

# J. LUNA ZAGORAC

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Postdoctoral Researcher ◊ Perimeter Institute ◊ Waterloo, ON N2L 2Y5

## EMPLOYMENT

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<b>Perimeter Institute for Theoretical Physics, Waterloo, ON</b> Postdoctoral Fellow	<i>Sep 2022 - Aug 2025</i>
<b>Yale University, New Haven, CT</b> Physics Researcher	<i>June 2022 - Aug 2022</i>

## EDUCATION

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<b>Yale University, New Haven, CT</b> Ph.D. in Physics	<i>Aug 2016 - May 2022</i>
<b>Colgate University, Hamilton, NY</b> B.A. with Honors in Astronomy/Physics & Anthropology	<i>Aug 2012 - May 2016</i>

## SKILLS AND QUALIFICATIONS

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<b>Programming Languages</b>	Python, C/C++, MATLAB, Chapel, Pascal
<b>Python Packages</b>	Jupyter, Matplotlib, Numba, NumPy, SciPy, PyFFTW, AstroPy
<b>Software &amp; Tools</b>	LaTeX, Excel, Mathematica, ImageJ
<b>Communication skills</b>	Science & grant writing, outreach, public speaking, data visualization
<b>Certifications</b>	Yale Poorvu Center Certificate for Public Communication, Certificate of College Teaching Preparation
<b>Languages</b>	English & Serbian (native) French & Italian (proficient), Arabic (conversational) Latin & Middle/Late Egyptian (intermediate)

## HONORS & AWARDS

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<b>Future Investigator in NASA Earth and Space Science and Technology</b> <i>NASA Grant for \$90k funding two years of doctoral work and independent investigations of ULDM.</i>	<i>May 2020</i>
<b>Leigh Page Award for Excellence in Graduate Student Teaching</b> <i>Award for \$500 which recognizes broad and valuable contributions to physics education at Yale, science communication, and work fostering a welcoming learning environment for students.</i>	<i>Nov 2021</i>
<b>Loyde and William C. G. Ortel Fellowship in Physics</b> <i>Awarded to an outstanding student pursuing a Ph.D. in Physics.</i>	<i>Nov 2020</i>
<b>Franke Science &amp; Humanities Interdisciplinary Research Award</b> <i>Yale Fellowship for \$3000 funding two years of interdisciplinary work on Egyptian constellations.</i>	<i>Sep 2019</i>
<b>Colgate Physics and Astronomy Department Founders Award</b> <i>Awarded periodically to a senior who has demonstrated four years of outstanding progress and development of their understanding of physics or astronomy.</i>	<i>Apr 2016</i>
<b>Sigma Pi Sigma Physics Honors Society</b> <i>Honorary membership to Sigma Pi Sigma Honors Society.</i>	<i>Apr 2016</i>
<b>Alumni Memorial Scholar at Colgate University</b> <i>Scholars are selected at the time of admission to Colgate for their dedication and interest in scholarship and have the opportunity to apply for grants totaling up to \$5,000 to fund independent research.</i>	<i>Aug 2012</i>

## RESEARCH EXPERIENCE

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**UltraLight Dark Matter Simulations and Observational Constraints** Jan 2019 - Aug 2022  
*Professor Nikhil Padmanabhan & Professor Richard Easther* *Yale University*

Developing the [CHAPELULTRA](#) pseudo-spectral solver, optimizing it for HPC use, using it to simulate UltraLight Dark Matter, and assessing candidate feasibility. Projects currently underway include:

- developing calculator for ULDM eigenstates and comparing them with perturbation theory.  
Publication: [Zagorac et al. \(2021\)](#)
- investigations of the core-halo mass relation and imprints of merger history on ULDM halos
- modelling stellar streams around a ULDM halo using the streakline method
- probing ULDM phenomenology in the presence of baryonic disk potentials

**An Astronomical View of Ancient Egyptian Star Clocks** Sep 2019 - May 2021  
*Professor Priya Natarajan & Professor John Coleman Darnell* *Yale University*

Developed the code [DECANO.PY](#) to track and analyze the movement of Ancient Egyptian decans in the night sky and compare the results with primary sources. Results were [presented](#) at the 2021 Meeting of CT Digital Humanities (CTDH) and the 72<sup>nd</sup> Annual Meeting of the American Research Center in Egypt (ARCE). This interdisciplinary project was funded by the Franke Program in the Humanities & Natural Sciences at Yale.

**Gravitational Signatures of Primordial Black Holes** Sep 2017 - Mar 2019  
*Professor Nikhil Padmanabhan & Professor Richard Easther* *Yale University*

Modeled primordial black hole creation mechanisms in the early universe, constrained their 2-body interactions and dynamics, and calculated resultant gravitational wave spectra from mergers for allowed parameter space.

Publication: [Zagorac et al. \(2019\)](#)

**Particle Mesh Code for Bi- and Power Spectra** Jan 2017 - Aug 2017  
*Professor Nikhil Padmanabhan* *Yale University*

Wrote particle mesh code to calculate the power spectrum and bispectrum from GADGET-2 simulation data in C++. Tested the code by generating a Gaussian random field to run through the code and compared results with analytically calculated power spectra and bispectra for the Gaussian case.

**Data Reduction for SMARTS Consortium at Yale** Nov 2016 - May 2017  
*Professor Charles Bailyn* *Yale University*

Reduced a backlog of AGN spectra collected by the Yale SMARTS Consortium using Yale's software pipeline. Prepared data for online publication for use by collaborators.

**Supermassive WIMP Production in the Early Universe** Aug 2015 - May 2016  
*Professor Patrick Crotty* *Colgate University*

Wrote an equation solver in Python, using Numpy and Scipy for analysis and Matplotlib for visualizations. Varied coefficients describing shape of sigmoid inflaton field and calculated resulting DM abundances with assumed particle mass. Presented preliminary results at Syracuse University Undergraduate Research Day. This work constituted my senior honors thesis titled "Constraining WIMPzilla Production in the Inflationary Phase of the Early Universe."

**Volunteer Archaeologist at South Asasif Conservation Project**

Jun - Jul 2015

Dr. Elena Pischikova

Luxor, Egypt

Supervised team of workers doing excavation; organized, labeled, and stored finds, and documented site progress daily. Used dumpy-level photography and measurements to produce accurate technical drawings of the site. Wrote up extensive field reports for the site director.

**Observations and Analysis of 2014 Flare of Blazar 3C454.3**

Jun 2014 - Aug 2014

Professor Thomas Balonek

Colgate University

Observed AGN at Foggy Bottom Observatory at Colgate University on a 16-inch, Newtonian-Cassegrain telescope. Reduced all data using UNIX, IRAF, and Pascal-based software, with analysis focusing on 3C454.3 and its historic flare that summer. Compared our optical data with Yale SMARTS data of the same object to find excellent agreement, as well as radio data from the Submillimeter Array. No correlation between radio and optical flares was found.

**PUBLICATIONS**

4. **Zagorac**, Kendall, Padmanabhan, and Easter. “Soliton Formation and the Core-Halo Mass Relation for Synthetic ULDM Halos: An Eigenstate Perspective.” *In prep, expected early-2023*.
3. **Zagorac**, Sands, Padmanabhan, and Easter. “Schrödinger-Poisson Solitons: Perturbation Theory.” (2021). *Physical Review D* 105, no. 10 (2022): 103506.
2. Padmanabhan, Ronaghan, **Zagorac**, and Easter. “Simulating Ultralight Dark Matter with Chapel: An Experience Report.” (2019). *2020 IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW)*
1. **Zagorac**, Easter, and Padmanabhan. “GUT-scale primordial black holes: mergers and gravitational waves.” *Journal of Cosmology and Astroparticle Physics* 2019.06 (2019): 052.

**PRESENTATIONS**

† = Invited Speaker

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| 27. <b>240th Meeting of the American Astronomical Society</b><br><i>A Light in the Dark: UltraLight Dark Matter Phenomenology in Simulations</i> | June 2022<br>Virtual           |
| 26. <b>Chapel Implementers and Users Workshop</b><br><i>UltraLight Dark Matter in Simulations: A Chapel-Powered Eigenstate Perspective</i>       | June 2022<br>Virtual           |
| 25. † <b>Colgate University Physics &amp; Astronomy Seminar</b><br><i>UltraLight Dark Matter Dynamics in the Language of Eigenstates</i>         | Apr 2022<br>Colgate University |
| 24. † <b>Stockholm University</b><br><i>UltraLight Dark Matter Dynamics in the Language of Eigenstates</i>                                       | Jan 2022<br>Virtual            |
| 23. † <b>Perimeter Institute</b><br><i>UltraLight Dark Matter Dynamics in the Language of Eigenstates</i>  | Dec 2021<br>Virtual            |
| 22. † <b>Stony Brook University</b><br><i>UltraLight Dark Matter Dynamics in the Language of Eigenstates</i>                                     | Nov 2021<br>Virtual            |
| 21. † <b>University College London</b><br><i>UltraLight Dark Matter Dynamics in the Language of Eigenstates</i>                                  | Oct 2021<br>Virtual            |
| 20. † <b>Carnegie Observatories</b><br><i>UltraLight Dark Matter Dynamics in the Language of Eigenstates</i>                                     | Oct 2021<br>Virtual            |
| 19. † <b>University of Hawaii Institute of Astronomy</b><br><i>UltraLight Dark Matter Dynamics in the Language of Eigenstates</i>                | Oct 2021<br>Virtual            |

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| 18. †Northwestern University CIERA Science Happy Hour<br><i>UltraLight Dark Matter Dynamics in the Language of Eigenstates</i>                                 | Oct 2021<br><i>Virtual</i>                           |
| 17. †Newcastle University Cosmology Journal Club<br><i>Schrödinger-Poisson Solitons: Perturbation Theory.</i>  | Sep 2021<br><i>Virtual</i>                           |
| 16. Weak Interaction Discussion Group at Yale<br><i>Linear Approximations to UltraLight Dark Matter Stationary States</i>                                      | May 2021<br><i>Virtual</i>                           |
| 15. American Research Center in Egypt Annual Meeting<br><i>In Search of Lost Time: An Astronomical View of Ancient Egyptian Star Clocks</i>                    | Apr 2021<br><i>Virtual</i>                           |
| 14. Aspen Winter Conference, A Rainbow of Dark Sectors<br><i>UltraLight Dark Matter &amp; Its Eigenstates</i>  | Mar 2021<br><i>Virtual</i>                           |
| 13. †Yale Institute of Sacred Music<br><i>Cosmogonies, Cosmologies, &amp; Time</i>   | Mar 2021<br><i>Virtual</i>                           |
| 12. †Connecticut Digital Humanities<br><i>In Search of Lost Time: An Astronomical View of Ancient Egyptian Star Clocks</i>                                     | Feb 2021<br><i>Virtual</i>                           |
| 11. †Bay Area Science Festival Science Cafe Mini-Talks in Astronomy<br><i>Cosmic Archaeology, or: How Do We Know the Things We Know?</i>                       | Oct 2020<br><i>Virtual</i>                           |
| 10. 236th Meeting of the American Astronomical Society<br><i>Parametrizing UltraLight Dark Matter Haloes Through Binary Soliton Core Mergers</i>               | Jun 2020<br><i>Virtual</i>                           |
| 9. †Center for Computational Astrophysics<br><i>Parametrizing UltraLight Dark Matter Haloes Through Binary Soliton Core Mergers</i>                            | May 2020<br><i>Virtual</i>                           |
| 8. Weak Interaction Discussion Group at Yale<br><i>Parametrizing UltraLight Dark Matter Haloes Through Binary Soliton Core Mergers</i>                         | May 2020<br><i>Virtual</i>                           |
| 7. 235th Meeting of the American Astronomical Society<br><i>A Light in the Dark: Ultra Light Dark Matter in Theory and Simulation Hawaii Convention Center</i> | Jan 2020   |
| 6. Great Lakes Cosmology Workshop<br><i>Pseudo-Spectral Solvers for Fuzzy Dark Matter</i>  | Aug 2019<br><i>Rochester Institute of Technology</i> |
| 5. Tri-Institute Summer School on Elementary Particles<br><i>Gravitational Wave Spectrum of Ultralight Primordial Black Holes</i>                              | Jul 2018<br><i>Perimeter Institute</i>               |
| 4. Colgate University Honors Thesis Defense<br><i>Saving Tokyo: Constraining WIMPzilla Production in the Early Universe</i>                                    | Apr 2016<br><i>Colgate University</i>                |
| 3. Syracuse University Undergraduate Research Day<br><i>Constraining WIMPzilla Production in the Early Universe</i>  | Dec 2015<br><i>Syracuse University</i>               |
| 2. Keck Northeastern Astronomy Consortium<br><i>The Optical and Radio Variability of the Blazar 3C 454.3</i>   | Nov 2014<br><i>Swarthmore College</i>                |
| 1. Colgate Physics & Astronomy Welcome Seminar<br><i>The Variability of Blazar 3C 454.3</i>  | Sep 2014<br><i>Colgate University</i>                |

## TEACHING EXPERIENCE

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### Certificate of College Teaching Preparation (CCTP)

May 2022

*Yale Poorvu Center for Teaching and Learning*

A record of participation in teaching activities and reflections on those experiences. Earning the CCTP, also meets requirements for the [Center for Integration of Research, Teaching and Learning](#) Associate.

### Curriculum Development & Lecturing

Summer 2019 - 2021

*Yale Bootcamp on Physics Fundamentals*

Co-developed a curriculum for 20 hours of Classical Mechanics instruction, met weekly with staff supervisor to polish lectures and example problems. Delivered 10 hours of lecture at the Bootcamp. Developed a Mathematica tutorial for incoming graduate students. Re-vamped the curriculum and moved it online for Summer 2020 and Summer 2021.

### Head Teaching Fellow Positions

Aug 2017 - May 2018

*PHYS170/171 - University Physics for the Life Sciences*

Organized other teaching fellows, staffed weekly help sessions and office hours, held review sessions on material before exams, graded weekly homework, proctored and graded exams.

### Teaching Fellow Positions

S&DS176 - YData: Humanities Data Mining

*Spring 2022*

PHYS/ASTR600 - Cosmology

*Fall 2020*

PHYS442 - Introduction to Nuclear and Elementary Particle Physics

*Spring 2020*

PHYS410 - Classical Mechanics

*Fall 2019*

ASTR343 - Gravity, Astrophysics, and Cosmology

*Spring 2019*

PHYS165/166 - General Physics Laboratory

*Fall 2016 - Spring 2017*

## SCIENCE COMMUNICATION

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### Public Communication Certificate

Oct 2021

*Yale Poorvu Center for Teaching and Learning*

Certification in public communication through extensive preparation for the 3MT Competition. Areas: Text, Speech, and Visual Design; Feedback and Revision; Peer and Interdisciplinary Collaboration.

### Popular Science Presentations

Bay Area Science Festival “Astro Coffee” Presenter: *Cosmic Archaeology*

*Oct 2020*

“Ask a Scientist” Webinar Presenter: *Dark Matter*

*May 2020*

“Astronomy on Tap” Presenter: *Cosmic Archaeology*

*Aug 2019*

“3 Minute Thesis” Yale Finalist: *How Small Black Holes Teach Us about the Big Bang*

*Apr 2019*

### Writing

Astrobits Media Intern at AAS238

*Jun 2021*

Astrobits Contributing Author (>15 [articles and interviews](#))

*Dec 2019 - Dec 2021*

ComSciCon at AIP Participant

*Sep 2019*

## SERVICE & LEADERSHIP

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### University Positions

Yale Digital Humanities Lab Consultant	<i>Sep 2020 - May 2022</i>
McDougal Graduate Student Life Fellow at Yale	<i>Aug 2018 - May 2019</i>
Graduate Affiliate, Pauli Murray College at Yale	<i>Fall 2017 - Spring 2022</i>

### Committee Work

Astrobites Diversity, Equity, and Inclusion Committee Member	<i>Mar 2020 - Dec 2021</i>
Physics Climate and Diversity Committee Member	<i>Jan 2018 - May 2020</i>

### Conference & Seminar Organization

Co-organizer: Black in Physics Week at Yale Event Series	2020
Volunteer: Conference for Undergraduate Women in Physics	2019-2020
Co-organizer: Equity in the Job Search Symposium	2018-2019

### Outreach Volunteering

Astronomy Ambassador, American Astronomical Society	<i>Jan 2020 - Present</i>
Volunteer, Yale Pathways to Science	<i>Fall 2018 - Spring 2019</i>
Activity Leader, CT Students Exploring Engineering Day	<i>Spring 2018</i>
Activity Leader, Girls Science Investigations	<i>Sep 2016 - Mar 2020</i>

## MENTORSHIP

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### Undergraduates Researchers Supervised

Claire Recamier, junior at Yale: <i>Stellar Streams in UltraLight Dark Matter Halos</i>	<i>Jun 2021 - Present</i>
Isabel Sands, now Ph.D. student at Caltech: <i>Constructing a Binary Soliton Merger Library</i> <i>Linear Approximations to UltraLight Dark Matter Stationary States</i>	<i>Jan 2020 - Jun 2021</i>

### Formalized Mentoring Activities

SU(5) Group Mentor	<i>Fall 2020</i>
Científico Latino Graduate Student Mentoring Initiative (GSMI) Mentor	<i>Fall 2019</i>
Women in Science at Yale (WISAY) Mentor	<i>2016-2019</i>