MAP-fis Essay Proposal, 2013-2014

(*please write in English*)

Supervisor

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This proposal has co-advisors J.C. Degollado (post-doc) and E. Radu (IF principal researcher), both at the University of Aveiro.

Title

Analytical and numerical methods for studying strong gravitational dynamics

Area

(*Materials, Optics, Condensed Theory, High Energy Theory,....*);

General Relativity

Summary of Proposal

Over the last decade, the study of strong gravity dynamics has thrived. The coalescence of an astrophysical black hole (BH) binary and its gravitational wave signal, or the interaction of BHs with matter/fundamental fields are now under control, due to sophisticated numerical infrastructures to perform fully non-linear numerical simulations in general relativity [1-3].

This infrastructures may be further used to evolve bosonic fields in the vicinity of BHs to:

- study their gravitational wave signal and test alternative theories of gravity;

- test these fields as dark matter candidates;

- understand the development of the superradiant instability of BHs beyond toy models [4,5].

- understand the stability of recently found solutions of Kerr BHs with scalar hair [6].

These studies will be the aim of this interdisciplinary thesis, motivated by cosmology, astrophysics and high energy physics.

At a technical level, part of the innovation of this thesis will be to develop numerical relativity (NR) and analytical tools for solving the relevant strong gravity systems. These tools will be interfaced with the recently released EINSTEIN TOOLKIT, an open, state-of-the-art, community platform for NR - of which the advisors of this thesis is a Consortium Member

(http://einsteintoolkit.org/about/members/).

(*continue if necessary*)

References

(*to allow students first look at topic*)

[1] “NR/HEP: Roadmap for the future”, V.Cardoso, L.Gualtieri, C.Herdeiro, U.Sperhake et al. Class. Quant. Grav. 29 (2012) 244001, e-Print: arXiv: 1201:5118 [hep-th].

[2] “Numerical Relativity and High Energy Physics”, V. Cardoso, L. Gualtieri, C. Herdeiro, U. Sperhake (editors), International Journal of Modern Physics A, Special issue, 28 (2013) N. 22n23.

[3] “Exploring new physics frontiers through numerical relativity”, V. Cardoso, L. Gualtieri, C. Herdeiro, U. Sperhake, to appear in Living Reviews in Relativity (2014).

[4] “Time evolution of superradiant instabilities for charged black holes in a cavity”, Juan Carlos Degollado, Carlos Herdeiro, Phys. Rev. D89 (2014) 063005; e-Print: arXiv:1312.4579.

[5] “Rapid growth of superradiant instabilities for charged black holes in a cavity”, Juan Carlos Degollado, Carlos A. R. Herdeiro, Helgi Freyr Rúnarsson, Phys. Rev. D88 (2013) 063003, e-Print: arXiv:1305.5513 [gr-qc].

[6] “Kerr black holes with scalar hair,” Carlos A. R. Herdeiro, Eugen Radu; e-Print: arXiv:1403.2757