Offer #2024-07735

Post-Doctoral Research Visit F/M Numerical modeling of acoustic waves in an active Sun

Contract type : Fixed-term contract

Level of qualifications required : PhD or equivalent

Fonction : Post-Doctoral Research Visit

Context

We propose a two-years postdoctoral position in computational asteroseismology in the context of the ANR-DFG project BUTTERFLY which aims to develop numerical tools for use in seismological investigation of surface magnetic activity of the Sun and solar-like stars. The project is joint between INRIA Team Makutu (https://team.inria.fr/makutu/) and the Max Plank institute for solar system research (MPS, https://www.mps.mpg.de/helioseismology-asteroseismology). The postdoctoral position takes place in the team Makutu, located at the University of Pau and Pays de l'Adour, in the Southwest of France.

Travel expenses for research stay at the MPS are also covered within the project.

Assignment

The objective of the postdoctoral position is to investigate and develop accurate methods and software to compute numerically the Green's kernel in a Sun displaying magnetic activity by coupling boundary element method (BEM) with hybridizable discontinous galerkin method (HDG). Green's kernel forms a key ingredient in forward modeling as well as inversion in helioseismology and asteroseismology which employ seismological techniques to reconstruct the interior structure and dynamics of the Sun and solar-like stars. Radially symmetric standard solar models, such as model S [3], represent the Sun at minimum magnetic activity, called 'quiet' Sun. Effects of magnetic activity on solar acoustic modes can be represented as near-surface 3D perturbations in wave speed. In this way, wave propagation in the Sun is modeled by a time-harmonic scalar wave equation with sound speed coefficient containing these perturbations. Adding these perturbation breaks the radial symmetry of standard models, thus resolution is carried out in 3D but can be prohibitively costly. In the case of compact perturbations, we will construct a more computing-resource frugal alternative, employing a BEM method coupled with Hybridizable Discontinuous Galerkin (HDG) method.

The post-doctoral fellow will participate in regular meetings with the MPS group and in the organization of joint workshops.

Main activities

The program will be divided into two main phases, with all software development and numerical implementation performed in the open-source code hawen developed in the team Makutu, https://ffaucher.gitlab.io/hawen-website/.

- Phase 1: The first task is to compute the full quiet Sun Green's kernel in exploiting axis-symmetry and implement numerical integration involving this kernel to be employed in boundary integral equation method. We will consider Garlekin boundary element method with Sauter--Schwab quadrature rather than collocation method, cf., [4,5,2].
- Phase 2 The second task is to solve the solar acoustic equation, cf. [1], with compactly perturbed sound speed by BEM-HDG method. In this approach, wave propagation in the entire Sun is reformulated as a scattering problem of the Green's kernel associated with the quiet Sun, constructed in Phase 1, by (fictitious) scatterers which enclose active regions. Using potential layer operators, the problem is reduced to one on the closure of the scatterers and we need to investigate a stable coupling between BEM and HDG in the spirit of [3].

Références

[1] H. Barucq, F. Faucher, D. Fournier, L. Gizon, and H. Pham, Efficient and Accurate Algorithm for the Full Modal Green's Kernel of the Scalar Wave Equation in Helioseismology, SIAM Journal of Applied Mathematics, 80 (2020), p. 2657.

[2] T. Betcke and M. W. Scroggs, Designing a high-performance boundary element library with OpenCL and NUMBA, Computing in Science & Engineering, 23 (2021), pp. 18–28.

[3] Z. Fu, N. Heuer, and F.-J. Sayas, A non-symmetric coupling of boundary elements with the hybridizable discontinuous Galerkin method, Computers & Mathematics with Applications, 74 (2017), pp. 2752–2768.

[4] S. A. Sauter and C. Schwab, Boundary element methods, Springer, 2011.

[5] W. Śmigaj, T. Betcke, S. Arridge, J. Phillips, and M. Schweiger, Solving boundary integral problems with BEM++, ACM Transactions on Mathematical Software (TOMS), 41 (2015), pp. 1–40.

Skills

The applicant must have a solid background in applied mathematics, in particular in partial differential equations for wave propagation; knowledge in boundary element methods and finite elements is recommended. Numerical implementation will be within the open-source platform hawen, it is necessary that the applicant is familiar with programming, including parallel computer architecture to launch experiments. In addition, the applicant is expected to write reports/articles.

The applicant must be comfortable with teamwork in an international collaboration.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Possibility of teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Remuneration

2788€ / month (before taxs)

General Information

- **Theme/Domain :** Numerical schemes and simulations
  Scientific computing (BAP E)
- **Town/city :** Pau
- **Inria Center :** Centre Inria de l'université de Bordeaux
- **Starting date :** 2025-01-01
- **Duration of contract :** 2 years
- **Deadline to apply :** 2024-06-30

Contacts

- **Inria Team :** MAKUTU
- **Recruiter :**
  Faucher Florian / florian.faucher@inria.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

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Instruction to apply

Thank you to send:
- CV
- Cover letter
- Support letters (mandatory)
- List of publication

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated

in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.