Turbulence stabilization due to high beta and fast ions in high-performance plasmas at ASDEX Upgrade and JET

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For reaching high fusion performance, high plasma beta ($\beta = 8\pi p_0/B_0^2$) is desired. However, the dependence of the thermal confinement time τ_E on β is still unclear: dedicated experiments yielded inconclusive results [Petty PoP 2008] and most theoretical results are obtained in simplified setups (see e.g. [Doerk PoP 2015] for a summary. In this work, turbulent transport in the plasma core is studied by means of the gyro kinetic code GENE for plasma parameters and realistic geometry of recent ASDEX Upgrade and JET (with ITER-like-wall) discharges.

At ASDEX Upgrade we analyze a factor-of-two beta variation in H-Mode in which $\rho^\star$ and $\nu^\star$ are kept about constant. In these discharges, ion temperature gradient (ITG) modes linearly co-exist with microtearing modes (MTMs), but the transport associated with MTM magnetic flutter is found to be weak. Thus, we find strong reduction of the turbulence level in the core, as β is increased. However, the observed trend is within the experimental uncertainty of the temperature gradient. The measured weak degradation of the global confinement time is likely due to an interplay with edge physics.

For JET we have focussed on a power-scan in hybrid-configuration at low triangularity, which exhibits a weaker power degradation than that of the IPB98(y,2) scaling. Interestingly, the high-power JET case is very close to the transition from ITG to KBM turbulence. In nonlinear GENE simulations, high beta stabilizes ITG turbulence very efficiently, and additional turbulence reduction is observed, when the concentration of fast ions becomes large.

Overall, our results indicate that turbulence stabilization due to increased beta and/or fast particles contributes to improved plasma confinement, providing a tool for optimising future experiments.