CEA/CADARACHE
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INSTITUT DE RECHERCHE SUR LA FUSION PAR CONFINEMENT MAGNETIQUE (IRFM)
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PhD PROPOSAL 2011

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Title :
Non-local turbulent transport in ITER plasmas

Summary :

Turbulent transport in fusion plasmas is a key issue regarding ITER design as well as the ultimate performance to be achieved. Regarding thermodynamics two means to drive the system out of equilibrium are considered, on the one hand one can impose particle and/or heat fluxes and analyse the response of turbulent transport in terms of the average thermodynamical force, for instance the temperature gradient, and on the other hand one can consider the system as bridging two thermal baths. The latter then defines the average thermodynamical force across the system, the transport flux characterising the turbulent response. It is to be stressed that this mean force is usually stratified, the driving force condensing in the boundary layers. A third way to set the system out of equilibrium has been devised to ensure a constant thermodynamical force throughout the system. Although clearly unrealistic from the experimental point of view, the latter paradigm in routinely considered when addressing turbulent transport in fusion plasmas. As a consequence, and unsurprisingly, the turbulent transport is then readily described in terms of a local diffusion. To address the more realistic flux-driven physics requires that one considers a global approach. Our team is a leading one in the physics of flux driven systems. We have shown that the system is then characterised by intermittency, transport activity in bursts, with long ranges propagation of coherent turbulent structures. The strongly non-local evidence, with properties that are reminiscent of self-organised criticality, is then difficult to reconcile with a local diffusive transport.

The aim of this PhD work is to analyse the dynamics and the impact of non-local features of turbulence in the global properties of transport. The analytical work will take advantage of the existent of quasi-invariants and their impact on large scale flows and on the non-linear selection rule of the dominant structures. A key parameter in this analysis will be the extent of the system along the direction of the thermodynamical force and the effect of the boundary layers. This approach will be completed with numerical simulations using the GYSELA gyrokinetic code as well as a fluid toy model. 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