priority topic

CEA/CADARACHE
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PhD PROPOSAL 2013

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Title : The impact of MHD instabilities on the transport of impurity and energetic particles in tokamak plasmas

Summary :
Tokamaks are subject to relaxation oscillations, called sawteeth, which lead to a reorganization of the magnetic field in the core plasma. Each crash is associated with a flattening of the density and temperature profiles, i.e. to a transient loss of confinement. Sawtooth crashes may play a detrimental role by favoring an inward penetration of heavy impurities and a premature outward loss of alpha particles produced by fusion reactions.

This issue is of particular interest in view of ITER operation, whose divertor plates will be made of Tungsten. Recent experiments on JET in a configuration close to ITER show that Tungsten sometimes accumulates in the plasma core, leading to enhanced core radiation. Tungsten concentration is the control parameter, which results from a balance between inward penetration and exhaust during sawtooth crashes, and also on turbulent and collisional transport. Also the MHD activity is modified when Tungsten accumulates in the core. This dynamics is not well understood and is the subject of this PhD thesis. The goal is to understand the impact of sawteeth on Tungsten penetration and the consequences on the MHD activity itself. Models will be validated on present devices and it is planned to predict the impurity behavior in future equipments such as WEST (upgrade of the Tore Supra tokamak with a tungsten divertor), and ITER. In a second step this work will be extended to investigate the impact of sawteeth on alpha particle confinement.

The main simulation tool will be the XTOR code, which allows simulating MagnetoHydroDynamic (MHD) instabilities responsible for sawteeth activity in nonlinear regime. For energetic particles, a “hybrid” version will be used, which computes the evolution of energetic ions coupled to MHD equations. It is planned to develop synthetic diagnostics, in order to compare the code results with measurements (UV and soft X rays) available on the TORE SUPRA, ASDEX-Upgrade and JET tokamaks. In a second step the feedback of impurities on MHD stability will be investigated by taking into account modifications of the resistivity and radiative losses in the heat equation.

This study will be led in collaboration with the Centre de Physique Théorique at the Ecole Polytechnique, where the XTOR code is developed. Stays at ASDEX-Upgrade (Garching, Germany) and/or JET (Culham UK) will also be organized in order to interact with experimentalists on site, gather data and participate to experiments.

Skills : Master level in plasma physics. Skills in numeric, signal analysis , theory and modeling are desirable.