



Double-Diffusive Instabilities : From Planets to Neutron Stars

Job offer from Institut de physique du globe de Paris | UMR 7154

Postdoctoral position in	Geophysical and Astrophysical Fluid Dynamics
Assignment	Geological Fluid Dynamics
Duration	2 years – Full-time (100%)
Salary	Based on qualifications and experience
Publication date	24/09/2025
Expected start date	01/02/2026
Location	IPGP, 1 rue Jussieu – 75005 Paris UMR AIM, Orme des Merisiers – 91191 Gif-sur-Yvette

The Institut de physique du globe de Paris

A world-renowned geosciences research institution affiliated with CNRS and a component establishment of Université Paris Cité, IPGP brings together over 500 researchers and covers all disciplines of Earth and planetary sciences through observation, experimentation, and modeling across all temporal and spatial scales.

Research themes are structured around four major interdisciplinary pillars: Earth and Planetary Interiors, Natural Hazards, Earth Systems, and Origins.

IPGP also operates certified observatories in volcanology, seismology, geomagnetism, gravimetry, and erosion. Notably, its permanent observatories monitor all four of France's active overseas volcanoes in Guadeloupe, Martinique, La Réunion, and Mayotte (REVOSIMA).

The institute hosts state-of-the-art computational resources, cutting-edge experimental and analytical facilities, and benefits from top-tier technical support. Through its graduate and doctoral training department, IPGP offers geosciences programs that integrate observation, quantitative analysis, and modeling, reflecting the quality, breadth, and thematic diversity of research conducted by its teams.

This position is funded by the HERMES project, awarded under the inlEx 2025–2030 program of Université Paris Cité, supported by IPGP in collaboration with the APC and AIM laboratories. This transdisciplinary program aims to strengthen the links between research, training, and scientific outreach, fostering a new generation of researchers at the frontiers of Earth and Universe studies.

The Team

This project promotes a new collaboration between two teams at Université Paris Cité, based at IPGP and UMR AIM.

- > The IPGP team consists of Thomas Gastine (gastine@ipgp.fr) and Alexandre Fournier (fournier@ipgp.fr). Thomas Gastine is the lead developer of the MagIC code (github.com/magic-sph/magic), which will be used for simulations. Alexandre Fournier is the scientific head of IPGP's high-performance computing service, S-CAPAD. Together, they previously supervised the PhD thesis of Théo Tassin and have long-standing expertise in modeling planetary interiors.
- > The UMR AIM team includes Raphaël Raynaud (raphael.raynaud@cea.fr) and Jérôme Guilet (jerome.guilet@cea.fr). They have adapted the MagIC code to model different types of dynamos in proto-neutron stars.

Objectives

This project aims to study the dynamics and consequences of double-diffusive convection in geophysical and astrophysical contexts. Salt-finger convection is a type of double-diffusive instability that occurs in the presence of a stabilizing thermal gradient and a destabilizing compositional gradient. Initially studied in oceanography, this instability is likely to develop in the liquid cores of terrestrial planets like Earth or Mercury, in stars, white dwarfs, and proto-neutron stars (where it forms neutron fingers analogous to oceanic salt fingers). This thermo-compositional convection drives heat and compositional transport, altering the structure and evolution of planets and stars. In proto-neutron stars, neutron fingers may enhance neutrino luminosity, playing a role in supernova explosion mechanism, and could generate intense magnetic fields explaining neutron stars' surface magnetism.

To date, salt-finger convection has primarily been studied via local Cartesian numerical models, with only a few simulations in spherical geometry (relevant for astrophysical objects). Given the dynamically crucial roles of rotation and magnetic fields in planetary and stellar interiors, the project will explore their impact on salt-finger convection in spherical geometry.

Activities

The postdoctoral researcher will perform 3D global spherical simulations of salt-finger convection using the open-source MagIC code, a pseudo-spectral solver with hybrid MPI-OpenMP parallelization for solving Boussinesq-approximation MHD equations in spherical geometry.

- > Initial work at IPGP will focus on the effect of rotation on salt-finger convection in purely hydrodynamic regimes. A parametric study will derive scaling laws to estimate transport efficiency and assess rotation's impact on zonal wind formation.

- > Subsequent work at AIM will extend to magnetized cases, first studying imposed magnetic field configurations, then evaluating dynamo capability in unexplored parameter regimes.

Required Skills

- > Background : Fluid dynamics, magnetohydrodynamics, high-performance computing
- > Technical tools : Fortran, Python
- > Professional qualities : Rigor, autonomy, collaborative spirit

Constraints

- > Full-time position
- > The researcher will be hosted at IPGP for the first 12 months, then at UMR AIM for the remaining 12 months. Both teams will jointly supervise the project throughout its duration.

Qualifications and Experience

- > Degree : PhD
- > Desired expertise : Incompressible fluid dynamics (geophysical/astrophysical applications), magnetohydrodynamics, high-performance computing, pseudo-spectral methods

Application Process

- > Submit a CV and a cover letter to **gastine@ipgp.fr** and **raphael.raynaud@cea.fr**
- > Two references required for interviews
- > Application deadline : position will remain open until filled
- > Interviews will start in November 2025