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Prevention of the H-mode density limit by various heating schemes through control of the plasma state space

Early reaction to ultimately all, approaching disruption types is one of the major requirements for ITER and DEMO. This early reaction must be targeted on a prevention of the disruption. In present experiments mainly mitigation is applied routinely to specific disruption types. In the future, stability boundaries have to be identified for all expectable disruption types. The proximity to this boundary, accessible in real time, controls the measures for the disruption prevention. Appropriate reactions with available actuators have to be established and tested in present devices. The portability to different devices, in particular to larger ones, has to be shown. In general this can only be achieved via a physics understanding defining the stability boundaries and an understanding of the stabilizing mechanisms of the actuators.
For the case of the H-mode density limit (HDL) in pure deuterium plasmas, an empirical stability boundary in a two dimensional state space (normalized confinement time, H98y2, versus an empirically normalized electron density) has been identified at ASDEX Upgrade (AUG). The same boundary has been successfully used for disruption prevention at TCV. The physics understanding of this empirical boundary and its portability is an ongoing effort.
On AUG and TCV, the orthonormal distance to the boundary in the state space has been used as a control parameter to linearly increase, with decreasing distance, additional heating power. As actuators, NBI heating, central ECRH, off-axis co-ECCD and central ICRF heating have been applied resulting in different efficiencies for preventing or delaying the HDL evolution. These variations have to be understood in terms of heat flux and transport towards the plasma edge. Transport modelling is required to understand the behaviour and make predictions for future experiments. An overview of the present status for the prevention of the H-mode density limit will be given.
In the case of simultaneously approaching several stability boundaries, possibly competing or even contradicting actuator request might arise. For example in the MHD-caused beta limit [1] co-ECCD is required on the resonant surface. Thus in any future framework appropriate decision logics and actuator management have to be established in preparation of the ITER operation.

[1] A.Pau, this meeting

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