Offre n°2024-07089

Internship position F/M Optical sensitivity of Gap Plasmon Resonators

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

Type de contrat : Convention de stage

Niveau de diplôme exigé : Bac + 5 ou équivalent

Autre diplôme apprécié : Master in applied mathematics or scientific computing

Fonction : Stagiaire de la recherche

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

This internship project is part of a collaborative project between the Atlantis project-team (Inria Research Center at Université Côte d'Azur) and Institut Pascal at Université Clermont Auvergne in the context of the ANR SWAG-P starting in January 2024. Atlantis is a team from Inria Research Center at Université Côte d'Azur located in Sophia Antipolis. It gathers researchers in numerical mathematics and computational physics, with an interdisciplinariy focus. The team has developed a specific expertise in the efficient numerical modeling of propagation of electromagnetic wave in complex media with a strong emphasis on nanoscale light-matter interactions. Through the years, the Atlantis team has developed a strong expertise in the design, analysis and development of dedicated efficient numerical methods (based on high order accurate Discontinuous Galerkin finite elements methods). More recently, the team has also acquired a know-how of numerical optimization using various techniques, and a solid experience on high performance computing practices (parallel numerical algorithms and parallelization strategies for large-scale problems). This materializes concretely through the DIOGENeS software suite [1] that has already proven its crucial efficiency in nanophotonics. DIOGENeS will be the corner stone to numerically address the various complex scenarios in this internship project.

The Elena team at the Pascal Institute works closely with the Atlantis team on different subjects in plasmonics. Both teams have known each other and collaborated for years, particularly on advanced physical descriptions of the optical response of metals. Members of the Elena team specialize in modeling, physics-based numerical simulation, and optimization of nanophotonic structures ranging from plasmonic resonators to multilayer structures.

[1] DIOGENeS: a DG-based software suite for nano-optics. https://diogenes.inria.fr/

Mission confiée

Designing efficient nanoscale biosensors is currently an active field of research in nanophotonics. Several criteria such as cheapness of fabrication, miniaturization and high sensitivity are strongly desirable. However, meeting all these criteria at the same time is challenging. In this problematic, optical based biosensors, consisting in plasmonic nano-resonators, sound very promising. Plasmonic waves can manifest when the electrons of a metal are collectively excited by light, and the exploitation of their peculiar optical properties (such as light confinement, light focusing) are the subject of intense research. A single nanocube of a few tens of nanometers on a dielectric film deposited on a thin metal layer is a perfect illustration of a typical plasmonic resonant structure. The latter exhibits, in particular, a special kind of plasmonic wave called a gap plasmon (existing in a metal-dielectric-metal gap). As such, this simple device acts as a powerful individual gap plasmon resonator. It has in particular proved to have a high and easy measurable optical sensitivity to any environment change. This makes this device a very good candidate to be exploited as an elementary brick in patches to design an efficient biosensor (see illustration in Figure 1). To achieve this objective, it is thus of high importance to be able to characterize the optical response of single and multiple such resonators. Moreover, due to their high sensitivity, it is in particular essential to study the influence of any environment or geometrical change. In addition, the (possibly costly and difficult) use of direct experiments to address this problem, numerical methods are of high importance and provide essential support in this characterization step. Providing accurate and efficient numerical simulations in this context is highly challenging and requires robust discretization strategies and algorithms. In this context, the general objective of the internship project is to numerically study the sensitivity of the optical response of a given Gap Plasmon Resonator (GPR) to e.g. variation of optical indices and geometrical parameters (metal layer width, spacer size, cubes sizes, rounding of the corners of the cubes, etc.).

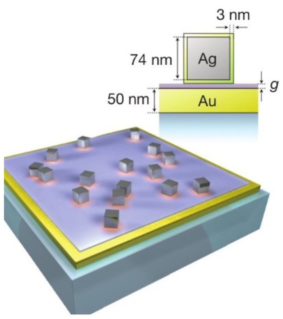

Figure 1: Gap-plasmon resonators constituted of silver nanocubes spread on a spacer deposited on a gold metallic surface [3]. Such structures are very efficient at concentrating and absorbing the incident light.

[1] Elsawy, M. M., Gourdin, A., Binois, M., Duvigneau, R., Felbacq, D., Khadir, S., P. Genevet, Lanteri, S. *Multiobjective statistical learning optimization of RGB metalens* ACS Photonics, 8(8), 2498-2508 (2021)

[2] M.R. Elsawy, M. Binois, R. Duvigneau, S. Lanteri and P. Genevet.*Optimization of metasurfaces under geometrical uncertainty using statistical learning*. Optics Express, Vol. 29, pp. 29887-29898 (2021)

[3] Moreau, C. Ciraci, J. Mock et al.*Controlled-reflectance surfaces with film-coupled colloidal nanoantennas*. Nature, vol. 492, no 7427, p. 86-89 (2012)

We are pleased to announce that the internship comes with the potential for continued research at the Ph.D. level, made possible by the funding secured within the framework of the ANR SWAG-P project.

Principales activités

To achieve this goal, Uncertainty Quantification (UQ) from the perspective of robust optimization techniques will be used,by building on the pre-existing Bayesian optimization tools implemented in the DIOGENeS software tool. Several steps are envisaged, which may depend on the precise background of the candidate. She/He will first have to become familiar with the global physical context of the project: classical optics, nanoplasmonics and gap plasmons resonators. He/She will also have to acquire the necessary basic knowledge of numerical methodologies and discretization strategies used to address optical simulation in the framework of the DIOGENeS software tool. This mandatory step will then allow the candidate to get into and correctly use this software tool. To put this into practice, several direct simulations of settings related to the project will be carried out. Finally, the candidate will get into sensitivity analysis technique from the perspective of robust optimizations (see *e.g.* [1], [2]), and study some specific GPR configurations.

Compétences

Technical skills and level required :

- Master or engineering degree in numerical mathematics or scientific computing
- Sound knowledge of numerical analysis for PDEs
- Basic knowledge of physiscs of electromagnetic wave propagation

Software development skills : Python and Fortran 2003

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)

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 :** 2024-03-01
- **Durée de contrat :** 6 mois
- **Date limite pour postuler :** 2024-12-31

Contacts

- **Équipe Inria :** ATLANTIS
- **Recruteur :**
  Lanteri Stéphane / Stephane.Lanteri@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.