(BL85/2025)

Post-Doctoral Research Fellowship

Applications are open for 1 Post-Doctoral Research Fellowship, within the framework of project/R&D institution FCT PeX Grant 2023.12549.PEX Program/1018P.06678 – Threshold, financed by national funds through FCT with the financial support of FCT through national funds, under the following conditions:

Scientific Area: Astronomy and Astrophysics FIS-AST

Admission Requirements:

a) *to hold a PhD degree obtained in the 3 years previously to the submission of the fellowship application.*

b) *to have carried out the research work that led to the PhD degree in a different entity from the host institution of the fellowship.*

c) *Not to exceed, with this fellowship contract, including the possible renovations, an accumulated period of 3 years in this type of fellowship, continuously or with interruptions.*

d) *Not to have previously held a post-doctoral fellowship from IST.*

Workplan: Classic work in mathematical and numerical relativity lead to our current best understanding of gravitational collapse and cosmic censorship. One aspect of this picture is that, at least in spherical symmetry for a given matter model, solutions that lie precisely at the threshold of black hole formation are in a certain sense unique. Consequently if we consider various one parameter families of spacetimes and tune the parameter of each family to the threshold of black hole formation, we will recover identical spacetimes in a region near the origin where the collapse occurs. These very special spacetimes that lie between dispersion and black hole formation exhibit discrete self-similarity and contain naked singularities. Due to their uniqueness they are known as critical solutions. Spherical spacetimes close to criticality exhibit behavior, such as power-law scaling and periodicity, that has come to be known as critical phenomena in gravitational collapse. Despite the foundations of this knowledge being laid three decades ago, the complete generalization to dynamical spacetimes without symmetry remains mysterious. In the last five years our team has redrawn the standard picture of critical collapse, enumerating various subtleties that manifest as symmetry is dropped. In this project we will continue the push towards a complete understanding of the threshold of black hole formation without symmetry.

This improved understanding will be attained through a multidisciplinary approach. Rigorous mathematics will be relied upon to control the continuum equations of general relativity to the greatest extent possible. Since we require the solutions in hand pure theory can only take us so far, however. For the rest we rely upon advanced computational methods, informed by numerical analysis wherever possible. In particular we will use the massively parallel, adaptive-mesh multidomain pseudospectral code, bamps, to make the most dense study of the threshold of black hole formation to date. We will additionally work towards the open-source release of the code, which our team develops. Specific questions to be answered concern the nature of the breakdown of the naive spherical picture for scalar field matter, the characterization of the threshold of collapse in gravitational wave spacetimes and finally establishing the genericity of the emerging picture by sourcing the field equations with various matter models.

Legislation and Regulations: Statute of Scientific Research Fellow, approved by Law nr. 40/2004, of August 18, as worded by Decree-Law nr. 123/2019, of August 28; FCT Regulation for Research Studentships and Fellowships,

available on https://www.fct.pt/apoios/bolsas/docs/RegulamentoBolsasFCT2019.pdf and https://dre.pt/application/file/a/127230968.

Workplace: The work will be developed at CENTRA - Centro de Astrofísica e Gravitação, IST – Instituto Superior Técnico, under the scientific supervision of Dr. David Hilditch.

Duration: The research fellowship(s) will have a duration of 18 months. It's expected to begin June 1st 2025, and may be eventually renewed up to the maximum of 36 months, including the duration of the initial contract.

Monthly maintenance allowance: According to the values for Research Fellowships awarded by FCT in Portugal (https://www.fct.pt/fct-atualizou-o-valor-das-bolsas-para-2025/), the amount of the monthly maintenance allowance is €1851,00 being the payment method by wire transfer.

Selection methods: The selection methods will be the following: *Curriculum evaluation* and *individual interview*, with the respective weight of 50%+50%

Composition of the selection Jury: David Hilditch, Richard Brito, Hannes Rüter.

Announcement/ notification of the results: The final evaluation results will be communicated to all applicants by email.

Deadlines and procedures of complaint and appeal. A complaint may be lodged from the final decision within 15 working days, or an appeal to the Executive Board of IST-ID within 30 working days, both counted from the respective notification.

Application deadline and formalization: The call is open from May 5 until May 16, 2025.

It is mandatory to formalize applications with the submission of the following documents: i) B1 Form – Fellowship application (https://drh.tecnico.ulisboa.pt/bolseiros/recrutamento/); ii) *Curriculum Vitae*; iii) academic degree certificate.

Applications must be submitted to the email*:* david.hilditch@tecnico.ulisboa.pt