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Modeling and Simulation of Pedestal Control Techniques for NSTX-U

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In this paper we present high level simulations and modeling of pedestal control for NSTX-U. Real-time pedestal control is a crucial topic for future fusion reactors and ITER where pedestal has to be kept Edge-Localized-Modes (or ELMs) free. We developed and tested many different control schemes to adjust and regulate the pedestal at DIII-D and we plan to test them on NSTX-U. But to do this it is important to understand the physics bases for how the control actuators affect the pedestal. It has been observed many times that a control scheme that work for a specific machine or a regime might not be applicable to other machines and regimes. This is especially the case for future reactors such as ITER.

We thus do high-level numerical simulations with the M3D-C1 code. M3D-C1 has been developed to study the plasma response when several actuators are triggered (gas puffing, 3D magnetic perturbations and LGI). The aim is to combine all these methods to get an adaptive and automatic pedestal control in tokamaks.

In this paper, we focus on the effect of each actuators on the ELM frequency and amplitude. First modeling results of ELM-triggering by LGI have been obtained with M3D-C1. Mesh adaptation techniques and high order 3D finite elements allow simulation of sub-mm granules, without constraints on the granule toroidal width. This unique capability of M3D-C1 allows the simulation of realistic pellet sizes. For this study, two models for LGI are implemented in M3D-C1. The first one is a Neutral Gas Shielding Model (NGS) calibrated on DIII-D experimental measurements of the Lithium granule ablation rates. The second one is valid for small size granules (sub-mm) where the contribution of plasma ions to the ablation of the granule is not negligible. In the simulation, it takes about 100 microseconds for the pellet to totally being ablated.

NSTX-U L-mode and H-mode simulations have been done and will be compared to available experimental data. Moreover, stability calculations from ELITE and M3D-C1 during the penetration process will be presented, as well as comparison with the EPED code.
Among the granule parameters, it is found that the most important are the type of element in the pellet, its size and the angle of attack.

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