event for 10 physics students to explore physics identity through creative mediums.
- Analyzed survey data using Excel, summarized findings, and provided recommendations for future surveys and departmental improvements.

### Secretary of Society of Physics Students

Sep 2022 - Present

*Department of Physics and Astronomy, Haverford College*

Haverford, PA

- Compiled and distributed weekly meeting summaries to facilitate collaboration within the organization.
- Spearheaded the planning and execution of two successful movie nights, fostering a sense of community among over 30 physics students.
- Led the coordination of an REU (Research Experience for Undergraduates) Q&A session, providing valuable insights and networking opportunities for more than 20 aspiring researchers.
- Organized a physics social event, strengthening peer relationships and engagement among over 10 students.

### Teaching Assistant and Grader for PHYS H214B

Jan 2024 - May 2024

*Department of Physics and Astronomy, Haverford College*

Haverford, PA

- Assisted in teaching and grading for 28 students in the Introductory Quantum Mechanics course.
- Held weekly office hours for 1.5 hours to assist students with coursework.
- Graded written homework assignments for 6 hours each week.

**Teaching Assistant and Grader for PHYS H213A**

*Department of Physics and Astronomy, Haverford College*

Sep 2023 - Dec 2023

Haverford, PA

- Assisted in teaching and grading for 29 students in the Waves and Optics course.
- Conducted weekly TA sessions for 2 hours, providing homework and Mathematica assistance.
- Graded written homework assignments for 5 hours each week.

**Awards and Grants**

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**Haverford KINSC Workshop Funding**, Jul 2024

Haverford College, Amount: \$1500

**Haverford KINSC Conference Funding**, Apr 2024

Haverford College, Amount: \$1500

**Haverford KINSC Summer Scholars**, Mar 2024

Haverford College, Amount: \$5000

**Haverford KINSC Summer Scholars**, Mar 2023

Haverford College, Amount: \$4600

**Skills**

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**Language:** English (Fluent), Chinese (Native), Shanghainese (Native), Cantonese (Elementary)

**Software:** Python, Mathematica,  $\text{\LaTeX}$ , Linux, HTML