

Itamar J. Allali

Provost's Postdoctoral Society of Science Fellow
Department of Physics and Astronomy, University of Notre Dame
225 Nieuwland Science Hall
Notre Dame, IN 46556

CONTACT INFORMATION

Email: cosmos@itamarallali.com, itamar.allali@gmail.com
Website: www.itamarallali.com

[Connect on LinkedIn](#)

RESEARCH INTERESTS

My interests include: the intersection of particle physics and cosmology; high energy theory and phenomenology; astrophysics and astro-particle physics; gravity and quantum physics; dark matter and dark energy

ACADEMIC APPOINTMENTS

Department of Physics and Astronomy, University of Notre Dame
Provost's Postdoctoral Society of Science Fellow November 2025 to present

Department of Physics, Brown University
Postdoctoral Research Associate September 2023 to October 2025

EDUCATION

Tufts University **August 2018 to May 2023**
Degree: Ph.D. in Physics, *Advisor:* Mark P. Hertzberg Earned: May 2023

Dissertation: *Axions in a Dark Universe: Dark Matter Behavior and Novel Dynamics Inform Cosmological Observations*

Degree: M.S. in Physics Earned: May 2020

GPA: 4.0

Selected Awards:

- John F. Burlingame Graduate Fellowship in Physics – Sept. 2022 - Aug. 2023
- Outstanding Contributions to Undergraduate Education Award – April 2021

University of Illinois at Urbana-Champaign **August 2014 to May 2018**

Degrees: B.S. in Specialized Physics; B.S. in Astronomy

GPA: 3.96

Selected Awards:

- James Scholar, Chancellor's Scholar (UIUC Honors) – Aug. 2014 - May 2018
- Robert A. Stein Award (Department of Physics) – 2016
- John A. Gardener Undergraduate Research Award (Department of Physics) – 2017
- Preble Research Scholarship (Liberal Arts and Sciences) – 2017

PAPERS AND PUBLICATIONS

Up-to-date list at: <https://inspirehep.net/authors/1839174>

Summary: [h-index: 11] [total citations: 403] [publications: 14] [total papers and preprints: 15]

1. *Clustering of cosmic string loops within a Milky-way like halo.*
Itamar J. Allali, Mudit Jain, Shi Yan,
e-Print: 2512.23811[astro-ph.CO].
2. *Axion Perturbations: A General Analytical Treatment.*
Itamar J. Allali, Priyesh Chakraborty, JiJi Fan, Matthew Reece,
e-Print: 2510.07371[hep-ph]. Published: Phys. Rev. D 114 (2026) 4, 043517
3. *Cosmic τ ensions Indirectly Correlate with Reionization Optical Depth.*
Itamar J. Allali, Lingfeng Li, Praniti Singh, JiJi Fan,
e-Print: 2509.09678[astro-ph.CO]. Published: Phys. Rev. D 113 (2026) 8, 083515
4. *Reionization and the Hubble Constant: Correlations in the Cosmic Microwave Background.*
Itamar J. Allali, Praniti Singh, JiJi Fan, Lingfeng Li,
e-Print: 2503.05691[astro-ph.CO]. Published: JCAP 08 (2025), 082
5. *The Juno Mission as a Probe of Long-Range New Physics.*
Praniti Singh, Shi Yan, Itamar J. Allali, JiJi Fan, Lingfeng Li,
e-Print: 2409.10616[hep-ph]. Published: JHEP 01 (2025), 098
6. *Neutrino mass bounds from DESI 2024 are relaxed by Planck PR4 and cosmological supernovae.*
Itamar J. Allali, Alessio Notari
e-Print: 2406.14554[astro-ph.CO]. Published: JCAP 12 (2024), 020
7. *Cosmological probes of Dark Radiation from Neutrino Mixing.*
Itamar J. Allali, Daniel Aloni, Nils Schöneberg
e-Print: 2404.16822[astro-ph.CO]. Published: JCAP 09 (2024), 019
8. *Reduced Hubble tension in dark radiation models after DESI 2024.*
Itamar J. Allali, Alessio Notari, Fabrizio Rompineve
e-Print: 2404.15220[astro-ph.CO]. Published: JCAP 03 (2025), 023
9. *Dark Sectors with Mass Thresholds Face Cosmological Datasets.*
Itamar J. Allali, Fabrizio Rompineve, Mark P. Hertzberg
e-Print: 2305.14166[astro-ph.CO]. Published: Phys. Rev. D 108 (2023) 2, 023527
10. *Reduced Axion Abundance from an Extended Symmetry.*
Itamar J. Allali, Mark P. Hertzberg, Yi Lyu
e-Print: 2211.07661[hep-ph]. Published: Phys. Rev. D 107 (2023) 4, 043535
11. *Altered Axion Abundance from a Dynamical Peccei-Quinn Scale.*
Itamar J. Allali, Mark P. Hertzberg, Yi Lyu
e-Print: 2203.15817[hep-ph]. Published: Phys. Rev. D 105 (2022) 12, 123517
12. *Dark Sector to Restore Cosmological Concordance.*
Itamar J. Allali, Mark P. Hertzberg, Fabrizio Rompineve
e-Print: 2104.12798[gr-qc]. Published: Phys. Rev. D 104 (2021) 8, L081303
13. *General Relativistic Decoherence with Applications to Dark Matter Detection.*
Itamar J. Allali, Mark P. Hertzberg
e-Print: 2103.15892[gr-qc]. Published: Phys.Rev.Lett. 127 (2021) 3, 031301
14. *Decoherence from General Relativity.*
Itamar J. Allali, Mark P. Hertzberg
e-Print: 2012.12903[gr-qc]. Published: Phys.Rev.D 103 (2021) 10, 104053
15. *Gravitational Decoherence of Dark Matter.*
Itamar J. Allali, Mark P. Hertzberg
e-Print: 2005.12287[gr-qc]. Published: JCAP 07 (2020), 056

ONGOING RESEARCH

- **Probing New Physics with Structure:** I have been interested in how analytical and computational methods of understanding the formation of dark matter haloes can be leveraged to study new physics phenomena. I am interested in using excursion set theory calculations of the halo mass function, complemented by data of the Ultraviolet Luminosity function from the Hubble Space Telescope and James Webb Space Telescope, to study the impact of primordial features during inflation on the formation of structures at late times. In addition, I am using these tools to understand the impact of phase transitions in the early universe on small structures and applying these analyses to probes of substructure like microlensing. I am further developing this work with machine learning approaches to study nonlinear formation of structure in a broader class of models.
- **Cosmic Correlations:** Discrepancies between Λ CDM inferences from different cosmological data require resolutions. I have developed a methodology for tackling these problems centered around correlations: by quantifying how parameters and datasets relate to one another within a cosmological inference, I can trace a tension to its direct drivers and identify which extensions of Λ CDM could resolve it. I make use of Pearson and partial correlation coefficients to understand parameter relationships as well as causal directions between data and observables.
- **Epoch of Reionization:** Recent and upcoming telescopes are opening up an unprecedented window into the epoch of reionization. I am particularly interested in the relationship between tensions in cosmological data and the observation of the effects of reionization on the CMB via the optical depth parameter. Direct observations of reionization can also be leveraged to differentiate between cosmological models that resolve these tensions.
- **Dark Matter:** I am working on novel models of dark matter relating to axions, in particular the QCD axion. In addition, I am interested in interesting signatures of axions and axion-like-particles in cosmological observables such as the CMB, large-scale-structure, and more. I am also exploring new models of thermal DM, including models inspired by molecular-type interactions and other models motivated by signatures in large scale structure.
- **Cosmological Concordance:** The most recent cosmological data, including CMB data from the Atacama Cosmology Telescope (ACT) and the South Pole Telescope (SPT); Baryon Acoustic Oscillations measurements from the Dark Energy Spectroscopic Instrument (DESI); cosmic shear and supernovae observations from the Dark Energy Survey (DES); and more, have reached unprecedented precision in constraining our models of cosmology. I am actively exploring the degree to which modifications to the concordance Λ CDM model of cosmology are either ruled out or required by these new data, including claims of the dynamical nature of dark energy, the effects of neutrino mass on cosmological observables or lack thereof, constraints on the existence of new physics near the recombination epoch, and the persistent discrepancy between the inferred rate of expansion in Λ CDM and the more local measurements made using Type Ia supernovae. My work analyzes how the correlations between datasets and parameters can help us understand and evaluate models.

TALKS AND PRESENTATIONS

Cosmic Correlations Provide Insight into Observational Tensions and New Physics Searches

- New Synergies Workshop 2026 June 18, 2026
Aspen Center for Physics
- Chicagoland Cosmology & AI Meeting 2026 August 12, 2026
Fermilab

Primordial Features and Their Impact on Halo and Galaxy Formation

- Dark Frontiers 2026 August 6, 2026
University of Illinois at Urbana-Champaign
- Pheno 2026 May 12, 2026

University of Pittsburgh

Cosmological Perturbations of Axion Dark Matter

- Current Trends in Particle Theory VI June 1, 2026
University of Illinois Chicago
- Sydney CPPC Seminar May 28, 2026
UNSW/University of Sydney

Cosmic τ ensions and the Optical Depth to Reionization

- PACMAN October 24, 2025
Flatiron Institute

The Hitchhiker's Guide to Axion Perturbations

- COSMO 25 Conference October 13, 2025
Carnegie Mellon University

Reionization and the Hubble Constant: Correlations in the Cosmic Microwave Background

- High Energy Theory Seminar May 9, 2025
Boston University

The Juno Mission as a Probe of Long Range New Physics

- Cosmic Physics Seminar February 24, 2025
Fermilab
- High Energy Physics Seminar February 3, 2025
Weizmann Institute of Science

Constraints on Light Species from DESI 2024: Neutrinos, Dark Radiation, and the Hubble Tension

- Particle Physics Seminar December 3, 2024
University of Notre Dame
- Astrophysics, Relativity, Cosmology Seminar November 20, 2024
ICASU, University of Illinois at Urbana Champaign

Neutrino mass bounds from DESI 2024 are relaxed by Planck PR4 and cosmological supernovae

- TeVPA 2024 August 27, 2024
University of Chicago [[Slides](#)], [[Abstract and Conference Webpage](#)]

Dark Radiation with Baryon Acoustic Oscillations from DESI 2024 and the H_0 Tension

- PACMAN October 18, 2024
Center for Computational Astrophysics, Flatiron Institute
- Tufts/MIT Cosmology Seminar April 30, 2024
Tufts University

Cosmological Probes of Dark Radiation from Neutrino Mixing

- DPF/PHENO 202, May 14, 2024
University of Pittsburgh, Carnegie Mellon University [[Slides](#)], [[Abstract and Conference Webpage](#)]

Dark Radiation Sectors with Mass Thresholds and Their Promise to Resolve the Hubble Tension

- Dark Matter Journal Club, November 21, 2023
Kavli Institute for Cosmological Physics, University of Chicago
- Elementary Particle Theory Seminar, October 30, 2023
University of Maryland

Light Stepped Dark Sectors Face Cosmological Data Sets

- PHENO 2023 May 9, 2023
University of Pittsburgh, [Slides], [Abstract and Conference Webpage]
- ITC Luncheon January 26, 2023
Institute for Theory and Computation, Harvard Center for Astrophysics

Light Dark Sectors Attempting to Restore Cosmological Concordance

- Astronomy Seminar, Tufts University March 27, 2023

Axions in a Dark Sector to Restore Concordance and Other Axion Phenomenology

- IDEA Seminar, November 10, 2022
Brown University
- High Energy Theory Seminar, September 15, 2022
Boston University

Altered Axion Abundance from a Dynamical Peccei-Quinn Mechanism

- PPC 2022 June 8, 2022
Washington University in St. Louis, [Slides], [Abstract and Conference Webpage]
- PHENO 2022 May 9, 2022
University of Pittsburgh, [Slides], [Abstract and Conference Webpage]

Gravitational Decoherence with Applications to Dark Matter Phenomenology

- Institute of Theoretical Physics October 19, 2021
Chinese Academy of Sciences
- Helsinki Institute of Physics October 6, 2021
University of Helsinki
- COSMO 2021 August 4, 2021
University of Illinois at Urbana-Champaign
[Slides], [Conference Webpage], [Abstract]
- PASCOS 2021 June 14, 2021
IBS-CTPU Daejeon, Korea
[Slides], [Conference Webpage], [Abstract]
- PPC 2021 May 20, 2021
University of Oklahoma
[Slides], [Abstract and Conference Webpage]

A Dark Sector to Restore Cosmological Concordance

- PHENO 2021 May 25, 2021
University of Pittsburgh, [Slides], [Abstract and Conference Webpage]

TEACHING AND MENTORSHIP

Mentorship Roles

University of Notre Dame

- Mentored graduate student in constructing a neural-network-based emulator for predicting nonlinear structure formation from linear matter power spectrum
- Mentored graduate student in dark matter substructure calculations, gravitational dynamics calculations, data analysis
- Concurrently mentored non-Notre Dame graduate student in cosmological data analysis projects
- Organized journal clubs and group meetings for graduate students to develop discussion skills

and disciplinary knowledge

- Taught informal introductory cosmology during semester-long lunch meetings with new graduate students interested in cosmology

Brown University

- Mentored graduate student in cosmological data analyses using Monte Carlo Markov Chain codes and various datasets (student now routinely does independent analyses)
- Mentored graduate student in writing code to calculate post-Newtonian dynamics equations for binary black holes
- Taught masters student to use N-body simulations and analyze results for topological defect applications
- Mentored graduate students in producing fifth force constraints from orbital mechanics and data from Juno spacecraft
- Organized weekly journal clubs for graduate students to develop literature skills
- Supported development of paper-writing skills and oral presentation skills for graduate students

Tufts University

- Mentored undergraduate student through two summers projects, including end-of-summer presentation of findings
- Taught undergraduate student about QCD axion literature
- Mentored undergraduate student in calculations of cosmic history of QCD axion dark matter models

Teaching Training

Postdoctoral Program for Teaching Excellence

Sep 2025 – April 2026

Kaneb Center for Teaching Excellence, University of Notre Dame

Graduate Institute for Teaching (GIFT)

June – December 2024

Graduate School of Arts and Sciences, Tufts University

Teaching Postitions

Brown University

Providence, RI

Instructor, Brown Pre-college Programs

July 2024, July 2025

- Instructed active-learning style classes for pre-college course “Origins of the Universe: From the big bang to black holes”
- Compiled daily readings and videos with checkpoint questions, at appropriately accessible level for high schools students
- Created cosmology curriculum based on graduate-level concepts for varying levels of high school math and physics exposure
- Constructed and executed class activities and lectures, blending methods of active learning, group assignments, and large group discussions
- *Example activities:* measuring the height of the building to learn about distance measurements in cosmology; using python to simulate different fates of the universe; building a model of the universe’s expansion using bungee cords
- Hosted student help hours and mentoring sessions, providing students with feedback on their work and answering questions about careers in science

Tufts University

Medford, MA

Instructor of Record

June to Aug. 2020, 2021, 2023

- Instructed active-learning style classes for Physics 13 (Modern Physics)
- Organized course materials, including daily readings, daily checkpoint questions, weekly homework assignments, and exams
- Graded student work, providing calculated and meaningful feedback
- Conducted help hours and one-on-one meetings with students to support their learning and progress in the course
- Piloted research-based final project in Summer 2021

Tufts University

Medford, MA

Fellow, Graduate Institute for Teaching (GIFT)

June to December 2021

- Co-instructed/coordinated Physics 1 (introductory) course for 200 students
- Facilitated active-learning style lectures once a week
- Designed a research-based final project for the course to replace traditional final exam
- Hosted twice weekly help hours for students to seek assistance
- Organized twice-weekly meetings with co-instructor to prepare lessons and course logistics
- Participated in 3-week teaching workshop

Tufts University

Medford, MA

Teaching Assistant

August 2018 to June 2020

- Instructed introductory physics lab courses, supporting students' problem solving skills in an experimental setting
- Conducted introductory physics discussion sections, guiding students in working through course material
- Organized regular meetings with professors and other TA's to plan class sessions
- Graded students' assignments and exams, providing calculated and meaningful feedback
- Conducted help hours and one-on-one meetings with students to support their learning and progress in the course
- Courses taught include Physics 1 and 11 (introductory physics lab and recitation/discussion), Physics 13 (modern physics recitation/discussion)

University of Illinois at Urbana-Champaign

Urbana, IL

Course Facilitator

February to May 2018

- Taught EPOL 199 - The Intersection of Social Identity in Residential Communities for incoming University Housing student staff in the roles of Resident Advisor and Multicultural Advocate
- Facilitated classroom discussion about social identity, diversity, equity, inclusion, and justice (DEIJ) on a university campus
- Graded student reports and reflections on topics relating to social identity and DEIJ

Sinai Temple Religious School

Hebrew School and Religious School Teacher

Champaign, IL

August 2014 to May 2018

- Taught and mentored two separate classes of 5th to 8th grade students, one focused on Hebrew language skills and one focused on religious and cultural topics
- Collaborated with colleagues and supervisor to formulate lesson plans and construct materials to use in classroom

PROFESSIONAL ACTIVITIES

Referee: Physical Review D, Physics Letters B, Nuclear Physics B, Astrophysical Journal Letters

Organizer: Phenomenology in Illinois, Kentucky, Indiana, Michigan, and Ohio (20th meeting); Notre Dame College of Science/Engineering Research Horizons Symposium (2025 and 2026)

COMMUNITY OUTREACH

MSEF Region IV Science Fair

Somerville, MA

Scientific/Safety Review Committee Member

August 2019 to Present

- Review high school science fair project submissions for safety measures
- Attend science fair committee meetings to plan science fair logistics

Pioneer Charter School of Science

Everett, MA

Presentation

October 19, 2021

- Presented on contemporary cosmology for high school physics students during science speaker week

SKILLS

Physics Courses: classical mechanics, electrodynamics, quantum mechanics, statistical mechanics, astrophysics (stellar, planetary, and interstellar), general relativity, cosmology, quantum field theory, particle physics

Math Courses: Statistics, multivariable calculus, differential equations, linear algebra, Fourier analysis, complex analysis, basic tensor analysis, basic differential geometry

Programming Languages: Python, Mathematica, C, C++, SQL, Latex, MATLAB

Languages: English, Hebrew, French, Japanese

Other: MS Office