NITheCS Colloquium

NITheCS
National Institute for Theoretical and Computational Sciences

The Origin of the First Heavy Elements

Prof Nico Orce (University of the Western Cape)

Monday, 27 July 2026 | 16h00–17h00 SAST

HOW TO ATTEND:

In person (main venue):

- Road House Cinema
(Neelsie)
Stellenbosch University

Watch at a satellite venue:

- MITP Boardroom P215,
2nd Floor Physics Building
University of the Witwatersrand
- Seminar Room K310
Physics Building G5
North-West University

Online (live stream)

--- Please note, a recording of the lecture will be published on the NITheCS YouTube channel following the event ---

ABSTRACT

Elements up to iron are produced in stellar interiors through exothermic fusion reactions, as described by Einstein's famous equation, $E = mc^2$. Beyond iron, nucleosynthesis becomes more complex because fusion is no longer energetically favoured. Instead, heavier elements are formed during stellar explosions through reaction networks governed largely by neutron availability. These include the slow (s), intermediate (i) and rapid (r) neutron-capture processes, which occur on the neutron-rich side of the valley of stability, and the proton (p) or gamma-process, which produces rare proton-rich isotopes primarily through photodisintegration of pre-existing heavy nuclei. Approximately half of the isotopes heavier than iron in the Solar System are produced by the s-process and half by the r-process, while the p-process forms a small number of proton-rich isotopes. The i-process has recently emerged as an important mechanism for explaining heavy-element abundance patterns that cannot be reproduced by the s- and r-processes alone.

High-resolution spectra of extremely metal-poor stars, obtained with SALT/HRS and other large telescopes, provide a unique window into these nucleosynthetic processes. As some of the oldest known objects in the Universe, their relatively simple spectra reveal elemental abundance patterns that distinguish between material produced by the s- and r-processes, offering insights into the chemical evolution of the early Universe.

In this talk, I will examine these questions from a nuclear-physics perspective, presenting recent experimental measurements and theoretical studies of nuclear dipole polarisability, and discussing their implications for the stellar collapse events that produced the first heavy elements in the Universe.

References: Orce *et al.*, *MNRAS* (2023); Orce, Ngwetsheni & Brown, *Phys. Rev. C* (2023); Orce & Ngwetsheni, *J. Phys. G* (2024); Orce, *Eur. Phys. J. A* (2025); Orce, *Physica Scripta* (2025).

BIOGRAPHY

Prof Nico Orce is a nuclear physicist whose research combines cutting-edge experiments and theory to explore the structure of atomic nuclei and the origin of the elements. He has authored more than 150 publications across nuclear physics and related disciplines. His recent work on nuclear polarisation has refined our understanding of the reaction pathways responsible for element formation in stellar explosions, helping to explain the observed abundance of the chemical elements.

As Principal Investigator, Prof Orce has secured more than R50 million in research funding and led pioneering African-led experiments at CERN, as well as major research infrastructure projects, including the GAMKA spectrometer at iThemba LABS and the MANDELA facility at UWC. He is actively involved in research at iThemba LABS, TRIUMF, CERN and SALT, serves as Associate Editor of *Atomic Data and Nuclear Data Tables* (Elsevier), and is an Honorary Visiting Professor at the University of York. He has presented invited talks at leading institutions, including CERN, Yale, Cambridge and Oxford.

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