Pellet-plasma interaction studies at ASDEX Upgrade

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**Mechanism of the ELM triggering.**

**Pellet path measurements at different pellet parameters**

- **Observation system**
  - The light emitted by the cloud surrounding the pellet was detected with both photodiodes and digital cameras. The photodiodes detect the time evolution of the light emission which is proportional to pellet ablation rate. The cameras detect the spatial distribution of the emission.

**Typical positions and times**

- **Experimental parameters**
  - **Target plasma:** Lower single null (LSN) plasma configuration 
  - Lower Single Null (LSN) plasma injection: B = 1 MA, B = 2.7 T, q95 = 4.9
  - **Type of ELM regime:** ELM frequency ωELM = 0.25 - 0.45 Hz
  - **Auxiliary heating power close above the L-H transition:** NBI = 5 MW, HIB = 1 - 2 MW
  - **Pellets injection:** Mass: 7.4x10^10 1.0-atoms
  - **Pellet velocity:** 240 - 600 m/s
  - **Injection frequency:** 6 Hz

**Modeling**

- The calculated ablation rate along the pellet path for two pellet velocity and mass

**Determination of the pellet path in space and time**

**Pellet monitor signal**

- **Pellet monitor signal #20041**
  - **Pellet position at ELM onset**
  - **Pellet position at the pellet onset**

**Camera trigger time**

- **Camera exposure times**
  - Time elapsed after previous - natural - ELM. If the elapsed time is greater than 5-10ms the delay times seem to be constant - these events are similar.

**ELM delay time**

Averaged values of the delay times as a function of the inverse pellet velocity

**Motivation**

Cryogenically hydrogen gas pellet injection for edge plasma control (Edge Localised Mode: ELM - pulse making) by means of frequent small and shallow penetrating pellets. For this ELM control investigations the understanding of the underlying processes depends highly on the information regarding localization of the pellet under the ELM. High resolution ablation profiles and pellet path measurements at different pellet parameters (mass and velocity) are required understand the mechanism of the ELM triggering.

**Aim**

- The strong local perturbation caused by the pellets deposited by the pellet is the origin of the ELM triggering. The ELM triggering is due to the direct impact or the result of the spreading perturbation. From its onset, the ELM grows until it becomes detectable. Hence, the detected perturbation released.

**Ablation rate**

- **Ablation rate** [10^10 s^(-1)]

**Observation system**

- **Injection frequency:** 6Hz
- **Pellets injection:**
  - **NBI:** 5 MW
  - **Auxiliary heating power close above the L-H transition.**
  - **Type-I ELM regime - ELM frequency fELM = 25 - 45 Hz**
  - **IP = 1 MA, Bt = -2.7 T, q95 = 4.9**

**Discussion**

**ELM delay time**

The delay between the time when the pellets were at the separatrix and the ELM onset as the function of the time elapsed after previous - natural - ELM.

- **For elapsed times less then 5-10ms, the delay times are higher - the plasma is not recovered after the previous ELM collapse. If the elapsed time is greater than 5-10ms the delay times seem to be constant - these events are similar.**

**Outlook, future plans**

- **New pellet injector: Laiden frost blowar gun**
- **For better spatial resolution: smaller pellet velocity**
- **LFS pellet injection to compare LFS-HFS pellet ELM triggering**
- **Different injection angle: perturbation at different magnetic/flux surfaces**

**Perspective**

The ELM is triggered somewhere between the separatrix and the position where the pellet was at the ELM onset.