Boundaries of high density operation due to plasma edge turbulence in ASDEX Upgrade

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Next step tokamaks, ITER and DEMO, require a stable operation at high edge densities to meet both the criteria for power exhaust and high confinement (H-Mode). The operation of a tokamak at high edge densities is found to be limited by several constraints such as the back transition from high to low confinement or the density limits occurring in both confinement regimes. These particular boundaries of operation were investigated in terms of a combination of dimensionless parameters describing interchange-drift-Alfvén turbulence[1]. The derived boundaries successfully describe the operational space of the ASDEX Upgrade tokamak (Fig. 1). We conclude that high density H-Mode operation is limited by two independent boundaries, namely ideal ballooning modes acting as a soft limit and increasing interchange turbulence responsible for the back transition to L-Mode at high densities. If the resistive ballooning mode (RBM) is electrostatic, the L-mode is stable, if the RBM gets more electromagnetic (EM), the discharge is observed to disrupt. The dependence of these boundaries on shaping effects, current and toroidal field will be discussed. In this respect, particular attention is given to QCE discharges in ASDEX Upgrade, a scenario with highest separatrix densities, enlarged power width and absence of Type-I ELMs[2].

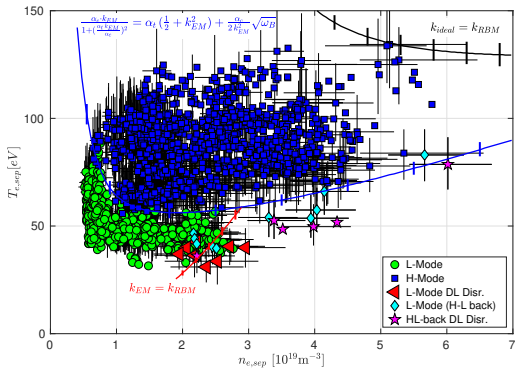

Figure 1: *Existence diagram spanned by separatrix electron density and temperature:*
Black: Ideal Ballooning Mode limit
Red: Transition to electromagnetic RBM
Blue: Sustained shear flow turbulence suppression
(Fig. Reproduced from [1] under CC BY 3.0)

References

[1] T.Eich, P.Manz et al., Nucl.Fusion **61**, p.086017 (2021)

[2] M.Faitsch et al., Nuclear Materials and Energy, **26**, p.100890 (2021)