# Offer #2025-08639

# Internship : Deep Neural Networks for the design of nanophotonic devices

**Contract type :** Internship agreement

**Level of qualifications required :** Graduate degree or equivalent

**Other valued qualifications :** Master in applied mathematics or scientific computing

**Fonction :** Internship Research

## 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 di?erent 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

Nanophotonics is the science that studies the interactions between light and matter at the nanoscale. Light is an electromagnetic wave whose wavelength is in the

visible spectrum, i.e., between approximately 400 nm to 800 nm. In this context, one refers to as sub-wavelength structuring of matter. The structuring of matter at these scales allows these interactions to be shaped for a variety of technological and societal applications. Numerical modeling is extensively used for understanding the physical phenomena underlying light-matter interactions, but also for tailoring or harnessing these interactions guided by specific performance objectives. The first objective requires to numerically solve the system of time-domain or frequency-domain Maxwell equations coupled to differential equations modeling the behavior of propagation media at optical frequencies while the seond goal is addressed by leveraghing a numerical optimization algorithm in the framework of an inverse design workflow. For both objectives, the Atlantis team from the Inria Center at Université Côte d'Azur is developing the DIOGENeS [https://diogenes.inria.fr/] software suite, which is dedicated to the numerical study of multiscale problems relevant tonanophotonics and nanoplasmonics. DIOGENeS implements several Discontinuous Galerkin (DG) type methods for which the team has developed a long-term expertise **[1-3]**. It also includes a includes an inverse design component, which relies on statistical learning-based global optimization methods for single-objectove, multi-objevctive and robust optimization **[4-6]**. Beside the above-mentioned high-fidelity DG-based electromagnetic solvers, since 2022 the team is also actively studying alternative modeling and design approaches leveraging Deep Neural Networks (DNNs) **[7]**.

**[1]** J. Viquerat. *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.

**[2]** S. Lanteri, C. Scheid and J. Viquerat. *Analysis of a generalized dispersive model coupled to a DGTD method with application to nanophotonics*. SIAM J. Sci. Comp., Vol. 39, No. 3, pp. A831–A859 (2017)

**[3]** E. Agullo, L. Giraud, A. Gobé, M. Kuhn, S. Lanteri and L. Moya. *High order HDG method and domain decomposition solvers for frequency?domain electromagnetics*. Int. J. Numer. Model. Electr. Netw. Dev. Fields, Vol. 33, No. 2 (2019)

**[4]** M.M.R. Elsawy, S. Lanteri, R. Duvigneau, G. Brière, M.S. Mohamed and P. Genevet. *Global optimization of metasurface designs using statistical learning methods.* Scientific Reports, Vol. 9, No. 17918 (2019)

**[5]** M.M.R. Elsawy, A. Gourdin, M. Binois, R. Duvigneau, D. Felbacq, S. Khadir, P. Genevet and S. Lanteri. *Multiobjective statistical learning optimization of RGB metalens*. ACS Photonics, Vol. 8, No. 8, pp. 2498–2508 (2021)

**[6]** M.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)

**[7]** A. Clini de Souza, S. Lanteri, H.E. Hernandez-Figueroa, M. Abbarchi, D. Grosso, B. Kerzabi and M. Elsawy. *Back-propagation optimization and multi-valued artificial neural networks for highly vivid structural color filter metasurfaces*. Scientific Reports, Vol. 13, No. 1, pp. 21352 (2023)

# Assignment

This internship project is expected to be a first step toward a PhD project that will be concerned with the development of novel DNN-based approaches for the design of complex nanophotonic devices such as metasurfaces. The objective of the internship will be to propose, develop and assess different building block approaches relying on DNNs for designing a nanophotonic device. For this, the following steps will be considered: (1) Review of state-of-the art approaches in the bibliography on AI-based modeling for nanophotonics; (2) Formulation and coding of a few selected approaches; (3) Critical assessment and proposition of research directions for methods beyond the state-of-the art and taking into account the modeling challenges of complex nanophotonic devices; (4) Synthesis end publication of results.

# Skills

Technical skills and level required :

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

Software development skills : Python and PyTorch

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

Other valued appreciated : good level of spoken and written english

# 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 :** 2025-04-01
- **Duration of contract :** 6 months
- **Deadline to apply :** 2025-12-31

# Contacts

- **Inria Team :** ATLANTIS
- **Recruiter :**
  Lanteri Stéphane / Stephane.Lanteri@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.