

CaNPAN Activities 2022-2024

A summary of activities of the Canadian Nuclear Physics for Astrophysics Network (CaNPAN) for the academic years 2022/2023 and 2023/2024.

Contact: Dr. Chris Ruiz (ruiz@triumf.ca), Dr. Falk Herwig (ferwig@uvic.ca) and Dr. Pavel Denisenkov (pavelden@uvic.ca)

Introduction

The Canadian Nuclear Physics for Astrophysics Network (CaNPAN) continues to advance the integration of realistic astrophysics nuclear network simulations and nuclear physics experiments through student-involved research and education. CaNPAN recognizes that the multi-disciplinary training of the next generation in astrophysics simulations and nuclear physics experiments is key for long-term success of nuclear astrophysics to reveal the secrets of how the elements form in stars and stellar explosions. In 2022-2024, CaNPAN engaged 22 graduate students from 5 countries, focusing on computational tools for nova and i-process nucleosynthesis simulations. Key activities included online lectures, workshops, and the development of new computational resources. Here we summarize the network's achievements and activities during this period. An Appendix summarizes links to resources mentioned in the report.

Educational Activities

CaNPAN's educational program expanded significantly during 2022-2024. In the 2022/2023 academic year, five 1.5-hour online educational meetings were organized and recorded, covering the basics of nuclear astrophysics and computational tools such as TINA, Nova, and X-ray burst. The program engaged 6 Canadian and 8 international graduate students. In 2023/2024, participation included 6 Canadian and 2 international students, with additional lectures focusing on one-zone Monte Carlo simulations and analysis techniques.

A directed studies course, ASTR 580 "Nuclear Astrophysics Simulation Tools and Methods," was offered at the University of Victoria, providing in-depth training on CaNPAN computational tools. This course led to the initiation of the "First-Peak" research project, which aims to identify critical (n,γ) reactions in i-process nucleosynthesis (a publication involving four CaNPAN students is in preparation).

Research Projects

CaNPAN students engaged in diverse research projects. In nova nucleosynthesis, Amanda Edwin conducted direct measurements of the $^{23}\text{Mg}(p,\gamma)^{24}\text{Al}$ reaction rate at TRIUMF, while Mallory Loria performed stellar evolution simulations of CO and ONe novae, focusing on K, Ar, and Ca abundances (Loria et al. 2024 ApJ submitted).

The i-process nucleosynthesis studies included investigations of (n,γ) reaction rate uncertainties on trans-iron element abundances. Lauren Harewood's project on "Impact of Constrained Sr Reaction

Rates for the i Process" at Lawrence Livermore National Laboratory exemplified the network's collaboration with international institutions.

Workshops, Meetings, and Achievements

CaNPAN organized several significant events during this period. The first annual meeting was held from October 31 to November 2, 2022, at TRIUMF, Vancouver, bringing together network members and international experts. The i-process Nucleosynthesis Workshop and School took place from May 14-19, 2023, in Limassol, Cyprus, featuring lectures by CaNPAN faculty members.

The second CaNPAN annual meeting, held from May 1-3, 2024, at TRIUMF, Vancouver, included a student-led first day, showcasing the network's commitment to student development. This commitment was further evidenced by Mallory Loria's "Best Presentation Award" at the 19th Russbach School on Nuclear Astrophysics in Austria, March 2024, and Lauren Harewood's presentation at the 2023 Fall Meeting of APS DNP and JPS in Hawaii.

Computational Tools and Resources

CaNPAN significantly enhanced its computational resources during this period. New GitLab repositories, i-process-tools and an updated weak-i-process-impact, were created to support research activities. The Astrohub servers (TINA, Public & Outreach, NuGrid WENDI) continued to be vital for simulations.

The network extended its Monte Carlo simulation methods to include various reaction types, broadening the scope of possible investigations. These tools were instrumental in student projects and collaborative research efforts.

International Collaborations and Nuclear Physics Experiments

CaNPAN's international reach expanded through collaborations with the International Research network for Nuclear Astrophysics (IReNA) on i- and n-process nucleosynthesis. The network hosted visiting students from Michigan State University and Ohio University in 2024, with Canadian students serving as peer mentors, fostering a rich exchange of ideas and expertise. Notably, two IReNA-funded graduate students, Artemis Tsantiri from Michigan State University and Chirag Rathi from Ohio University, visited Dr. Falk Herwig's research group at the University of Victoria in May and October 2024. Both worked on computational research projects focusing on astrophysical reaction rate impact studies of i-process nucleosynthesis in stars, under the supervision of Dr. Pavel Denisenkov and Dr. Falk Herwig, with Canadian CaNPAN students Mallory Loria and Joshua Issa serving as peer mentors. New faculty CaNPAN member Dr Liliana Caballero was able to visit Michigan State University with IReNA support.

In collaboration with JINA/CeNAM and NuGrid, CaNPAN conducted nuclear reaction sensitivity studies that informed and motivated experimental proposals. Cumulatively based on astrophysical impact studies performed by CaNPAN members over the past years, 23 experiments were approved at TRIUMF, FRIB, NSCL, and ANL, demonstrating the network's influence in shaping the field's experimental landscape.

Faculty Team Updates

The CaNPAN faculty team underwent changes during this period. While Drs. Reiner Krücken and Dennis Muecher left Canada, the team welcomed Drs. Liliana Caballero, Rodrigo Fernández, and Annika Lennarz, bringing fresh perspectives and expertise to the network.

Appendix: Further Information

A guide to further information on the internet on topics discussed in this report is provided below:

Keyword	Description	Link
CaNPAN	Canadian Nuclear Physics for Astrophysics Network website	https://canpan.ca/index.html
Students	List of CaNPAN students	https://canpan.ca/training-program.html
Experiments	List of CaNPAN-related approved experiments	https://canpan.ca/experiments.html
Tools	CaNPAN computational tools on GitHub	https://github.com/dpa1983/canpan_projects/tree/main
Astrohub	Astrohub server for computational astrophysics	https://astrohub.uvic.ca/
Lecture 1	Introduction to nuclear astrophysics (video)	https://www.youtube.com/watch?v=KS0aX1ohfh4
Lecture 2	Continuation of nuclear astrophysics introduction (video)	https://www.youtube.com/watch?v=CPjzGE76MvU
Lecture 3: TINA	Lecture on TINA computational tool (video)	https://www.youtube.com/watch?v=8w2V33Tpa9o
Lecture 4: Nova	Lecture on Nova computational tool (video)	https://www.youtube.com/watch?v=VedEE9B_vUA
Lecture 5: X-ray burst	Lecture on X-ray burst computational tool (video)	https://www.youtube.com/watch?v=mrUji5HlpYs
CaNPAN 2022	First CaNPAN annual meeting website	https://sites.google.com/view/canpan2022
CaNPAN 2024	Second CaNPAN annual meeting website	https://indico.triumf.ca/event/517/
IReNA	International Research Network for Nuclear Astrophysics website	https://www.irenaweb.org
i-process-tools	GitLab repository for i-process tools	http://206-12-89-164.cloud.computecanada.ca/NuGrid/i-process-tools
JINAbase	Database for stellar abundances	https://jinabase.pythonanywhere.com
JINA Reaclub	Library for nuclear reaction rates	https://reaclub.jinaweb.org