

## S E M I N A R



**Dr Mariam Campbell**  
(University of Cape Town)

Dr Campbell recently obtained her PhD from the University of Cape Town under the supervision of Prof Peter Dunsby. Her research interests include astrophysical testing of frameworks beyond General Relativity, inflationary dynamics, and the initial singularity problem

**Date:**

Thursday, 30 April 2026

**Time:**

12h15-13h15 SAST

**Venues:**

- **NITheCS Seminar Room**  
University of KwaZulu-Natal  
Westville Campus  
3rd Floor, H-Block,  
School of Chemistry and Physics
- **Online**

**WHO SHOULD ATTEND?**

All are welcome.

**ENQUIRIES:**

Email Dr Cerene Rathilal:  
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# Bridging Scales with Dynamical Systems: Applications in Cosmology and Relativistic Stars

**ABSTRACT**

This talk demonstrates how the robust framework of dynamical systems serves as a vital bridge for probing extended theories of gravity across vastly different physical scales, from the early universe to the interiors of compact stars. Modified gravity models, such as  $f(R)$  and scalar-tensor theories, offer compelling alternatives to General Relativity for resolving fundamental challenges such as the initial singularity and the search for physically viable stellar configurations.

The first part of the talk focuses on the early universe, where we use dynamical systems to investigate bouncing scenarios as a solution to the singularity problem. We demonstrate how a stable bi-scalar tensor model facilitates a cosmic bounce that naturally transitions into an inflationary era. Furthermore, we show that in Dirac-Born-Infeld (DBI) field models, a phase space analysis reveals that initial conditions favourable to a bounce become increasingly likely in the ultrarelativistic limit.

Transitioning to the astrophysical regime, we apply these same mathematical frameworks to study relativistic stars within quadratic gravity. By employing a reconstruction algorithm within the (1+1+2) covariant formalism, we identify two new exact, physically viable stellar solutions: a unique quasi-isotropic configuration featuring a double-layer shell structure, and a highly compact model that matches smoothly to an exterior Schwarzschild vacuum.

By highlighting the shared focus on stability and phase-space evolution, this talk illustrates how dynamical systems provide a unified lens through which we can explore the "Beyond Einstein" frontier. We conclude by discussing ongoing research and how the structural signatures of these models could provide observable tests for modified gravity in future astrophysical surveys.

**REGISTER:** <https://bit.ly/3Q7ZUJy>

