TAE-induced alpha-particle transport in the Q=10 ITER baseline scenario

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The goal of the international ITER burning plasma experiment is to produce 500MW of fusion power for 50MW of heating power. A baseline scenario with plasma current 15 MA is being considered as the highest priority for achieving this goal of fusion gain Q=10. The burning plasma experiments to be attempted in ITER will differ from previous experiments in that non-thermal fusion alpha-particles must be highly confined, both to ensure machine safety, and to attain conditions required for new burning plasma physics studies. These 3.5MeV non-Maxwellian fusion alpha-particles have characteristic transit speeds that are super-Alfvénic, thereby allowing resonant destabilisation of Alfven normal modes. The toroidal Alfvén eigenmodes (TAEs) have been shown to be particularly dangerous, with up to 70% of neutral beam power being lost to machine components in some experiments due to modes of this type.

For assessing the TAE-induced re-distribution of alpha-particles in the ITER Baseline scenario, we have conducted the most comprehensive nonlinear study so far of all relevant TAEs in the ITER baseline scenario, computing their coupled growth and final amplitudes with realistic calculations of the thermal Landau and radiative damping. The effects of TAE frequency sweeping were also included via unlocking the mode phases, in order to examine possible phase space hole and clump convective losses. We find that even-parity core-localised TAE with their frequencies at the bottom of gap in the Alfvénic continuum have the highest growth rates (in agreement with linear theory), and that linearly stable global TAEs can be destabilised nonlinearly when the alpha-particle re-distribution becomes high enough. Thermal ion Landau damping is found to be an important in reducing the TAE saturation amplitudes to $\frac{dB_r}{B} \approx 10^{-4}$ (Fig. 1). For these TAE amplitudes, stochastic transport of alpha-particles is restricted to a narrow region where predominantly core-localised modes are found (Fig. 2). For the flat-q profile predicted for the ITER baseline scenario, formation of a transport barrier for alpha-particles was found at about a half of the minor radius thus effectively separating the region of core-localised strongly driven TAEs and the weakly driven global TAEs. As a result, for this ITER scenario alpha particle redistribution by TAEs is minimal. Our conclusions on stochastic diffusion of alpha particles are robust enough to tolerate a factor of ≈50 increase in our estimates of saturated mode amplitudes before alpha-particles from the core region are lost. Work is underway to include additional TAE drive from neutral beam heating and will be presented at the conference.

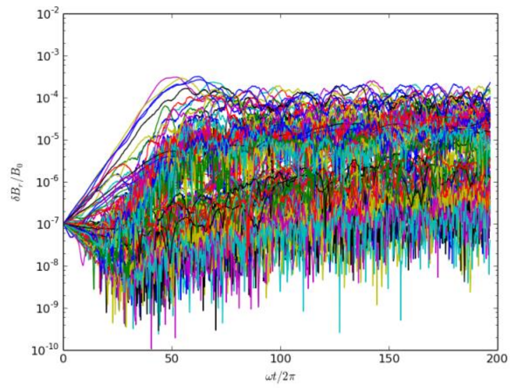

***Figure 1**. Amplitude growth and saturation of 129 TAEs including the effects of damping and unlocked mode phases.*

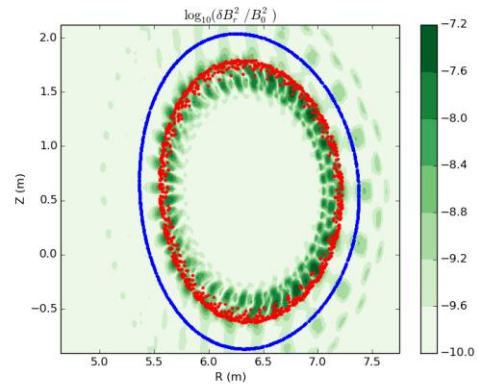

***Figure 2.** Poincare plots of test particle orbits in the presence of core localized (red) and global (blue) TAEs.*