priority topic

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 2014

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Title : Magnetohydrodynamics and kinetic modeling of tokamak disruptions and of their mitigation by massive gas injection

Summary : Plasma discharges in nuclear fusion research facilities, in particular tokamaks, may be interrupted by the appearance of macroscopic instabilities leading to a fast loss of the plasma called a “disruption”. These events generate heat flux spikes on the tokamak inner wall as well as large electromagnetic forces on the structure, and can furthermore create high energy electrons, called “runaways”, which may severely damage the wall. In ITER, disruptions may strongly hinder the operation, hence the need for a disruption mitigation system. The development of this system is a very active research topic, both experimentally and theoretically. The main envisaged technique consists in massively injecting gas into the plasma when a disruption is predicted, which triggers a milder disruption.

The present PhD proposal aims at understanding the physical ingredients at play in disruptions and their mitigation by massive gas injection (MGI), in particular :
-the dynamics of magnetohydrodynamics (MHD) instabilities at the heart of disruptions
-the interaction between the injected gas and the hot plasma, in particular atomic processes at the gas/plasma interface as well as the processes governing gas transport inside the plasma
-the physics of runaway electrons, which necessitates a kinetic and relativistic treatment.

Work is ongoing at IRFM in order to reproduce a disruption mitigated by MGI using the non-linear 3D MHD code JOREK. Simulations performed to this date show the destabilization of MHD activity by MGI, but to a much lower degree than observed experimentally. The simplified MGI model used in these simulations is a suspected cause for this behavior and a study with a 1D fluid code is being performed to test the relevance of this model. Depending on the outcome, one may have to implement in JOREK a more complex MGI model. Runaway electron physics is also being studied at IRFM using a kinetic relativistic model, but the important question of the interaction between MHD and runaway electrons, which constitutes an almost unexplored field of research, has not been attacked yet. A theoretical and numerical work is foreseen in order to develop hybrid MHD-kinetic tools allowing to study this physics.

Work will therefore be centered on a theory and modeling activity but we will seek to validate our models on experimental data on present day machines (Tore Supra, JET, ASDEX-U, etc.), which may imply participation in experimental campaigns.

Skills : General physics, plasma physics, scientific computing