OPTIMISATION OF MHD STABILITY USING ECCD IN ASDEX UPGRADE

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The active control of core magneto-hydro-dynamic (MHD) activity in fusion plasmas plays a very important role for increasing the performance of a reactor. Recently, in ASDEX Upgrade, a significant effort has been made to optimise the control of MHD stability using the presently installed electron cyclotron heating (ECH) system, which include three gyrotrons with f=140GHz, P=3×0.5MW and T=2s. The modification of stability and behaviour of core MHD with local ECH and current drive (ECCD) are presented. Particular attention is put on the optimisation of the control of sawteeth and of neoclassical tearing modes (NTM).

Sawteeth typically appear when the central q-value drops below unity. The effects of the sawtooth activity can be both favourable (removal of impurities from plasma core) and detrimental (triggering of NTMs, loss of fast particles, profiles flattening). Hence, external control of sawtooth period and amplitude is necessary. The sawtooth stability depends in particular on the local shear at q=1, which can be modified by local on/off-axis co-/counter-ECCD around q=1. The effects on the sawtooth period between wide and narrow CD widths are compared. It is shown that the strongest effects are obtained in co-ECCD and with narrow CD width. In addition, it is shown that the effects of ctr-ECCD with wide deposition are dominated by the heating contribution, while the ones with narrow deposition by the driven current density contribution.

NTMs normally appear in plasmas with high normalised pressure $\beta_N = \beta_t/(I_p/aB_T)$. The flattening of the pressure profile within the magnetic island leads to a hole in the bootstrap current profile, which is the main drive for the growth of the NTM, hence to a reduction of the plasma performance. The sawteeth themselves can trigger NTMs, therefore, by controlling sawteeth, the excitation of NTMs can be influenced as well. Once NTMs are excited, they can be fully stabilised at high β_N with co-ECCD at the resonant surface. Detailed experiments on the dependence of the control of NTMs on the ECCD deposition width and on the total driven current are presented, together with NTM stabilisation studies using modulated and non-modulated ECCD. It is shown that, by reducing the CD width, the stabilisation efficiency can be significantly improved. In particular, full NTM stabilisation with narrow ECCD width is obtained at higher β_N than before.

Presently, ASDEX Upgrade is being enhanced with a new ECH system, which will include four gyrotrons delivering 1MW for 10s, two 2-frequency at f=140, 105GHz and two step-tuneable with four frequencies between 105 and 140GHz. The launching system will be equipped with four independent poloidal fast steerable mirrors. In addition, a feedback control system is being developed with the aim of ensuring real-time control of MHD stability. Hence, the new ECH, together with the feedback control system, will provide more flexibility for the control of core MHD activity, and in particular, with the increased power, the possibility of extending the stabilising possibilities of the (2/1) NTM.