Dynamics of the edge barrier collapse in intrinsic and pellet triggered ELMs

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A promising solution to the type-I ELM power load problem in ITER is ELM pacing by pellets, as demonstrated on ASDEX Upgrade. Since extrapolation requires detailed knowledge about the basic physics involved, ELM onset and edge barrier collapse have been and are being investigated for pellet induced ELMs (in perturbative or full pacing mode) in comparison to spontaneous ones. Among the most important fast diagnostics employed are the toroidal and poloidal arrays of magnetic pick-up coils, reflectometry from the magnetic high (HFS) and low field side (LFS), ECE radiometry, and a set of D_α diodes in main chamber and divertor. Pellets were launched from the HFS using the centrifuge fuelling system with a wide range of pellet mass and velocity. In addition, a novel dedicated LFS pellet system is put into operation, which allows injection at different vertical positions and poloidal angles relative to flux surfaces.

In previous pellet fuelling and ELM pacing studies, we have found that oversized pellets cause bursts of ELMs with an atypically high energy and mass loss, and that even quasi-continuous injection of smaller pellets can affect plasma parameters and hence the intrinsic ELM characteristics mainly because of the associated fuelling flux. Therefore a series of complementary studies has been performed with sufficiently small pellets at injection rates small compared the intrinsic ELM rates. Such pellets were found to trigger ELMs almost identical to their intrinsic counterparts. Detailed investigations were performed comparing the ELM onset and the resulting barrier collapse as detected at various locations by different diagnostics for both ELM species.

For strong type-I ELMs in the (intrinsic) frequency range below 100 Hz the onset becomes visible on magnetic probes at any observed position within about $30\mu s$ and can be used as a time mark in the ELM evolution. Within less than $100\mu s$, variations of edge density and temperature are observed as well as the resulting pulse arrival at the divertor. In the case of HFS pellet triggered ELMs, a delay of about $70\mu s$ was found between the creation of the seed perturbation and the ELM onset seen on magnetic probes. This delay time may still be the sum of two components, the communication time from the local HFS pellet perturbation to the region where the ELM first appears, usually the LFS, and the ELM growth time to a detectable amplitude, limiting the time available for HFS-LFS communication. The HFS pellet induced ion sound wave arrives at the LFS mid plane after about $50\mu s$, while much faster communication is provided by shear Alfvén wave and fast electron transport along field lines. A final discrimination between these effects should be possible in near future, when results from the new LFS pellet system are available. One should notice that, since communication mostly happens along (sheared) magnetic field lines, the mapping between the injection point and the location of a specific diagnostic has to be taken into account, at least for the first toroidal revolutions of the perturbation front.