
Contract type: Public service fixed-term contract
Renewable contract: Oui
Level of qualifications required: PhD or equivalent
Fonction: Post-Doctoral Research Visit

About the research centre or Inria department

The Inria Sophia Antipolis - Méditerranée center counts 37 research teams and 9 support departments. The center's staff (about 600 people including 400 Inria employees) is composed of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrators. 1/3 of the staff are civil servants, the others are contractual. The majority of the research teams at the center are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Six teams are based in Montpellier and a team is hosted by the computer science department of the University of Bologna in Italy. The Center is a member of the University and Institution Community (ComUE) "Université Côte d'Azur (UCA)".

Context

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-Méditerrané 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) 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

Conventional optical components such as lenses, waveplates 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 and/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 mould 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 advancements in nanofabrication and characterization techniques, require to revisit the traditional electromagnetic design paradigm. Specific and rigorous strategies for the design of nanostructures are not yet fully established. The geometries that have been studied and designed so far require additional refinements by a fullwave electromagnetic simulation, carried out by sweeping
the relevant geometrical parameters through a given range. This time-consuming design process exacerbates the delay between proof of concept plasmonic 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 large search spaces easily accessible, where 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 objective of the present study will be to develop a methodology for the rigorous inverse design of nanostructured devices, aiming at the maximization of an assigned objective function in a continuous parameter space. In order to do so, we will couple efficient global optimization strategies [5] with a high order full wave time-domain Maxwell solver for the optimal design of 3D nanophotonic devices [6]. The later is part of the DIOGENeS software suite, which is developed by the Nachos project-team. Moreover, this study will be conducted in close collaboration with the Acumes project-team (Régis Duvigneau) for the aspects that are related to the optimization topic. In the recent years, this team has developed an expertise in shape optimization procedures, based on various geometrical parametrization (surface-based or volume-based) and optimization algorithms, ranging from descent methods which necessitate sensitivity analysis to black-box algorithms, like evolution strategies and response surface methodologies, implemented in the Famosa software toolbox.


Main activities

For what concern the development of the innovative optimal design methodology at the heart of this postdoctoral project, the following topics will be addressed:

1. Simulation of metasurfaces. A parallel high order DGTD solver of the system of 3D time-domain Maxwell equations coupled to a generalized model for taking into account the dispersion of metallic nanostructures at optical frequencies [6], which is built on top of the core library of the DIOGENeS software suite, will be adapted to cope with the specific modeling features relevant to metasurfaces.

2. Problem parametrization. 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). The selected parametrization strategies will be implemented in new modules that will be integrated in the DIOGENeS software suite afterwards.

3. Optimization strategies. We will investigate several optimization strategies available in the Famosa library, with an emphasis on an efficient global optimization technique based on a surrogate model [5].

Equally important to this project will be the successful application of the resulting methodology to the inverse design of metasurfaces that are studied and designed by the research group of Patrice Genevet at CRHEA. This postdoctoral project will thus also involve activities related to the evaluation and demonstration of the above-mentioned core topics to the numerical treatment of metasurface configurations of interest to our partners at CRHEA.

Skills

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.

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

**Benefits package**

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

**General Information**

- **Theme/Domain:** Numerical schemes and simulations
  Scientific computing (BAP E)
- **Town/city:** Sophia Antipolis
- **Inria Center:** CRI Sophia Antipolis - Méditerranée
- **Starting date:** 11/1/18
- **Duration of contract:** 1 year, 4 months
- **Deadline to apply:** 3/25/18

**Contacts**

- **Inria Team:** NACHOS
- **Recruiter:**
  Lanteri Stephane / stephane.lanteri@inria.fr

**Conditions for application**

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

Before to apply, and preferably before march 20, it is strongly recommended to contact the scientific in charge of this offer.

**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.

**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.