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Pellet-plasma interaction studies at ASDEX Upgrade

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Pellets produced from cryogenic hydrogen isotopes are used for efficient plasma refueling. Beyond this "classical" application, pellets pacing the frequency of Edge Localized Modes (ELMs) turned out to be a suitable technique to mitigate the power load on plasma facing components. Although pellet pacing is already integrated in the toolkit for plasma control, its underlying physics is still poorly understood. For investigations aiming to resolve where and how an ELM is triggered by the pellet imposed local perturbation precise knowledge of the ablation profile is required. This renewed and even boosted the interest to understand the interaction of pellets with the hot ambient plasma. Both the investigation of the pellet ablation and also its impact on the target plasma were highlighted. Dedicated investigations require precise information both in the space and time domain. E. g. it is necessary to determine the localization of the pellet at the moment it triggers the ELM as well as the actual imposed 3D distribution of the pellet cloud and its mass deposition profile. By these means, a spatial distribution can be mapped out for a local perturbation of the plasma sufficient to release ELMs. High resolution ablation profile and pellet path measurements at different pellet parameters (mass and velocity) could also help to understand the mechanism of the ELM triggering.

Recently pellet-plasma interaction is intensively investigated both experimentally at ASDEX Upgrade tokamak and theoretically based on the obtained experimental data. To gain detailed information an observation system was developed at ASDEX Upgrade consisting of digital cameras that detect the pellet cloud distribution and photo diodes that measure the time evolution of the light emission. The great variety of possible combinations of different images, timings and wavelength selections makes the detection sophisticated. Combination of triggered fast camera images and photo diode signals also enables us to localize the pellet cloud at a certain time (e. g. at the onset of the triggered ELMs).

In order to facilitate scaling studies for the next generation of tokamaks, a database containing the decisive parameters of the pellet-plasma interaction was developed using the experimental results obtained at ASDEX Upgrade. Based upon this database a statistical multiple regression analysis is performed using the forward selection method to determine the penetration depth dependence on the main plasma and pellet parameters.

Pellet ablation and cloud distribution is simulated by using 1D-Lagrangian cell code which was extended recently by combining it with the simulation of a neutral gas shielding model. Both a simple analytical approximation and a more elaborated quasi 2D approach were developed and validated with the experimental data.

In this conference contribution the recent results of these investigations are presented with particular attention to the ELM triggering by pellets and pellet cloud dynamics and drift.