Pellet perturbations for probing threshold conditions and investigating onset dynamics of paced ELMs

P.T. Lang, L. Fattorini, L.D. Horton, A. Kallenbach, K. Lackner,
M. Maraschek, W. Suttrop, ASDEX Upgrade Team

e-mail address of presenting author: Lorne.Horton@ipp.mpg.de
Max-Planck-Institut für Plasmaphysik, EURATOM Association,
Boltzmannstr. 2, D-85748 Garching, Germany

Edge localised modes (ELMs) causing a cyclic collapse of the edge transport barrier are observed in many H-Mode scenarios. Energy bursts leaving the plasma during the collapse phase can form a severe threat for in-vessel components especially in large tokamaks. An important task with respect to ITER is therefore to gain insight in the underlying physics of ELMs in order to avoid them or at least to control their size. Injection of cryogenic solid pellets produced from hydrogen has the potential both to contribute to physics investigations and to act as a control tool. Pellet imposed perturbations can probe stability against ELM onset, by triggering ELMs their frequency and intensity can be controlled. ELM mitigation via pellet pacing was demonstrated at AUG and confirmed recently at the larger size of JET as useful tool. However, for an optimization of this tool - e.g. eliminating fuelling effects by minimizing the pellet mass - again better knowledge on ELM trigger conditions is necessary.

Here we present a compilation of available results thought useful to shed some light on ELM trigger conditions and thresholds. They cover pellet injection into JET type-I and ELM free phases. For AUG type-I triggered ELMs in different scenarios with low and high edge resistivity and type-III were analysed as well as pellets launched into QH phases. Dedicated experiments at AUG performing a pellet velocity scan in type-I discharges revealed the location of the trigger perturbation and the delay until ELM onset. To find out if the triggering of ELMs is typical or not for MHD events, an analysis of pellet released NTMs and snakes was performed as well.

First of all, any pellet analysed so far arriving in type-I or type-III phases was found to trigger an ELM, ELM-free phases were terminated by the triggered ELM. Also, in all cases a prompt ELM component is released which can be attributed to the localised 3D perturbation created just ($\sim 1-4\ cm$) inside the separatrix. Dedicated AUG investigations assessed a position close to the ETB pressure gradients steepest slope. The delay between perturbation and related type-I ELM onset is about $50\mu s$. For both the AUG and JET pellets designed for fuelling purposes an ablated mass fraction of only about 1% is sufficient for triggering. In AUG, ELM related MHD activity measured by pick-up coils propagates within about $20\mu s$ through the entire plasma edge. During the following phase of rapid mode growth the MHD activity raises to its maximum amplitude within about $50\mu s$ in type-I ELM plasmas with low edge resistivity. For the set of investigated experiments, a raising edge resistivity was achieved by creating a radiating edge shell or by edge cooling via gas puffing. For spontaneous ELMs this results in an increasing mode growth time to about $200\mu s$ when discharges drop into type-III regime. Triggered ELMs however maintained the features typical for low resistive type-I ELMs. This could indicate, together with the fact every pellet yet triggered, for an imposed perturbation creating an ELM seed structure far beyond stability boundaries hence facing large growth rates. Pellets injected during QH phases triggered a MHD signature alike the fast type-I onset phase but than vanishing without causing any significant energy expulsion from the plasma. Triggering of MHD events seems to be a quite common feature achievable by pellet injection. Once onset conditions are established, pellets can reliably trigger for example NTMs or snakes. However, in these cases the triggering cannot necessarily be attributed to the local prompt pellet perturbation.

At present, experimental investigations aiming on a mapping of ELM onset conditions with enhanced temporal and spatial resolutions are under way at AUG, employing a newly developed pellet launcher designed for this tasks. First results will be reported as well.

P2-07