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PhD PROPOSAL 2017

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Title : Impurity transport by Magneto-Hydro-Dynamic instabilities, and its control

Topic description: Tokamaks are subject to Magneto-Hydro-Dynamics (MHD) instabilities leading to a reorganization of the magnetic field in the plasma. Each event is associated with a flattening of the density and temperature profiles, i.e. to a transient loss of confinement, and also affects the distribution of impurities, either leading to an expulsion or to a penetration. This effect of MHD adds to a background transport led by a broad spectrum turbulent activity. These issues are of particular interest in view of the operation of ITER, the international project for fusion energy that is being built close to the CEA center, since Plasma Facing Components will emit Tungsten and Beryllium impurities that need to be confined at the plasma periphery, while alpha particles produced by fusion reactions in the plasma core should be transported to the edge.

Among the MHD instabilities that are of particular interest, because they have a recognized effect on the impurity accumulation in the plasma core, we will focus on the tearing instability, characterized by the formation of island structure that is observed to accelerate greatly the impurity penetration. The tearing instability can be controlled by active means, namely the injection of a localized heat or current source. The subject of the PhD is to understand how impurities are transported during the MHD event, and how MHD control affects their distribution over the plasma. Indeed, while the control has a beneficial effect on the confinement in the first place, it could facilitate the impurity accumulation and lead to a confinement loss on a longer term.

The main simulation tool will be the XTOR code, which allows simulating MHD instabilities in the nonlinear regime. Simulations will be compared to observations on WEST (WEST is an upgrade of the CEA tokamak that will resume operation in 2017), as well as ASDEX-Upgrade or JET tokamaks. These three devices have metallic walls (as in ITER), and ASDEX-Upgrade is equipped with a localized heat and current source for the control of tearing modes.

This study will be led in collaboration with the Centre de Physique Théorique at the Ecole Polytechnique, where the XTOR code is developed, and will benefit from the support of the Eurofusion Consortium for the participation to experimental campaigns on JET and/or ASDEX-Upgrade.