# Offre n°2023-06440

## Post-Doctoral Research Visit F/M Advanced numerical modeling for quantum metasurfaces

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

**Type de contrat :** CDD

**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 centre at Université Côte d'Azur includes 37 research teams and 8 support services. The centre'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 regiona 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.

## Mission confiée

Metasurfaces are planar structures that possess remarkable capabilities to manipulate light beyond what conventional optical components can achieve [1]. These intriguing flat surfaces have garnered significant research interest and have led to the development of efficient metasurface-based devices, such as achromatic metalenses [2,3], color holograms [4], and even metasurfaces with active functionalities [5,6]. While metasurfaces were initially explored for classical applications of optics, recent research has demonstrated their potential for quantum technology [7]. Unlike classical applications of optics, which use wave-like descriptions of light, quantum applications rely on the manipulation of individual photons to achieve quantum information processing tasks.

Classical electromagnetic (EM) simulations are based on classical physics and describe the behavior of light as a wave. These simulations are often used to predict the response of metasurfaces to the incoming light, including the polarization, amplitude or even reshaping the wavefront [2,5,8,9]. However, when the interaction involves a single photon, classical EM simulations are not accurate enough to describe the behavior of the system. This is because classical physics assumes a continuous distribution of energy, while quantum mechanics describes energy as being quantized into discrete packets, called photons. Therefore, classical EM simulations cannot accurately capture the quantum mechanical effects of the interaction between a single photon and a metasurface.

## Principales activités

In the present post-doctoral project, a first objective will be to formalize and develop the appropriate modeling tools to study the interaction of a single-photon and metasurface. In particular, we will rely on and extend the high order DGTD method initially introduced in [11]. The second objective will be to apply the developed numerical tools for designing qunatum information processing metasurface configurations. This post-doctoral project will take place in the Atlantis project-team at the Inria research center at Université Côte d'Azur in Sophia Antipolis. Moreover, it will be conducted in close collaboration with our physics partners for the theoretical physical modeling questions, simulation results interpretation and potential applications.

[1] Nanfang Yu et al. "Light propagation with phase discontinuities : generalized laws of reflection and refraction". Science 334.6054 (2011), p. 333-337.

[2] Mahmoud Elsawy et al. "Multiobjective statistical learning optimization of RGB meta- lens". ACS Photonics 8.8 (2021), p. 2498-2508.

[3] Meiyan Pan et al. "Dielectric metalens for miniaturized imaging systems : progress and chal- lenges". Light : Science & Applications 11.1 (2022), p. 1-32.

[4] Qinghua Song et al. "Ptychography retrieval of fully polarized holograms from geometric- phase metasurfaces". Nature Communications 11.1 (2020), p. 1-8.

[5] Mahmoud Elsawy et al. "Universal active metasurfaces for ultimate wavefront molding by manipulating the reflection singularities". Laser Photonics Review (2023), p. 2200880.

[6] Inki Kim et al. "Nanophotonics for light detection and ranging technology". Nature Nanotech-nology 16.5 (2021), p. 508-524.

[7] Tomás Santiago-Cruz et al. "Resonant metasurfaces for generating complex quantum states". Science 377.6609 (2022), p. 991-995.

[8] Mahmoud Elsawy et al. "Global optimization of metasurface designs using statistical learning methods". Scientific Reports 9.1 (2019), p. 1-15.

[9] Thaibao Phan et al. "High-efficiency, large-area, topology-optimized metasurfaces". Light : Science & Applications 8.1 (2019), p. 48.

[10] Weng Cho Chew et al. "Quantum Maxwell's equations made simple : Employing scalar and vector potential formulation". IEEE Antennas and Propagation Magazine 63.1 (2020), p. 14-26.

[11] J. Viquerat et al. "Simulation of electromagnetic waves propagation in nano-optics with a high-order discontinuous Galerkin time-domain method". Ph.D. thesis, University of Nice-Sophia Antipolis, Dec 2015.

## Compétences

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

Required knowledge and skills:

- Theory and methodology: computational electromagnetics, finite element methods for PDEs, numerical optimization
- Sound knowledge of quantum optics, 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 (after 6 months of employment) 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

## Rémunération

Gross Salary: 2746 € per month

## Informations générales

- **Thème/Domaine :** Schémas et simulations numériques
  Calcul Scientifique (BAP E)
- **Ville :** Sophia Antipolis
- **Centre Inria :** Centre Inria d'Université Côte d'Azur
- **Date de prise de fonction souhaitée :** 2023-11-01
- **Durée de contrat :** 2 ans
- **Date limite pour postuler :** 2024-07-31

## Contacts

- **Équipe Inria :** ATLANTIS
- **Recruteur :**
  Elsawy Mahmoud / mahmoud.elsawy@inria.fr

## 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.

**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

**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.