Edge stability in tokamak plasmas

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One of the major problems in ITER and other large future tokamaks are the Edge Localised Modes (ELMs) that transport particles and energy in bursts from the plasma edge to the divertors. If the ELMs are large, they can cause unacceptable erosion of the divertor plates. To avoid the erosion the ELM phenomenon has to be understood and ways to either reduce the ELM size, mitigate their effects or suppress them completely have to be found.

In this paper, we present stability analysis results for various plasma devices (ASDEX-Upgrade, JET, MAST) and show that the ELMs are triggered by peeling-ballooning modes that are destabilised by the steep edge pressure gradient and the bootstrap current. When the plasma triangularity is increased or plasma configuration is changed from single-null to quasi-double-null, the unstable modes become narrower in radius and the mode number of the most unstable mode increases. Similar thing happens when the plasma core pressure is increased. This can explain the reduced ELM size in these conditions.

In MAST, where plasma rotates faster than in the other two devices, the edge stabilisation by the toroidal rotation plays a role in the ELM triggering. Between ELMs, the rotation profile has a strong gradient close to the plasma edge. During an ELM the profile flattens. In stability analysis, we find that the strongly sheared rotation stabilises the edge modes and only when the destabilising force from the pressure gradient and current exceeds the stabilising force from the rotation, an instability is triggered. The growing instability ties up the flux surfaces and flattens the rotation profile further destabilising the mode and triggering an ELM.

ELM triggering using pellets can reduce the ELM size [1]. The stability analysis shows that the pellet-triggered ELMs are triggered by the same mechanism as the intrinsic ELMs.

[1]P. Lang et al., Nuclear Fusion **43** (2003) 1110.