

The Nature and Control of Fast Collapse Events in Tokamak Plasmas

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Fast crash or collapse events are a common feature of tokamak plasmas. The three principal types are Edge Localised Modes (ELMs), sawteeth and disruptions. An ELM is an event where there is a sudden loss in confinement in the edge transport barrier. It manifests itself most clearly in a sudden burst of H_α radiation and a fall in edge pressure. The sawtooth is associated with a transition from a centrally peaked temperature profile to a flattened profile. A disruption is a global loss of plasma confinement that leads to plasma termination.

It will be shown that these apparently diverse phenomena have many features in common. The most noteworthy is their abrupt onset that can be as fast as $10\mu\text{s}$. Rapid radial transport of particles and energy over tens of centimetres and in less than $100\mu\text{s}$ are observed in all three phenomena. Non-thermal energy distributions are another common feature. Also, although MHD precursor and postcursor modes play an important role in the frequency and timing of these events, the transition itself appears to depend on completely different physics. The timing and occurrence of the transition is essentially chaotic or probabilistic^[1].

Such phenomena represent a major concern to the operation of ITER and future magnetic fusion reactors by putting excessive heat loads on the first wall. The best solution would be, of course, prevention of such phenomena but in general this would lead to a too restrictive domain of machine operation. Another approach being pursued is to mitigate against the harmful effects of these phenomena. The injection of “killer pellets” can limit the potential damage of a disruption, for example. The use of gas puffing at the plasma edge or the injection of small pellets can lead to small, frequent, less-harmful ELMs and suitable phasing of radio frequency heating can induce small high-frequency sawteeth. These mitigation techniques can come at a price, however, with increased plasma radiation or reduced confinement. Ongoing research aims to minimise such effects whilst improving the reliability of these techniques.

Acknowledgements: This work was partly funded by Euratom and the UK EPSRC and was partly performed under the European Fusion Development Agreement.

^[1]Itoh S-I.; Itoh K.; Zushi H.; Fukuyama A., *Plasma Phys. Controlled Fusion*, 1998, (40) 879-929