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INSTITUT DE RECHERCHE SUR LA FUSION PAR CONFINEMENT MAGNETIQUE (IRFM)
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PhD PROPOSAL 2017

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Title : High confinement mode transition in WEST, impact of the magnetic configuration

Topic description:

In a magnetic fusion reactor, the confinement relates the pressure reached in the plasma medium (on which fusion power depends) to the amount of additional heating power needed to reach and maintain this pressure. Physically, this is set by transport processes building up in the plasma against magnetic confinement. Primarily, turbulent instabilities are responsible for these losses, as in many hydrodynamic systems forced out of thermodynamical equilibrium. The peculiarity of magnetically confined hot plasmas is the onset, in certain conditions (additional power, density …), of a sudden stabilization of turbulence in stratified plasma layers, called transport barrier, robustly located at the edge of the confined plasma region. This local transition, known as *low to high confinement mode transition (L-H transition)*, leads to an impressive boost in the global performance of fusion plasma. The generally accepted idea is that flows can develop along stratified plasma layers of the confined magnetic topology, with a sufficient gradient across the stratification to deform and stabilize turbulent eddies. After the bifurcation takes place, large pressure gradients set across the transport barrier, which in turns induce flows of large amplitude to fulfill local force balance. Therefore the transport barrier is often considered as a self-organized state of reduced turbulence. However, this statement alone does not explain (1) the bifurcation itself, (2) the position and width of bifurcation, in contact with the interface between closed and open magnetic topology, (3) the parametric dependence of the bifurcation conditions: power, plasma density, magnetic field strength, global topology. In facts, the large experience gained worldwide has yet not permitted to make acceptable predictions for the conditions of transition in future reactors. The principal reason is that key physical mechanisms at tasks in the transition are still debated.

Project description:

The innovative axis of research envisaged for this PhD project aims investigating, *in experiments*, interactions of the stratified layers of interest with the surrounding plasma environment. Systematically, any model of transition fails to recover a transition when these couplings are absent. To be more specific, the project shall address three distinct coupling mechanisms: (i) transition between collisional regimes in closed magnetic topology, resulting in transitions in the force balance across the stratification, (ii) non-linear generation of zonal flows by turbulence and the back reaction on the turbulence intensity, (iii) the specific charge balance in the open magnetic topology, driving torques through the interface with the closed magnetic topology. These mechanisms and there interplay are expected, based on recent theoretical models, to refine the main parametric dependence of the transition observed in several devices. The main experimental activity will take place on the WEST tokamak device, which possesses unique geometrical parameters involved in this parametric dependence. Experiments on other international devices will also be encouraged through existing collaborations. In practice, the PhD project will focus on the experimental characterization of flows and turbulent density fluctuations in the edge stratified plasma layers. The main diagnostic will be a state of the art radar system, known as Doppler reflectometry, allowing simultaneous measurements of flows (equilibrium and turbulence generated) and of the turbulence properties. Additionally, a system of electrostatic probes will permit to characterize the properties of the open magnetic topology.

Experiments on large research instruments will be designed, conducted and analyzed, in synergy with theoretical and numerical projects made in parallel. The work shall be synthesized in papers published in top rank journals, and exposed in international conferences