Equation is highly anisotropic, this approach needs to develop reliable and vanishing current density outside the last closed flux line. Therefore, apply to the whole plasma domain the present one that uses a 1D description, it avoids the use of flux coordinate mesh that is used for the equilibrium step. Although this approach is more costly than and use instead a 2D description of the transport in the physical domain on the same time step. This system reveals extremely difficult to solve and in particular requires at each step. This leads to an highly non-standard set of equations where the 2D dependent variables are obtained by averaging. The physics of the plasma in a tokamak is extremely complex and its understanding requires a strong interaction between experiments, modeling, and large scale numerical simulations. This concept is studied in experimental devices called Tokamaks (A russian acronym for toroidal chamber). One of these machines called ITER (for International Thermonuclear Experimental Reactor : https://www.iter.org/fr/org/io) is currently being build in Cadarache (France) thanks to an international agreement involving 35 different countries. The physics of the plasma and its convection-diffusion equations for the plasma density and temperature and poloidal flux (transport step) while the momentum equation reduces to an equilibrium between the plasma pressure and the magnetic forces (equilibrium step). The coupling between equilibrium and transport is today address by coupling the 2D convection-diffusion equations for the plasma density and temperature and poloidal flux with the 1D convection-diffusion equations for the plasma pressure and the magnetic forces.

In the proposed work we propose to abandon the 1D description of the transport step and use instead a 2D description of the transport in the physical domain on the same mesh that is used for the equilibrium step. Although this approach is more costly than the present one that uses a 1D description, it avoids the use of flux coordinates and therefore apply to the whole plasma domain relaxing the unrealistic assumption of vanishing current density outside the last closed flux line. However as the convection-diffusion equation is highly anisotropic, this approach needs to develop reliable and efficient discretization of this type of PDE. For this, it is proposed to extend some recent results on Asymptotic Preserving discretizations. Moreover, it will be necessary to show that this approach is able to recover the results of the the 2D-1D coupling approach when this one is successful.

### General Information
- **Theme/Domain**: Earth, Environmental and Energy Sciences, Scientific computing (BAP E)
- **Town/city**: Sophia Antipolis
- **Inria Center**: CRI Sophia Antipolis - Méditerranée
- **Starting date**: 2018-11-01
- **Duration of contract**: 1 year, 8 months
- **Deadline to apply**: 2018-05-27

### Contacts
- **Inria Team**: CASTOR
- **Recruiter**: Guillard Herve / herve.guillard@inria.fr

### Conditions for application
- 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.

### Description of the post-doctoral work
In a tokamak at the slow resistive time scale, the magneto-hydrodynamics equations (MHD) is composed of a set of unsteady convection-diffusion equations for the plasma density and temperature and poloidal flux (transport step) while the momentum equation reduces to an equilibrium between the plasma pressure and the magnetic forces (equilibrium step). The coupling between equilibrium and transport is today address by coupling the 2D equilibrium step with the 1D convection-diffusion equations obtained by averaging the variables along the magnetic flux lines. This leads to an highly non-standard set of partial differential equations where the 2D dependent variables of the equilibrium step (here the magnetic poloidal flux) becomes the independent variable of the 1D step. This system reveals extremely difficult to solve and in particular requires at each time step iterations between the two systems to ensure his consistency and avoids numerical instabilities. In the proposed work we propose to abandon the 1D description of the transport step and use instead a 2D description of the transport in the physical domain on the same mesh that is used for the equilibrium step. Although this approach is more costly than the present one that uses a 1D description, it avoids the use of flux coordinates and therefore apply to the whole plasma domain relaxing the unrealistic assumption of vanishing current density outside the last closed flux line. However as the convection-diffusion equation is highly anisotropic, this approach needs to develop reliable and efficient discretization of this type of PDE. For this, it is proposed to extend some recent results on Asymptotic Preserving discretizations. Moreover, it will be necessary to show that this approach is able to recover the results of the the 2D-1D coupling approach when this one is successful.
Main activities
Develop a mathematical model describing coupling between Equilibrium and transport in a tokamak.
Develop a consistent discretization for this model.
Participation to Conference and Workshop.
Integrate the developed code into larger software platforms written in C++, Fortran, Python or MATLAB.

Skills
Knowledge in Computational Fluid dynamics and/or Plasma physics
Good programming skills in Python/Fortran/C or C++

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

Remuneration
Gross Salary: 2650 brutto per month