Offer #2023-06440

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

Contract type : Fixed-term contract

Level of qualifications required : PhD or equivalent

Fonction : Post-Doctoral Research Visit

Level of experience : From 3 to 5 years

About the research centre or Inria department

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.

Context

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.

Assignment

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.

Main activities

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.

Skills

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

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 (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

Remuneration

Gross Salary: 2746 € per month

General Information

- **Theme/Domain :** Numerical schemes and simulations
  Scientific computing (BAP E)

- **Town/city :** Sophia Antipolis
- **Inria Center :** Centre Inria d'Université Côte d'Azur
- **Starting date :** 2023-11-01
- **Duration of contract :** 2 years
- **Deadline to apply :** 2024-07-31

Contacts

- **Inria Team :** ATLANTIS
- **Recruiter :**
  Elsawy Mahmoud / mahmoud.elsawy@inria.fr

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.