M2 Internship / Stage de M2

Contribution to the physics modeling of shattered pellet injections in magnetic fusion devices

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Research type: Theory/Numerical Modeling/Comparison with Experimental data

Subject description: One of the most critical issues for future burning plasma experiments and reactors based on the tokamak concept such as ITER is the eventual occurrence of disruptions which are sudden losses of plasma confinement known as thermal and current quenches, generating high heat and particle fluxes on the plasma facing components (PFCs). The damage these events can cause for the vessel parts they strike in even more problematic for large high plasma current which is the case for ITER. Obviously, the best way to prevent such possible damages is to avoid disruptions. However, as it is not possible to guarantee 100% disruption-free operations, it is crucial to develop disruption mitigation techniques which can be used as a last resort for device protection. Currently, the most promising techniques are based on massive injection of particles with the massive gas injection MGI being one of the first ones. However, the MGI technique whose efficiency has been proven to be very good on present tokamaks, will not be efficient in large devices like ITER. A new similar technique, known as SPI for Shattered Pellet Injection has been recently tested with success on DIII-D. This technique has been adopted on JET and is seriously considered for ITER by ITER organization as can be attested by the increasing focus of the disruption mitigation system task force on the SPI technique activities like modeling and code validation.

This M2 proposal is aimed to accompany this dynamics through the contribution to the modeling and code validation of the process of disruption mitigation by SPI. The work will be focused on the modeling of the ablation/deposition model of shattered pellets. Depending on the availability of experimental data, the developed models will be valided through comparison with experimental data from present tokamaks. For this topics, many issues still need to be answered and solved. The size distribution of the pellet shards is not well known and it is furthermore suspected that pellets shards are mixed with gas. On the level of an individual pellet shard, the appropriate model for material deposition remains to be developed starting for instance from the well-known Neutral Gas Shielding (NGS) model [1], developed to simulate “killer pellets” [2]. A third issue concerns the modeling of the disruption mitigation itself.

Indeed, the 3D non-linear MHD codes like NIMROD [3] and JOREK [4] which have been developed for MGI should be modified and adapted to SPI. For the code validation task, several experimental data can be used. The most promising techniques that can be used for the characterization of the injection itself and the evolution of the plasma are based on spectroscopic analysis of the light emitted by the pellet shards during their ablation by the plasma and the plasma emission. The technique based on Stark broadening analysis of the ablation cloud radiation emission of single pellets [5] may be extended to pellet shards in order to determine the ablation rate and the local density and temperature of the plasmoid surrounding the stream of the pellet shards.

The M2 internship duration does not allow to seriously tackle all these issues and therefore they are proposed for a PhD thesis in the framework of the doctoral school.

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2. Gal K *et al*, Plasma Phys. Control. Fusion **50** (2008) 055006
3. Izzo V A and Parks P B, Nucl. Fusion **50** (2010) 058001
4. Nardon E et al, Plasma Phys. Control. Fusion **59** (0217) 014006
5. M. Goto, S. Morita, M. Koubiti, J. Phys. B.: At. Mol. Opt. Phys. **43** (2010) 144023