Offer #2024-07780

PhD Position F/M Wave propagation in unbounded hyperbolic media

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

About the research centre or Inria department

The Inria Saclay-Île-de-France Research Centre was established in 2008. It has developed as part of the Saclay site in partnership with **Paris-Saclay University** and with the **Institut Polytechnique de Paris** .

The centre has **40 project teams** , 32 of which operate jointly with Paris-Saclay University and the Institut Polytechnique de Paris; Its activities occupy over 600 people, scientists and research and innovation support staff, including 44 different nationalities.

Context

Hyperbolic metamaterials are artificially engineered anisotropic materials which exhibit some unusual properties, such as negative refraction and backward wave propagation.
The name 'hyperbolic' comes from the respective dispersive curves (which relate the frequency and the wave vector of the plane waves propagating in such media): these curves take a form of hyperbolae, rather than circles or ellipses. This property enables them to support, for a fixed wavelength, an arbitrary large wavenumber. Their applications include enhanced particle absorption, emission, and collection, e.g. for sensors and antennas; super-resolution imaging; stealth technologies; rogue wave generation etc.
Unlike isotropic metamaterials, media with hyperbolic dispersion exist in nature, examples including crystals of hexagonal boron nitride, bismuth telluride, or even cold plasma.

From the mathematical point of view, the main particularity of the corresponding models lies in the fact that in the frequency domain the respective problem is (think of the wave equation where the time is replaced by a spatial variable), at least for a range of frequencies. This is strikingly different from classical frequency-domain problems, which are \textbf{elliptic} (think of the Laplace equation). Despite the abundance of the physics literature on this subject, to our knowledge, there exist very few works on the mathematical justification of the hyperbolic metamaterial models. An important related work is a very recent theoretical paper on the Poincar\'e problem (see Dyatlov et al. 2023)

Main activities

The hyperbolicity of the PDE has serious implications on the well-posedness of underlying boundary-value problems. For example, it is well-known that the Dirichlet problem for the wave equation is in general ill-posed in bounded domains (cf. the classical article by F. John 1943). However, not much is known for the Klein-Gordon equation (wave equation with zero-order terms), especially when considered in the following settings: 1) unbounded domains (e.g. hyperbolic metamaterial waveguides), except for the free space case; 2) transmission problems, where the hyperbolic media interacts with vacuum, either in bounded or unbounded domains.

Skills

We are looking for a candidate with a strong background in numerical analysis for wave propagation, solid complex analysis skills and some knowledge of programming (MATLAB or C++).

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- 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

Remuneration

Gross salary : 2.100 euros / month

General Information

- **Theme/Domain :** Numerical schemes and simulations
- **Town/city :** Palaiseau
- **Inria Center :** Centre Inria de Saclay
- **Starting date :** 2024-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2024-09-30

Contacts

- **Inria Team :** POEMS
- **PhD Supervisor :**
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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.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

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.