Cosmological and astrophysical applications of modified theories of gravity

João Luís Rosa

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

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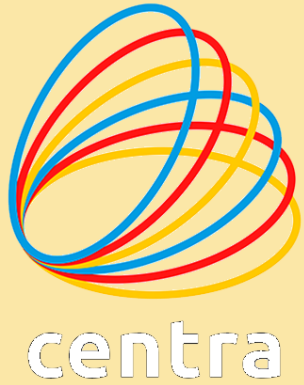
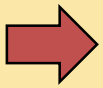


MOTIVATION

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:

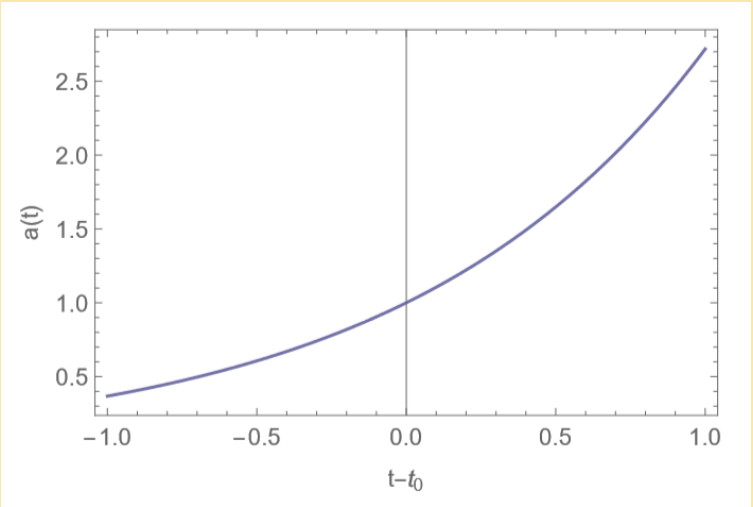
JUNCTION CONDITIONS (with J.P.S.Lemos)

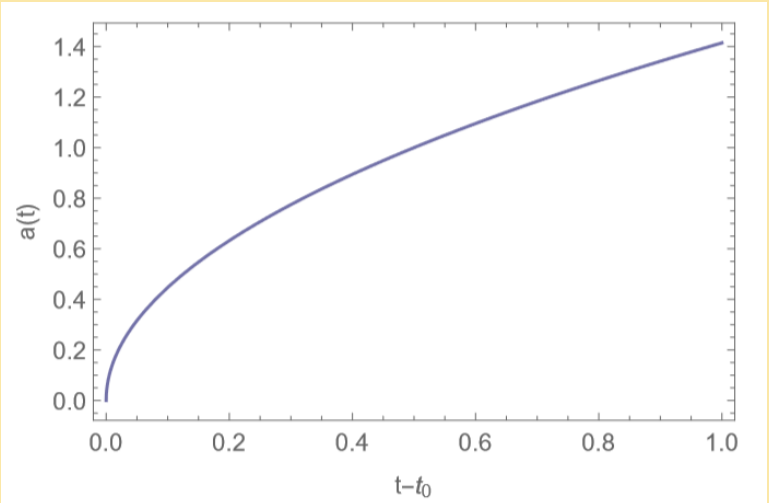
WHY: Thin shell formalism in the wormhole project requires the use of the junction conditions, which were not derived for this theory. These conditions for smooth and thin-shell matching in both scalar and geometrical representations were obtained

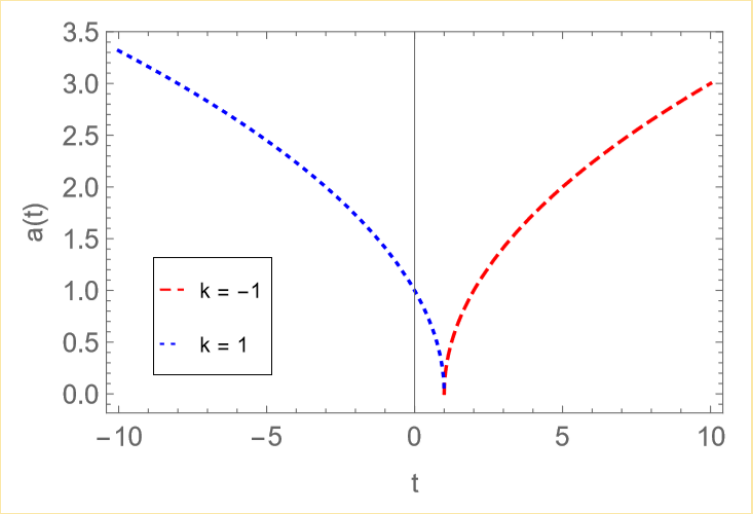
MORE DYNAMICAL SYSTEMS (with S.Carloni)

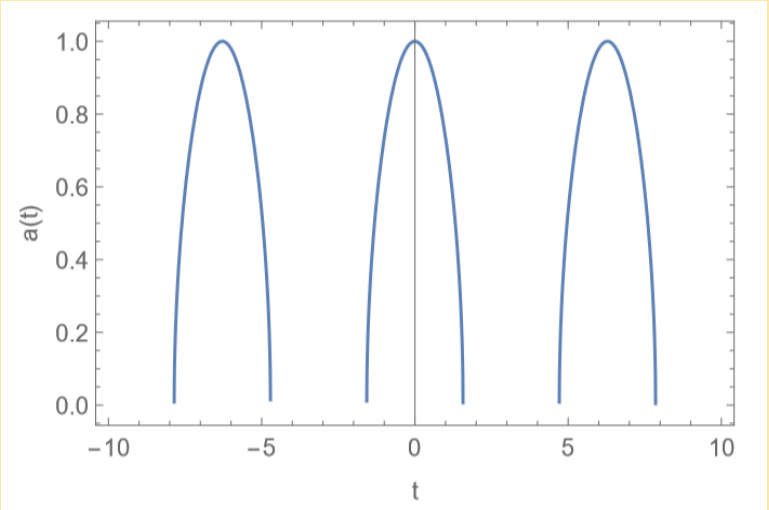
WHY: Studying the cosmological phase space of the generalized hybrid metric-Palatini gravity allowed me to collaborate with S.Carloni in the study of another dynamical system project of 6th and 8th order geometrical theories of gravity

RESULTS 1: COSMOLOGY

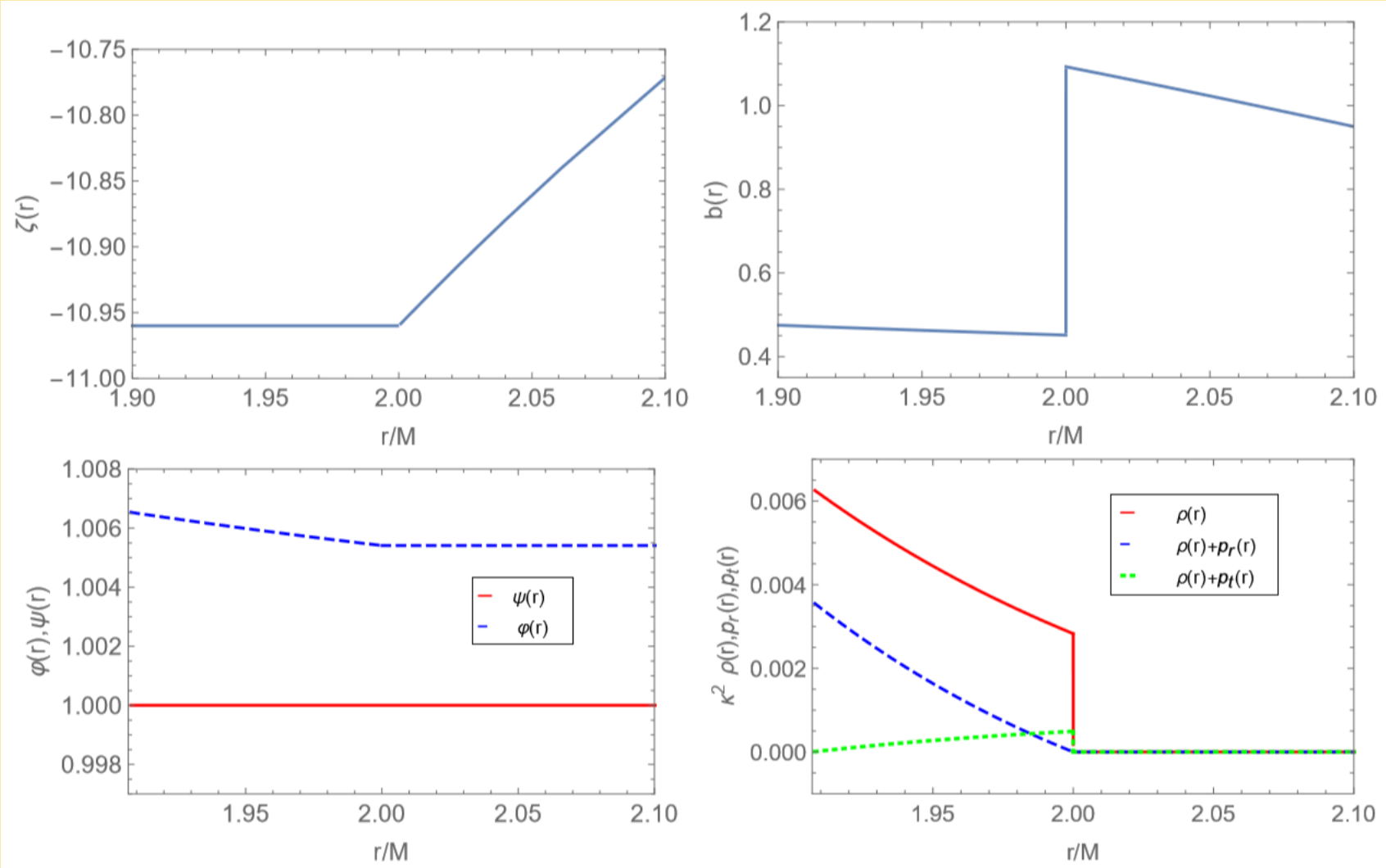








RESULTS 2: WORMHOLES



RESULTS 3: DYNAMICAL SYSTEMS

Point	Coordinates	Stability	Parameter s
$\mathcal{A}$	$K=-6$ $X=2$ $Y=-5$ $Z=-2$ $Q=-1$ $J=1$ $\Omega=0$	Saddle	-1
$\mathcal{E}_{\pm}$	$K=0$ $X=-\frac{1}{2}\left(5\pm\sqrt{33}\right)$ $Y=\frac{1}{2}\left(11\pm\sqrt{33}\right)$ $Z=-\left(5\pm\sqrt{33}\right)$ $Q=\frac{1}{2}\left(7\pm\sqrt{33}\right)$ $J=\frac{1}{2}\left(41\pm\sqrt{33}\right)$ $\Omega=0$	$\mathcal{E}_{+}$: Saddle $\mathcal{E}_{-}$: Attractor	$\frac{1}{2}\left(259\pm45\sqrt{33}\right)$

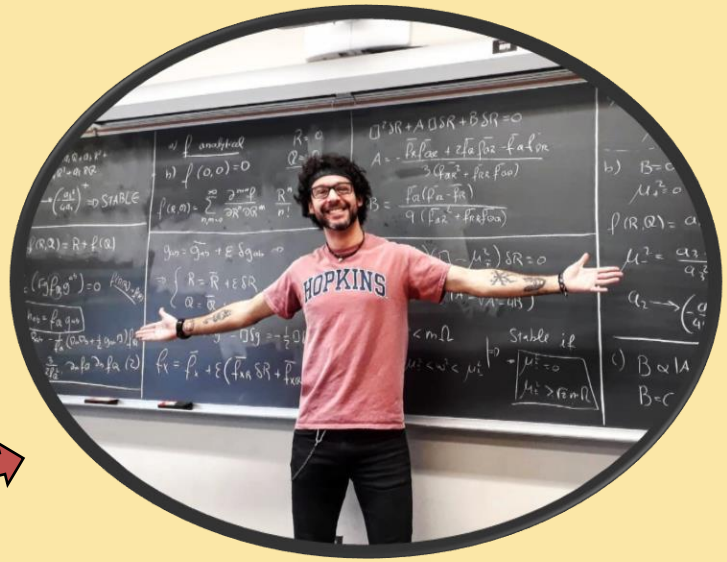
THE FULBRIGHT SAGA

I was awarded with a Fulbright Research Scholarship!

FULBRIGHT

JOHNS HOPKINS UNIVERSITY

From September 15th to January 31st I was a Visiting Scholar in the Bloomberg Center for Physics and Astronomy in the **Johns Hopkins University** in Baltimore, Maryland!



Picture of my last day ☹

FULBRIGHT PROJECTS

BOSON CLOUD DEPLETION (with E.Berti et al)

We studied how boson clouds deplete due to resonant transitions in binary Black-hole inspirals for co-rotating and counter-rotating orbits and also studied the effects of orbital eccentricity which create new resonances

SUPERRADIANT BOUND (with E.Berti, M.Richartz)

Superradiant instabilities can only occur if the superradiant modes are confined by a potential well. However, in this work we show that the existence of confinement is not enough to guarantee instabilities and obtain numerically the mass bound

BLACK-HOLE STABILITY (with E.Berti,J.P.S.Lemos,F.S.N.Lobo)

Black-holes described by the Kerr metric are shown to be solutions to the GHMPG field equations requiring simply that the action is analytical and specific forms of the action for which BHs are stable are obtained using perturbation theory