A disruption of a tokamak discharge is a sudden loss of confinement that in turn causes a quench of the plasma current. The fast release of thermal and magnetic energy could result in very large thermal and electromagnetic loads on the surrounding structures such as the vessel, especially in large devices such as JET and ITER. Understandably, considerable research efforts are dedicated to develop both timely detectors of these events and mitigating actions.

Magneto hydrodynamic (MHD) instabilities are often seen as precursors to disruptions. Overlapping magnetic islands are thought to be behind the destruction of the flux surface structure that provides the plasma confinement, triggering the thermal quench [1]. Most disruptions at JET feature a typical locked (i.e. non-rotating) mode precursor. These modes are therefore used to predict disruptions and usually the analysis of these modes focusses on how early and at what level they can first be detected. This paper will investigate a different but related question: is there a specific perturbation level at which the thermal quench occurs?

Prior to a disruption, the locked mode amplitude (measured by flux loops mounted on the outside of the vacuum vessel) increases after which a thermal quench is triggered. Although in most cases the mode is locked in a similar position, the exact phase seems not to be a prerequisite for triggering the disruption itself.

For a large database of JET disruptions (>300) the mode amplitude at the start of the thermal quench has been determined. A similar analysis is being performed for ASDEX Upgrade disruptions. It was found that the thermal quench was triggered at a distinct perturbation level depending predominantly on the plasma current. A regression analysis found that this maximum allowable amplitude scaled linearly with the plasma current (I_p) and furthermore depended on the internal inductance (l_i) and the inverse of the edge safety factor, q. This scaling is partly due to the fact that the measured mode amplitude decreases with the distance between coil and the mode position. This dependence of the measured perturbation on the mode position means that disruptions are triggered at smaller measured amplitude when operating at higher q. Obviously, this results in shorter durations from passing the warning threshold to the disruption itself.

This study provides experimental insight in the processes that trigger tokamak disruptions. The perturbation amplitudes that trigger thermal quenches at different devices, like JET and ASDEX Upgrade can be compared and the results form a strong physics basis to determine protection thresholds to be used at future devices such as ITER.


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