2019-015111 - PhD Position F/M [CORDIS2019-NACHOS] Multiscale finite element simulations applied to the design of photovoltaic cells

Type de contrat : CDD de la fonction publique  
Niveau de diplôme exigé : Bac + 5 ou équivalent  
Fonction : Doctorant

A propos du centre ou de la direction fonctionnelle

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)”.

Contexte et atouts du poste

This Ph.D. position is offered within the Nachos project-team (http://www-sop.inria.fr/nachos) at the Inria Sophia Antipolis-Méditerranée research center. The team specializes in the development of novel numerical schemes for the simulation of electromagnetic wave propagation in nanostructured materials.

The development of efficient solar cells is an attractive topic. Indeed, photovoltaic cells can produce clean and sustainable energy by harvesting sunlight. Photovoltaic cells are currently produced using polycrystalline silicon, and their efficiency is limited, due to undesirable light reflections. Recently, the idea of employing nanostructured thin-films has emerged. The use of nanostructuring permits to control the propagation of light, and improve the absorption properties of the manufactured cells, by precisely trapping sunlight. Thus, there is a potential to largely improve the efficiency of solar panels, and serious investigations are currently guided toward this goal.

Designing and optimizing the nanostructuring arrangement of a photovoltaic cell is a complex task, for which numerical simulations can be extremely insightful. Nevertheless, simulating the propagation of light into a nanostructured material accurately is a difficult matter. Indeed the problem exhibits different spatial scales (in particular, the size of the cell, the wavelength and the nanostructuring size), that may differ by orders of magnitude. As a result, the applicability of standard finite element tools is limited, since resolving the nanostructure usually leads to an unaffordable number of degrees of freedom.

The Nachos project-team started a collaboration with Frédéric Valentin (Senior researcher at LNCC) a few years ago, whose goal is to develop efficient simulation tools for multiscale wave propagation problems. Specifically, a novel family of numerical schemes, called Multiscale Hybrid-Mixed (MHM) methods, has been considered. The key idea is these multiscale techniques is to embed fine-scale information onto a coarser mesh. In contrast to standard finite element methods that utilize simple polynomial shape functions, the MHM method employs multiscale shape functions, that are defined through local boundary value problems. These techniques lead to a two-level strategy that can be efficiently parallelized on modern computer architectures.

We have obtained preliminary results for MHM discretizations of two-dimensional seismic wave propagation problems that are very promising. Building on these results, the objective of this Ph.D. are to develop, analyze and benchmark a MHM method to simulate the propagation of light into nanostructured photovoltaic cells.

Mission confiée

The Ph.D. student will collaborate with Théophile Chaumont-Frelet, Stéphane Lanteri and Frédéric Valentin. His first assignment will be to assimilate the key ideas of the MHM framework, by studying previously published works. He will also perform a general bibliographic study to become more familiar with existing discretization techniques for wave propagation in heterogeneous media.

The candidate will then study wave propagation problems linked with nanostructured photovoltaic cells in a simplified two-dimensional settings. In this case, the problem can be modeled with the Helmholtz equation. Although a MHM simulation tool is already available for this setting, the Ph.D. student will study some novelties that are specific to photovoltaic problems. In particular, quasi-periodic boundary conditions, and local dispersion models leading sign-shifting coefficients will be considered. These features are rather unusual and are therefore not completely analyzed in the mathematical literature yet. As a result, the Ph.D. student will propose both a mathematical analysis and numerical benchmarks in order to investigate the robustness of the discretization schemes with respect to these aspects.

After this thorough investigation of the two-dimensional case, the Ph.D. student will turn his attention to the three-dimensional cases. He will consider three-dimensional Maxwell’s equations, and propose a novel MHM formulation in close collaboration with his supervisors. Once a convenient formulation is carefully established, the Ph.D. student will utilize the DIOGENE software platform (https://diogenes.inria.fr) developed within the team to implement the method, and perform a validation through a sequence of simple test cases. Finally, he may undertake more prospective projects which include the evaluation of the method's efficiency in realistic photovoltaic cell examples, as well as the convergence analysis of the proposed numerical scheme.

Relevant bibliographic items include:

- A.S. Bonnet-Ben Dhia and L. Chesnel and P. Ciarlet Jr., T-coercivity for scalar interface problems between dielectrics and
Principales activités
- Mathematical analysis of wave propagation problems
- Numerical analysis of multiscale and finite element schemes
- Implementation in the DIOGENeS software suite (Fortran 2008)
- Testing and validation
- Publication of main results and communication in conferences

Compétences
The applicant is expected to have preliminary knowledge and experience in
- PDE analysis, ideally in link with wave propagation problems,
- Numerical analysis,
- Discretization methods, ideally high order finite element and discontinuous Galerkin methods,
- Programming languages, ideally Fortran.

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
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Rémunération
Duration: 36 months
Location: Sophia Antipolis, France
Gross Salary per month: 1982€ brut per month (year 1 & 2) and 2085€ brut/month (year 3)

Informations générales
- Thème/Domaine : Schémas et simulations numériques
- Calcul Scientifique (BAP E)
- Ville : Sophia Antipolis
- Centre Inria : CRI Sophia Antipolis - Méditerranée
- Date de prise de fonction souhaitée : 2019-11-01
- Durée de contrat : 3 ans
- Date limite pour postuler : 2019-05-05

Contacts
- Equipe Inria : NACHOS
- Directeur de thèse :
  Chaumont Frelet Théophile / theophile.chaumont@inria.fr

A propos d'Inria
Inria, l'institut national de recherche dédié aux sciences du numérique, promeut l'excellence scientifique et le transfert pour avoir le plus grand impact. Il emploie 2400 personnes. Ses 200 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3000 scientifiques pour relever les défis des sciences informatiques et mathématiques, souvent à l'interface d'autres disciplines. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 160 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.

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.
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.