CEA/CADARACHE
DIRECTION DES SCIENCES DE LA MATIÈRE (DSM)
INSTITUT DE RECHERCHE SUR LA FUSION PAR CONFINEMENT MAGNETIQUE (IRFM)
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PhD PROPOSAL 2011

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Title :
Fluid reduction underlying the kinetic evolution of plasma turbulence in ITER

Summary :

In ITER plasmas the effect of collisions on the particle dynamics are particularly tenuous. In particular one finds that the collisional mean free path exceeds significantly the scale of the device. This severely limits the applicability and relevance of the concept of “fluid particle”. The kinetic description of plasmas is based on investigating the dynamics of a class of particles defined both in terms of their position in space but also in terms of their velocity. This description in terms of the distribution functions in the appropriate one for plasma physics. The distribution functions are then solutions of the Vlasov equation completed by a collisional term, leading one to the so-called Landau equation. The time develop solutions then develop as characteristics that minimise the functional describing the evolution of “free” particles, that are only subject to the electromagnetic fields as well as characteristics that minimise the collisional functional. Although, the collisional functional is expected to have a small weight in this process, numerical simulations of plasma turbulence suggest that the distribution function remains close to a Maxwellian, therefore compatible with a fluid description.

The goal of the PhD work is to analyse the evolution of the plasma and sort out the aspects that are relevant to fluid dynamics, structuring the distribution function in the vicinity of a Maxwellian distribution, from those aspects that are specific to the kinetic properties, invariant conservation in particular. This analytic approach will be completed by numerical simulations with the GYSELA code, especially to measure the departure from the fluid dynamics. The output of this work should be find means to describe and evaluate the kinetic effects in the turbulent evolution, and, on the one hand, on the other hand, to investigate the possibility of splitting, with an appropriate reduction, the fluid-like and kinetic contributions. This could allow one to optimise the use of computer resources and eventually to revisit the issue of fluid closure. Numerical simulation will be performed with the GYSELA kinetic code and the SOLEDGE-3D fluid code being presently developed. The research activity will be performed within an internationally known team working on the theory of fusion plasmas.

Skills: master degree in physics, motivation to address statistical physics and numerical simulations, knowledge in plasma physics will be welcomed but is not mandatory.
Master degree: physics and/or numerical simulations