Recent studies on pre-ELM structures at JET with applied $n = 2$ magnetic perturbation fields

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Acknowledgements

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Background

- Pre-ELM structures have been observed both with and without applied error field correction coils (EFCCs) on JET, giving new input for understanding the triggering mechanism of ELMs.

**IR camera resolutions** [1]
Spatial: ~ 1.6 mm
Temporal: ~ 10 kHz

**Pre-ELM structures W.O MP** [2]:
Single cases, not common, less than ~ 10% of ELMs.

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Background

• Pre-ELM structures have been observed both with and without applied error field correction coils (EFCCs) on JET, giving new input for understanding the triggering mechanism of ELMs.

**Pre-ELM structures W.O MP [3]:**
Usually quite short life time.

**Pre-ELM structures with MP [3]:**
Longer time duration and clearer.

Background

- Thermoelectric current model might predict the appearance of the pre-ELM structures (at one moment) but not their radial propagation [3].

The effect of gas puffing position on recycling

- A period of detachment of strike line appears after each ELM crash phase, which is followed by a large Dα line radiation and particle flux detected by the Langmuir probes. These indicate the large impact from recycling process [4,5] close to the divertor.

These phases disable the observation for the pre-ELM structure on the divertor.

The effect of gas puffing position on recycling

Top gas puffing

- Pre-ELM structure in the whole inter-ELM phase with much less interference from local recycling.
- Consecutive pre-ELM structure could be seen when EFCC current is above \(~ 2.5 \text{ kA}\).
- Different magnetic topology due to different amplitude of perturbation.

EFCC = 2.5 kA

EFCC = 5 kA
The dependence of propagation speed on $q_{95}$

$q_{95} = \sim 4.82$: Radial Propagation speed increases from $\sim 3.26 \text{ m/s}$ to $\sim 17.29 \text{ m/s}$ while approaching ELM crash phase.

$q_{95} = \sim 5.3$: Radial Propagation speed increases from $\sim 13.23 \text{ m/s}$ to $\sim 36.42 \text{ m/s}$.

With 5 kA $n = 2$ EFCC applied:
- The ELM crash phase lasts more than 2 ms.
- The stripes in the ELM crash phase propagate radially with a speed in the range of 40 to 100 m/s.
The relation with ELM triggering

- Pre-ELM structures may be cut off by unusual weak ELMs or no ELMs at all in the cases with longer inter-ELM periods.
- Pre-ELM structure seem to be connected to the filamentary structures in the ELM crash phase which has larger radial velocity.
Summary and discussion

• Due to the change of gas puffing position, clear pre-ELM structures could be seen through the whole inter-ELM periods with less interference from local recycling.
• Certain threshold (~ 2.5 kA) of EFCC current is needed for the appearance of consecutive pre-ELM structures. Varying amplitude of the perturbation fields changes the footprints of pre-ELM structures.
• With increasing q95, the propagation speed of the pre-ELM structures increase.
• Pre-ELM structures may be cut off by unusual weak ELMs or no ELMs at all in the cases with longer inter-ELM periods.
• The appearance of pre-ELM structures should be related with the enhanced transport at the edge and the change of pedestal stability by magnetic perturbations.
• The radial propagation of pre-ELM structures may be due to the different coupling between external fields and plasma rotation.