2019-02018 - Post-Doctoral Research Visit F/M Advanced computational modeling and inverse design of planar optical devices

Type de contrat : CDD de la fonction publique
Contrat renouvelable : Oui
Niveau de diplôme exigé : Thèse ou équivalent
Fonction : Post-Doctorant

A propos du centre ou de la direction fonctionnelle

The Inria Sophia Antipolis - Méditerranéenne center counts 34 research teams as well as 8 support departments. The center's staff (about 500 people including 320 Inria employees) is made up of scientists, engineers, technicians and administrative staff. 1/3 of the staff are civil servants, the others are contractual agents. The majority of the center's research teams are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Four teams are based in Montpellier and two teams are hosted in Bologna in Italy and Athens. The Center is a founding member of Université Côte d'Azur and partner of the site MUSE supported by the University of Montpellier.*

Contexte et atouts du poste

This postdoctoral project will be conducted in the Nachos project-team, in close collaboration with researchers from the Acumes project-team at the Inria Sophia Antipolis-Méditerranée research center and CRHEA - Centre de Recherche sur l'Hétéro-Epitaxie et ses Applications [http://www.crhea.cnrs.fr/] - in Sophia Antipolis.

Nachos is a joint project-team between Inria and the Jean-Alexandre Dieudonné Mathematics Laboratory at University Nice Sophia Antipolis. The team gathers applied mathematicians and computational scientists who are collaboratively undertaking research activities aiming at the design, analysis, development and application of innovative numerical methods for systems of partial differential equations (PDEs) modeling nanoscale light-matter interaction problems. In this context, the team is developing the DIOGENeS software suite [https://diogenes.inria.fr/], which implements several Discontinuous Galerkin (DG) methods tailor-made for the system of time- and frequency-domain Maxwell equations possibly coupled to differential equations modeling the behaviour of propagation media at optical frequencies. DIOGENeS is a unique numerical framework leveraging the capabilities of DG techniques for the simulation of multiscale problems relevant to nanophotonics and nanophotonic devices.

Acumes is a joint project-team between Inria and the Jean-Alexandre Dieudonné Mathematics Laboratory at University Nice Sophia Antipolis. This project-team focuses on the analysis and optimal control of classical and non-classical evolutionary PDE systems arising in a variety of applications, ranging from fluid dynamics and structural mechanics to traffic flow and biology. The complexity of the involved dynamical systems is expressed by multi-scale, time-dependent phenomena subject to uncertainty, which can hardly be tackled using classical approaches, and require the development of unconventional techniques.

Mission confiée

Conventional optical components such as lenses, wave plates and holograms rely on light propagation over distances much larger than the wavelength to shape wavefronts. In this way substantial changes of the amplitude, phase or polarization of light waves are gradually accumulated along the optical path. Flat, ultrathin optical components dubbed 'metasurfaces' can produce abrupt changes over the scale of the free-space wavelength in the phase, amplitude or polarization of a light beam [1]-[2]. Metasurfaces are generally created by assembling arrays of miniature anisotropic light scatterers (that is, resonators such as optical antennas). The spacing between these nanostructures and their dimensions are much smaller than the wavelength. As a result the metasurfaces, on account of Huygens principle, are able to mold optical wavefronts into arbitrary shapes with subwavelength resolution by introducing spatial variations in the optical response of the light scatterers. However, designing metasurfaces is generally a challenging inverse problem.

The recent numerous discoveries in nanophotonics, driven by the achievements in nanofabrication processes and characterization techniques, require revisiting the traditional electromagnetic design paradigms. Specific and rigorous strategies for the design of nanostructures are not yet fully established. The geometries that have been studied and designed so far need additional refinements by a fullwave electromagnetic simulation, carried out by sweeping the relevant geometrical parameters through a given range. This time-consuming design approach exacerbates the delay between proof of concept devices and marketable technology. On the other hand, the automation of the design of nanostructures by rigorous inverse design strategies [3]-[4] could make very simple search spaces easily accessible, thus the user could look for a specific nanostructure meeting specific needs with unparalleled accuracy. Contrary to the solution of a direct problem, which simply aims at determining the electromagnetic field scattered by a given nanostructure of prescribed shape, size and composition, under assigned excitation conditions, the inverse design problem consists of determining the characteristics of the scattering object, based on the desired properties of the scattered electromagnetic field.

The general objective of this postdoctoral project is to develop a methodology for the rigorous inverse design of planar optical devices based on passive and active metasurfaces. In order to do so, high order discontinuous Galerkin (DG) solvers from the DIOGENeS software suite [https://diogenes.inria.fr/] developed in the Nachos team will be combined with statistical learning-based global optimization strategies [5] from the DiceOptim R toolbox developed by the Acumes team. Both teams are partners of the ANR OPERA project that was launched in May 2019 and which is funded by the French Defense procurement Agency.

Informations générales

- **Thème/Domaine :** Schémas et simulations numériques, Calcul Scientifique (BAP E)
- **Ville :** Sophia Antipolis
- **Centre Inria :** CRI Sophia Antipolis - Méditerranée
- **Durée de prise de fonction souhaitée :** 2020-03-01
- **Durée de contrat :** 12 mois
- **Date limite pour postuler :** 2019-12-31

Contacts

- **Equipe Inria :** NACHOS
- **Recruteur :** Lanteri Stéphane / Stephane.Lanteri@inria.fr

A propos d'Inria

Inria, l'institut national de recherche dédié aux sciences du numérique, promeut l'excellence scientifique et le transfert pour avoir le plus grand impact. Il emploie 2400 personnes. Ses 250 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3000 scientifiques pour relever les défis des sciences informatiques et mathématiques, souvent à l'interface d'autres disciplines. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 160 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

Consignes pour postuler

**Sécurité défense :**
Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

**Politique de recrutement :**
Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.

Attention : Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.
The following methodological topics will be addressed:

- Modeling and characterization of metasurfaces. High order DG solvers of the system of 3D Maxwell equations will be adapted to cope with the modeling features relevant to metasurfaces. Both time-domain and frequency-domain modeling settings will be considered with specific variants of the DG method that are implemented in the DIOGENeS software suite.
- Problem parameterization. The influence of the parameterization of nanophotonic device geometries will be investigated, by comparing ad-hoc representations (Gielis' formula) to generic geometrical models (B-Spline based free-form deformation). Multilevel parameterization techniques will also be studied. The selected parameterization strategies will be implemented in new modules that will be integrated in the DIOGENeS software suite afterwards.
- Optimization strategies. One overarching goal here will be to design inverse design strategies capable of dealing with large area planar optic devices. This will probably represent the more prospective and challenging part of this postdoctoral project, which will require to investigate various directions for reducing the computational overhead when dealing with metasurfaces with several hundreds to several thousands nanostructures.

### Compétences

Candidates must hold a PhD degree in applied mathematics/scientific computing/applied physics. Required knowledge and skills are: a sound knowledge of numerical analysis and development of finite element type methods for solving PDEs; a concrete experience in numerical modeling for computational electromagnetics; strong software development skills, preferably in Fortran 95/2008.

A previous research experience in applied nanophotonics will clearly be an asset for this position.

### Avantages

- 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 (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videconferencing, loan of computer equipment, etc.)
- Access to vocational training
- Social security coverage

### Rémunération

Gross Salary: 2653 € per month