Offre n°2024-08246

Post-Doctoral Research Visit F/M Postdoctoral project - Advanced modelling of nonlinear metasurfaces for efficient and ultra-compact short-wavelength infrared radiation

Le descriptif de l'offre ci-dessous est en Anglais

Type de contrat : CDD

Contrat renouvelable : Oui

Niveau de diplôme exigé : Thèse ou équivalent

Fonction : Post-Doctorant

Niveau d'expérience souhaité : De 3 à 5 ans

A propos du centre ou de la direction fonctionnelle

The Inria center at Université Côte d'Azur includes 42 research teams and 9 support services. The center's staff (about 500 people) is made up of scientists of different nationalities, engineers, technicians and administrative staff. The teams are mainly located on the university campuses of Sophia Antipolis and Nice as well as Montpellier, in close collaboration with research and higher education laboratories and establishments (Université Côte d'Azur, CNRS, INRAE, INSERM ...), but also with the regional economic players.

With a presence in the fields of computational neuroscience and biology, data science and modeling, software engineering and certification, as well as collaborative robotics, the Inria Centre at Université Côte d'Azur is a major player in terms of scientific excellence through its results and collaborations at both European and international levels.

Contexte et atouts du poste

Atlantis is a joint project-team between Inria and the Jean-Alexandre Dieudonné Mathematics Laboratory at Université Côte d'Azur. 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) modelling nanoscale light-matter interaction problems. In this context, the team is developing the DIOGENeS [https://diogenes.inria.fr/] software suite, which implements several Discontinuous Galerkin (DG) type methods tailored to the systems 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 nanoplasmonics.

This postdoctoral project will be conducted in close collaboration with scientific academic partners in the context of the recently started NO-RESTRAIN project funded by ANR (French National Research Agency): (1) MPQ – Paris Cité with NLMS fabrication; (2) PHELIQS – CEA - Grenoble University for the characterization of the fabricated designs.

Mission confiée

In the last decade metasurfaces **(MS**s**)**, i.e. 2D arrays of optical nanoantennas with subwavelength size and separation [1] have revolutionized the field of linear optics with the promise to replace bulky and difficult-to-align optical components with ultrathin and flat devices like metagratings, metalenses **(ML**s**)** and metaholograms, which can also implement new functionalities in terms of aberrations correction and arbitrary wavefront shaping.

The field of **flat optics** also showed its potential in the nonlinear regime [2] mostly with the huge of III-V semiconductors in two spectral ranges: mid-infrared based on the resonant of quantum-well inter sub band transitions and short wavelength infrared **(SWIR)** (based on non-resonant structures). In the latter domain, to date, the most studied phenomenon has been second harmonic generation **(SHG)**, which has proven very useful to assess the potential of nonlinear metasurfaces **(NLMS**s**)** for nonlinear conversion. However, sum frequency generation **(SFG)** looks much more promising to go beyond academic interest and develop potentially useful optoelectronic devices. The main reason for it is that the two SFG inputs can have different

powers and wavelengths.

Therefore: (a) a weak signal can be mixed with a strong pump and, as a result, one can increase the frequency conversion efficiency by increasing the pump intensity up to signal depletion or radiation damage; (b) the independent tuning of signal and pump wavelengths enables significant spectral agility.

Principales activités

The main goal of the present postdoctoral position is to model, design, and optimize **an efficient and ultra-compact upconverter of SWIR radiation into the silicon absorption band.** We start first with the **two-steps modelling design** in which the modeling involves three **linear simulations** in the frequency domain: one for the pump and signal inputs, and another for the generated nonlinear field, with the latter arising from the overlap of the nonlinear polarization and the nonlinear field distribution. In most of the cases the two-step approach is sufficient to provide a qualitative response of the nonlinear interaction. However, in circumstances where the time dynamics comes into play and/or there is broad spectrum excitation, two-step approaches are no longer appropriate, and one must simulate **the full nonlinearity inside Maxwell's equations**, which could be computationally costly. An alternative approach is to couple the linear Maxwell's equations to nonlinear ordinary differential equations describing the physical mechanism of the problem.

We will rely on our advanced numerical methodology introduced to design highly efficient NLMS. The first component of this methodology is a general modelling approach for the numerical characterization of metasurfaces by solving the full system of 3D time-domain Maxwell equations, which is referred to as the Discontinuous Galerkin Time-Domain (DGTD) method. This DGTD full-wave solver is implemented in the DIOGENeS software suite, which has been developed at INRIA since 2015 [3]. The second component of our modelling methodology is a numerical optimization method. We will rely on the Efficient Global Optimization (EGO) method, an adaptive statistical learning approach based on Gaussian Process (GP) models. The numerical methodology developed at INRIA has been used to optimize various linear metasurface configurations [4-7].

References

1. W. Chen et al., Flat optics with dispersion-engineered metasurfaces, Nature Review Material, vol. 5, 604 (2020)
2. C. De Angelis, G. Leo, D. Neshev, Nonlinear Meta-Optics, CRC Press - Taylor & Francis (2020)
3. DIOGENeS: A DG-based software suite for nano-optics https://diogenes.inria.fr/
4. Isnard et al., Advancing Wavefront Shaping with Resonant Nonlocal Metasurfaces: Beyond the Limitations of Lookup Tables, Scientific Reports 14, 1555 (2024).
5. Elsawy et al., Multiobjective statistical learning optimization of RGB metalens, ACS Photonics, vol. 8, 2498 (2021)
6. Elsawy, et al., Optimization of metasurfaces under geometrical uncertainty using statistical learning, Optics Express, vol. 29, 29887 (2021).
7. Elsawy et al., Universal Active Metasurfaces for Ultimate Wavefront Molding by Manipulating the Reflection Singularities, Laser Photonics Review, vol. 17, 2200880 (2023)

Compétences

Required knowledge and skills:

- Theory and methodology: computational electromagnetics, finite element methods for PDEs, numerical optimization
- Sound knowledge of nanophotonics, metasurface, metamaterial

Software development skills : Python and Fortran 2003, parallel programming with MPI and OpenMP.

Relational skills : team worker (verbal communication, active listening, motivation and commitment).

Other valued appreciated : good level of spoken and written english.

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 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
- Contribution to mutual insurance (subject to conditions)

Rémunération

Gross Salary : 2788 € per month

Informations générales

- **Thème/Domaine :** Schémas et simulations numériques
  Instrumentation et expérimentation (BAP E)
- **Ville :** Sophia Antipolis
- **Centre Inria :** Centre Inria d'Université Côte d'Azur
- **Date de prise de fonction souhaitée :** 2025-03-01
- **Durée de contrat :** 12 mois
- **Date limite pour postuler :** 2025-01-31

Contacts

- **Équipe Inria :** ATLANTIS
- **Recruteur :**
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A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 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.

L'essentiel pour réussir

Academic background: Ph.D. in Applied Physics or applied mathematics or scientific computing or electrical engineering.

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.

Consignes pour postuler

Applications must be submitted online on the Inria website. Collecting applications by other channels is not guaranteed.

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.