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ITR/P1-31: Assessing the Power Requirements for Sawtooth Control in ITER through Modelling and Joint Experiments

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Recent advances in theoretical understanding and numerical modelling of sawtooth oscillations have allowed the invention and application of experimental control techniques. This enhanced understanding, coupled with demonstration of control techniques in ITER-relevant plasmas and using real-time feedback, has facilitated prediction of control actuator requirements for ITER. The control of sawteeth is important for baseline scenario operation of burning plasmas, since plasmas with long sawtooth periods are empirically more susceptible to neoclassical tearing modes, which result in substantial confinement degradation. The stabilising effects of alpha particles are likely to exacerbate this, so recent experiments have identified methods for amelioration. Sawtooth control using electron cyclotron current drive has been demonstrated in ITER-like plasmas with a large fast ion fraction, wide q=1 radius and long uncontrolled sawtooth period in DIII-D and ASDEX Upgrade. Operation at beta(n)=3 without NTMs has been achieved in ITER demonstration plasmas in DIII-D using only modest ECCD power for sawtooth control. Further, real-time ECCD control techniques have been developed in TCV and Tore Supra. Numerical modelling suggests that the achieved driven current changes the local magnetic shear sufficiently to compensate for the stabilising influence of the fast particles. Extrapolating this to ITER, transport modelling coupled to ray-tracing predictions and using the linear stability thresholds for sawtooth onset suggests that 13MW of ECCD could be sufficient to reduce the sawtooth period by 30%, and this being the case, dropping it below the NTM triggering threshold. However, since the ECCD control scheme is solely predicated upon changing the local magnetic shear, it is prudent to plan for 10MW off-axis ICRH using 3He minority as a complementary scheme which directly damps the internal kink potential energy drive responsible for trapped fast ion stabilisation. Experimental evidence from JET plasmas heated with toroidally propagating ICRH using a He3 minority exhibited sawtooth control avoiding NTMs in H-mode, as predicted by drift-kinetic modelling. Such modelling suggests that 10MW of ICRH in ITER will negate the stabilising effect of alphas.

*See Appendix of F. Romanelli et al., Proc 23rd IAEA FEC 2010, Daejeon, Korea

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