Predictive nonlinear studies of TAE-induced alpha-particle transport in the Q=10 ITER baseline scenario

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We use the HAGIS code [1] to compute the nonlinear stability of the Q=10 ITER baseline scenario [2] to TAEs and the effects of these modes on fusion α-particle redistribution. Our calculations build upon an earlier linear stability survey [3] carried out using the MISHKA and CASTOR-K codes, which identifies relevant TAEs and provides accurate values of bulk ion, impurity ion and electron thermal landau damping for our HAGIS calculations, as well as a benchmark for our linear α-particle drive calculations. We also include analytical estimates for radiative damping. In linear calculations, it is found that even in the presence of γ/ω ~ 1\% thermal bulk damping of core localised modes, α-particle drive of core localised TAEs with toroidal mode numbers around n=29 can be as large as 3-5\%, and thus linearly unstable with large growth rates. Nonlinear calculations of 88 TAEs in the range n=15-35 and subsequent effects on alpha particles have been performed. The effects of frequency sweeping were also included to examine possible phase space hole and clump convective transport. We find that core localised modes are dominant (expected from linear theory), and that linearly stable modes are destabilized nonlinearly. When damping is neglected, the core localised modes reach a maximum amplitude of \( \delta B / B \approx 4 \times 10^{-3} \), with global modes being smaller by an order of magnitude or more. When damping is introduced, the maximum amplitude drops to \( \delta B / B \approx 3 \times 10^{-4} \) (Fig. 1). Stochastic transport occurs in a narrow region where the most unstable core localised modes are found (Fig 2), implying the formation of a transport barrier at \( r/a \approx 0.5 \), where the weakly driven global modes are found. We thus expect that for TAEs with n=15-35 in this scenario, α-particle redistribution will be confined to a small region and losses will be negligible. We are currently extending the study to include TAEs with n=10-14, and will include modelling of these modes in the results presented at the conference.

Figure 1. Amplitude growth and saturation of 88 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.

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