Nathan J. Carlson, PhD

Education

PhD Physics, University of Toronto &
Canadian Institute for Theoretical Astrophysics (CITA) 2019-2026
Honours BSc Physics, University of Ottawa 2015-2019

Research Experience

- **NASA Postdoctoral Program Fellow** (2026-)
  I will be starting a new position as a NASA Postdocotoral Program (NPP) Fellow at JPL in September 2026.
- **PhD Thesis with Prof. J. Richard Bond (CITA, University of Toronto): Searching for traces of Primordial Non-Gaussianity in the Cosmic Web** (2019-2026)
  Lead developer for the Peak Patch and WebSky cosmological simulations; implemented novel primordial non-Gaussianity treatments in these simulations to search for traces left behind in the large-scale structure of the universe. Currently producing forecasts for upcoming and next-generation Line Intensity Mapping surveys, cosmic microwave background (CMB) foregrounds, and other tracers of the Cosmic Web.
- **BSc Honours Thesis with Prof. Mark Boulay (University of Ottawa): Design of a Next-Generation Liquid Argon Dark Matter Detector** (2018-2019)
  Contributed to the design of a 300,000-kg liquid argon dark matter direct detection experiment in the SNOLAB Cryopit; ran MCMC simulations of WIMP detection events; designed technical schematics for tiling of spherical and cylindrical cryostats with silicon photomultiplier arrays.
- **Research Assistant with Prof. Jeff Lundeen (University of Ottawa): Development of the first variable partially polarizing beamsplitter (VPPBS)** (2016-2018)
  Worked on the design of the first VPPBS, an integral part of a photonic quantum logic gate, fundamental to photonic quantum computing; worked with non-linear optics, collected data and made figures for a peer-reviewed article; designed computer-controlled motorized beam blockers.
- **Intern at Ranovus Inc.** (2017)
  Contributed to research and development of proprietary quantum dot laser technology; learned MATLAB for instrument control; designed experiments to test performance of on-chip lasers.

Publications

- **N. J. Carlson**, J. R. Bond, D. T. Chung, P. Horlaville and T. Morrison, (2025) "The WebSky [CII] Forecasts and the search for primordial intermittent non-Gaussianity", *JCAP* (submitted), 45 pages, 14 figures, 1 table, arXiv:2510.18312 .
- M. Lokken, J. R. Bond, R. Hložek, **N. J. Carlson**, Z. Li, and A. van Engelen, (2025) "The superclustering of hot gas: cosmological sensitivity in the Websky simulations", *JCAP* (submitted), 31 pages, 11 figures, arXiv:2510.08331.
- J. Flórez, **N. J. Carlson**, C. H. Nacke, L. Giner, J. S. Lundeen, (2017) "A variable partially polarizing beam splitter", *Review of Scientific Instruments*, 9 pages, 8 figures, arXiv:1709.05209.
- J. Flórez, C. H. Nacke, **N. J. Carlson**, L. Giner, J. S. Lundeen, (2016) "A Variable Partially-Polarizing Beamsplitter", *Frontiers in Optics 2016*, DOI:10.1364/FIO.2016.FF1D.3.

Presentations

- **Contributed talk at the Line Intensity Mapping 2025 at Laboratoire d'Annecy de Physique Théorique (LAPTh)** 2025
  "Constraining primordial non-gaussianity in the WebSky2.0 line-intensity mock maps".
- **Invited talk at Cornel University** 2025
  "The search for primordial intermittent non-gaussianity with the WebSky2.0 CCAT mocks".
- **Invited talk at the Waterloo Centre for Astrophysics** 2025
  "Searching for primordial intermittent non-gaussianity with the WebSky2.0 mocks".
- **Contributed poster at the 2024 Annual General Meeting of the Canadian Astronomical Society (CASCA)** 2024
  "Cosmic Structure Evolving from Primordial non-Gaussianities".
- **Contributed talk at the 2023 Annual General Meeting of the Canadian Astronomical Society (CASCA)** 2023
  "Probing the Physics of Inflation with the Search for non-Gaussianity in the Cosmic Web".
- **Contributed talk at Cosmology From Home 2023** 2023
  Unveiling traces of primordial non-Gaussianity in the cosmic web with WebSky
- **CITA Blackboard Talk at Canadian Institute for Theoretical Astrophysics** 2023
  "The Twin Paradox on a Hypertorus: a case study on the value of reflecting on first principles".
- **Contributed talk at the Kavli Institute for Theoretical Physics (KITP)** 2023
  "The Cosmic Web as a Probe of Inflationary Physics".
- **Contributed talk at Instituto de Física Teórica (IFT), Madrid** 2022
  "Unveiling fundamental PNG with the Peak Patch & WebSky simulations of the Cosmic Web".

Workshops

- **Pan-Canadian Reionization Workshop** at CITA 2023
- **The Cosmic Web: Connecting Galaxies to Cosmology at High and Low Redshift** at the Kavli Institute for Theoretical Physics (KITP) 2023
- **Cosmology Summer School 2020** at the University of Michigan 2020
- **Canadian Astroparticle Physics Summer School (CAPSS)** hosted by Queen's University and SNOLAB 2018

Awards and Scholarships

- University of Toronto Faculty of Arts & Sciences Graduate Scholarship 2019-2025
  (average value $26,000 per year)
- Van Kranendonk Award for best Teaching Assistant 2023
  awarded by the Department of Physics, University of Toronto
- $3,000 University of Toronto Faculty of Arts & Sciences Graduate Admission Award 2019
- $3,000 University of Ottawa Renewable Admission Scholarship 2015-2018
- $1,000 University of Ottawa Undergraduate Research Opportunity Program award 2016

Collaborations and Service

- **Developer for the `Peak Patch` semi-analytic dark matter halo simulations and `WebSky` forward modelling mock map simulations** 2019-present
  As a lead developer for these simulations during my PhD, I have implemented new physics capabilities including novel early universe physics models, produced a comprehensive post-processing python library soon to be made public, and on request produced new simulation data for interested researchers.
- **Member of CCAT and COMAP collaborations** 2023-present
- **Organizer for CITA CosmoLunch** 2024-present
  Involved making arrangements for invited speakers, organizing, running meetings and designing inovative meeting formats such as "One Interseting Figure" round-tables. Was additionally a deputy organizer (2022-2024) in charge of organizing food and occationally standing in as organizer.
- **Member of Search Committee for Assistant Professor Teaching Stream in Physics Education** 2024
- **Member of Local Organizing Committee for the Pan-Canadian Reionization Workshop at CITA** 2023
- **Organizer of CITA Canoe Trip** 2022, 2023
  I organized two retreats for postdoctoral fellows and graduate students at CITA to camp for a weekend in Algonquin Provincial Park. Involved a number of activities designed to encourage collaboration and practice important skills, these included practice presentations, group paper discussions and brainstorming sessions to tackle ongoing difficult problems in research.
- **Co-chair of CITA Graduate Student Council and Primary Author of CITA Graduate Students' Handbook**

Teaching and Mentorship

- **Collaboration with CITA Summer Undergraduate Research Fellows** 2023-2025
  I have collaborated with two students in the CITA Summer Undergraduate Research Fellow (SURF) program who were primarily supervised by faculty or postdoctoral fellows at CITA.
- **Teaching Assistant at University of Toronto** 2019-present
  I have been a teaching assistant for 5 physics courses including the cross-listed graduate/undergraduate course General Relativity for which I have given lectures and taught tutorials. In 2022/2023 I was awarded the Van Kranendonk Award as one of 4 top Teaching Assistants in the University of Toronto Department of Physics.
  - PHY1483/483: Relativity Theory I (2023, 2024, 2025)
  - PHY180: Classical Mechanics (2019, 2020)
  - PHY151: Fundamentals of Physics I (2021, 2022)
  - PHY152: Fundamentals of Physics II (2021, 2022, 2023, 2024, 2025)
  - PHY132: Introduction to Physics II (2020,2021)

  On two occasions, I have been asked by students under my instruction to write reference letters in support of ultimately successful applications for summer research positions.

Volunteering and Science Outreach

- **Public talk at UofT AstroTours** 2023
  "What the Biggest Things in the Universe Can Tell Us About the Oldest and Smallest Things".
- **Volunteer at Coding the Cosmos** 2023,2024
  An annual workshop series run by the Dunlap Institute which introduces grade 9-11 students to coding with real astronomical data. I have assisted students with codes during workshops and contributed to making Jupyter Notebooks which students work on during the sessions.
- **Volunteer at UofT AstroTours** 2020-present
  I have volunteered numerous times during my graduate studies running science demos, answering questions from members of the public and guiding telescope observations of the night sky.
- **Volunteer at Canadian Conference for Undergraduate Women in Physics (CCUWiP 2019)** 2019
  I volunteered at this annual three-day conference promoting gender equity in physics when it was held at the University of Ottawa during my undergraduate studies. I contributed to set up for workshops, talks, and lunches, as well as delegate check-in, leading tours, clean-up and other odd jobs. Equity in physics and astronomy is a topic of great importance to me.

Skills

- High-Performance Computing (HPC): cosmological large-scale structure simulations on supercomputers, including the Trillium and Niagara Supercomputers (SciNet/Alliance Canada).
- Cosmological codes (CLASS and CAMB Boltzmann Solvers, cobaya MCMC code including custom theory realizations with power spectrum features).
- Programming in Python (NumPy, matplotlib, Astropy, Scipy, Jupyter Notebooks), Julia, Fortran, MATLAB, C++, Unix Shells (zsh, bash, etc.) and LabView; parallel computing (MPI, OpenMP).
- Document creation in LaTeX, macOS (Pages, Numbers, Keynote), Microsoft Office (Word, Excel, Power Point) and Google Drive.
- Experience with a range of scientific equipment including small optical telescopes, several types of lasers, interferometers, oscilloscopes, spectrum analyzers, nonlinear optics, photomultiplier tubes and semiconductor particle detectors. Working with tools involving electronics, mechanical devices and carpentry, including cell phone repairs, bicycle maintenance and various woodworking projects.

Languages

- English (native)
- French (conversational)
- Persian (basic)