

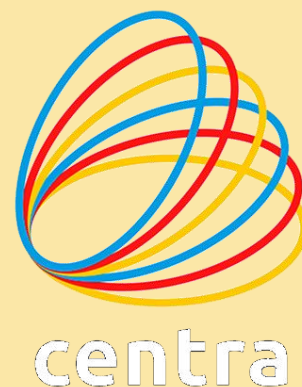
Cosmological and astrophysical applications of modified theories of gravity

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In colaboration with: J. P. S. Lemos, F. S. N. Lobo, S. Carloni, E. Berti(soon)



**4th IDPASC PhD Students Workshop
28-29 June, Coimbra, Portugal**

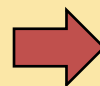


MOTIVATION

If **General relativity** is so successful, **why** study modified gravity?

GR PROBLEMS:

- 1) No quantum description of gravity
- 2) Dark matter & Dark Energy (Cosmology)
- 3) Exotic Matter (Wormholes)
- 4) Singularities (Compact Objects)



**Need for
modified
gravity!**

Types of modified theories of gravity studied in this thesis:

- 1) **Scalar-Tensor theories:** Add **scalar fields** to the usual GR action
- 2) **Higher-order theories:** Include **higher order** terms in the action

PROJECTS CONCLUDED

COSMOLOGY (with J.P.S.Lemos, S.Carloni, F.S.N.Lobo)

Seven different cosmological models (six of which analytical) were obtained in the Generalized hybrid metric-Palatini gravity, including power-laws, collapsing universes, and exponentially expanding universes for any perfect-fluid matter source

WORMHOLES (with J.P.S.Lemos, F.S.N.Lobo)

One analytical solution in the generalized hybrid metric-Palatini gravity describing an asymptotically anti de-Sitter traversable wormhole surrounded by a thin shell of matter that verifies the NEC for the entire spacetime was obtained

DYNAMICAL SYSTEMS (with J.P.S.Lemos, S.Carloni)

The phase space of the generalized hybrid metric –Palatini gravity was studied for three different models of the action. The fixed points for these models were obtained as well as their stability and possible evolutionary scenarios

EXTRA PROJECTS

Because **one** thing leads to **another** and new opportunities appear!

NEW PROJECTS THAT APPEARED:

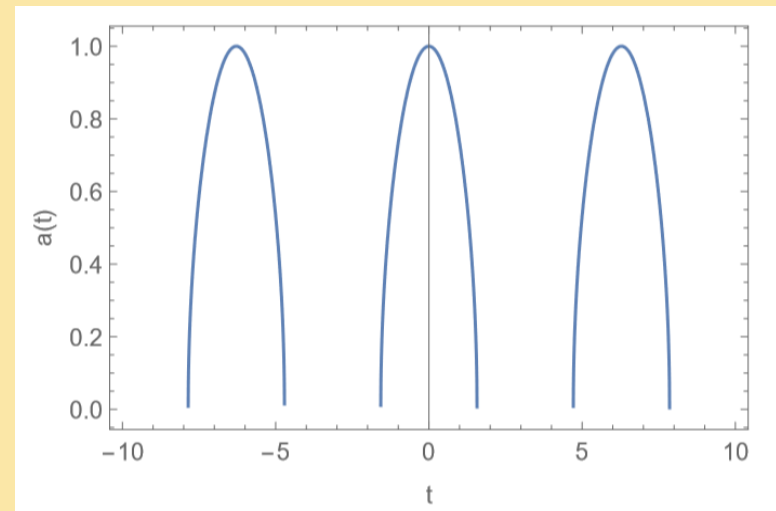
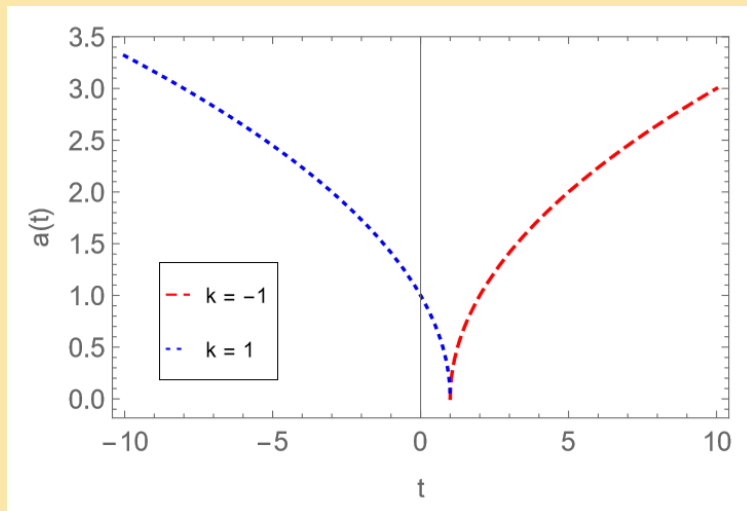
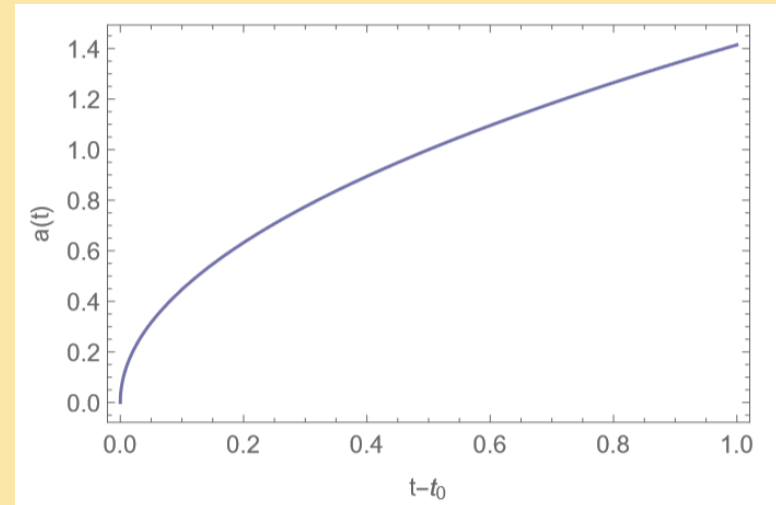
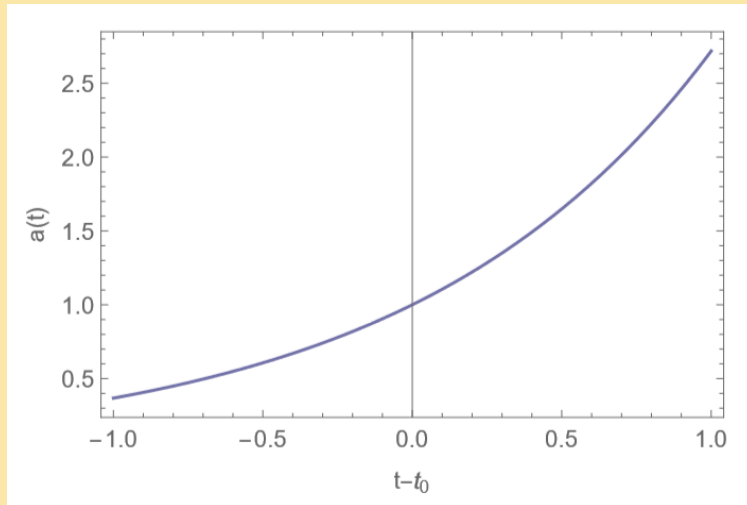
JUNCTION CONDITIONS (with J.P.S.Lemos)

WHY: Thin shell formalism in the wormhole project requires the use of the junction conditions, which were not derived for this theory. These conditions for smooth and thin-shell matching in both scalar and geometrical representations were obtained

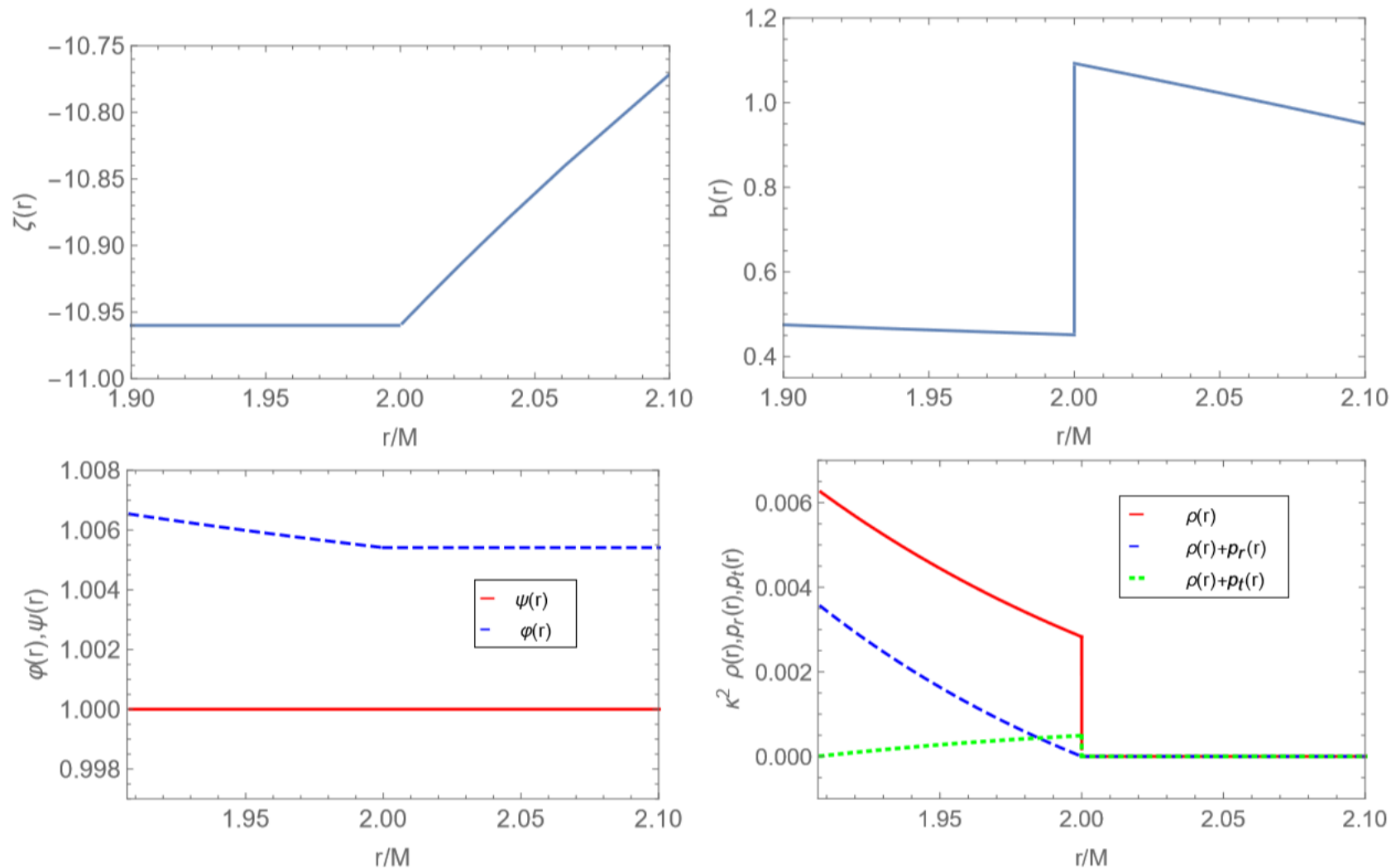
MORE DYNAMICAL SYSTEMS (with S.Carloni)

WHY: Studying the cosmological phase space of the generalized hybrid metric-Palatini gravity allowed me to collaborate with S.Carloni in the study of another dynamical system project of 6th and 8th order geometrical theories of gravity

RESULTS 1: COSMOLOGY



RESULTS 2: WORMHOLES



RESULTS 3: DYNAMICAL SYSTEMS

Point	Coordinates	Stability	Parameter s
\mathcal{A}	$K = -6$	Saddle	-1
	$X = 2$		
	$Y = -5$		
	$Z = -2$		
	$Q = -1$		
	$J = 1$		
	$\Omega = 0$		
\mathcal{E}_{\pm}	$K = 0$	\mathcal{E}_{+} : Saddle \mathcal{E}_{-} : Attractor	$\frac{1}{2} (259 \pm 45\sqrt{33})$
	$X = -\frac{1}{2} (5 \pm \sqrt{33})$		
	$Y = \frac{1}{2} (11 \pm \sqrt{33})$		
	$Z = - (5 \pm \sqrt{33})$		
	$Q = \frac{1}{2} (7 \pm \sqrt{33})$		
	$J = \frac{1}{2} (41 \pm \sqrt{33})$		
	$\Omega = 0$		

ONGOING PROJECTS

2+1+1 BOSON STARS (with S.Carloni, J.P.S.Lemos)

OBJECTIVE: Apply the 2+1+1 formalism to scalar-tensor theories of gravity with complex scalar fields to obtain new solutions for stable boson stars

DERRICK'S THEOREM (with S.Carloni)

OBJECTIVE: Generalize the Derrick's theorem, which states that no stable spherically symmetric solutions for scalar fields exist in flat spacetime, to curved spacetime

THICK SHELLS (with J.P.S.Lemos)

OBJECTIVE: Obtain pherically symmetric thick-shell solutions with Minkowski interior and Schwarzschild exterior and study the effects on well-known limits

FUTURE PROJECT



I was awarded with a **Fulbright** Research Scholarship!



JOHNS HOPKINS
UNIVERSITY

From September 15th to January 31st I will be in the **Johns Hopkins University** in Baltimore to work in a new project with Prof. Emanuele Berti:

BLACK HOLE OSCILLATIONS (with E.Berti)

OBJECTIVE: Compute BH oscillation frequencies for different couplings between scalar-fields and curvature and generalize the results to rotating BHs