3/2 NTM metastability scaling towards ITER

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3/2 Neoclassical Tearing Modes (NTMs) remain a serious concern for the ITER baseline scenario, the ELMy H-mode. They can decrease confinement by 10-20% (and fusion power by 20-40%), with a progressively worsening effect as β is raised (although some recovery is possible at higher β_N due to 'FIR' interaction with other modes and application of increased heating power). A key question therefore is how the underlying physics governing NTM behaviour scales? This controls not only the requirements for mode onset, but also for NTM control schemes (for example by ECCD systems in ITER).

Cross machine 'ITPA' identity experiments have now been executed on JET, DIII-D and ASDEX Upgrade to resolve this question, by using β ramp-down experiments in matched scenarios. First results, shown right, indicate a clear trend with the β threshold at which the mode self-stabilises (plotted in terms of local parameters related to the underlying NTM bootstrap drive) falling with normalised poloidal ion Larmor radius. This indicates that ITER will have a low β threshold for NTM metastability, making it important to consider control of NTM seeding instabilities.

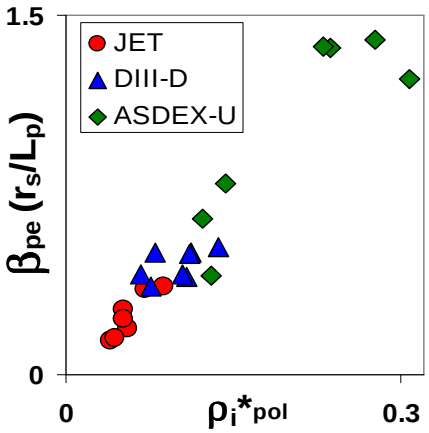

Figure: 3/2 NTM metastability threshold scaling

Modelling the evolution of these discharges can quantify the individual underlying physics to identify scaling and individual effects better. This analysis is complex, partly because the key measurements are made as the plasma approaches an H-L confinement transition, with profiles evolving. Nevertheless, by using a fully time-dependent treatment, local parameters and a full bootstrap calculation, it is possible to fit the small island size stabilisation terms (ion polarisation or island transport) at the point of self-stabilisation in each discharge. An example is shown left, with the evolution, final rise (due to a rise in bootstrap current from density and temperature gradients) and decay of island well reproduced. This shows how the small island stabilisation term modifies behaviour, giving the final mode decay. Preliminary results indicate that scale lengths for small island stabilisation terms do not vary substantially with $\rho_{i\theta}^*$, suggesting complete removal of modes will be challenging in ITER, although small ECCD controlled islands may have tolerable confinement effects. Full conclusions and scalings will be presented.

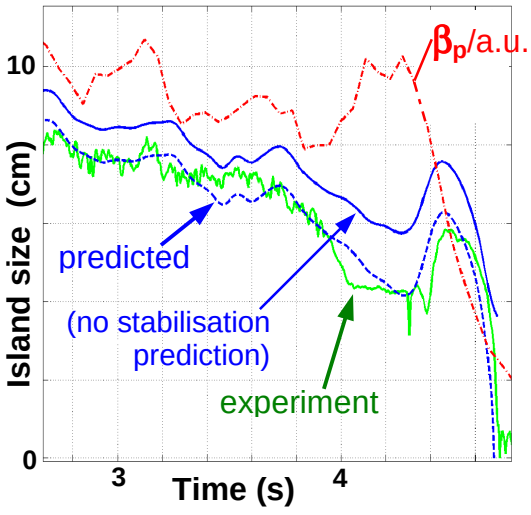

Figure: Decay of 3/2 NTM on DIII-D (111268) as β is ramped down.

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