Insights Into m/n=2/1 Tearing Mode Stability Based on Initial Island Growth Rate in DIII-D ITER Baseline Scenario Discharges[*]

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Deleterious $m/n=2/1$ tearing modes appear in some slowly evolving (ℓ_i decreasing, beta nearly constant) ITER baseline scenario DIII-D discharges [1,2]. The destabilization is interpreted as due an initially positive (destabilizing) classical tearing index balanced only in part by curvature and the small island stabilization effects of neoclassical tearing modes. By evaluating this at the onset, the classical tearing stability index Δ' is appraised before the island grows to large size and the plasma equilibrium has time to change. Examples of $m/n=2/1$ tearing occurring after at least 3 seconds into discharges ($\tau_R \sim 1$ s) are analyzed from low to high torque for "seeding" by either sawteeth or edge localized modes (ELMs). Island width evolution is evaluated by the Mirnov magnetic probe arrays using the motional Stark effect EFIT equilibrium reconstructions and calibrated by the electron cyclotron emission (ECE) diagnostic. The magnetics analysis code EIGSPEC [3] uses so-called subspace methods (instead of FFT methods) to estimate peaks in the array magnetics power spectrum to sort out multiple modes and determine the precise point at which the $m/n=2/1$ mode begins to grow. $\Delta' r$ for classical stability is determined from the modified Rutherford equation (MRE) by taking the helically perturbed bootstrap components (including both curvature and small island effects) and subtracting from the initial normalized island growth rate. The islands have slower beginning growth rates at smaller initial island size (w_{init}). $(\tau_R/1.22r)dw/dt$ is found to be just >0 for initial island width $w_{init} \sim 1.5 w_{bi}$ (where w_{bi} is the ion banana width) and to be ~1 for $w_{init} \sim 3 w_{bi}$. The form of the early evolution of $w(t)$ tends to be an exponential if a small island (Fig. 1) and linear if large. The data are well described (using the MRE) by the imbalance of the sum of the destabilizing classical tearing and the helically perturbed bootstrap current terms with the sum of the stabilizing curvature and polarization effects. ITER relies upon localized electron cyclotron current drive (ECCD) at $q=2$ to stabilize or suppress (limit to small amplitude transients) $m/n=2/1$ neoclassical tearing modes [4]. The effectiveness and power requirements of ECCD in ITER are predicated on an "educated guess" of the classical stability index ($\Delta' r \approx$-m). The DIII-D results suggest that there will be less classical stability in ITER and thus more ECCD power needed for stabilization than previously estimated.

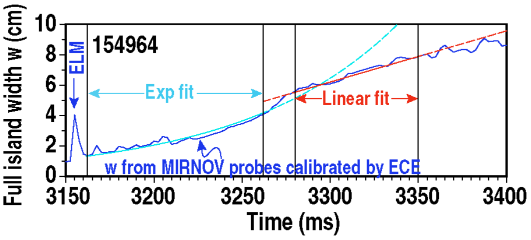

Fig. 1. $m/n=2/1$ tearing mode "seeded" by an ELM, initially grows exponentially, then linearly with time. Larger initial island sizes (not shown) start in the linear phase.

[1] F. Turco and T.C. Luce, Nucl. Fusion **50**, 095010 (2010).
[2] G.L. Jackson, *et al.*, "Long-pulse stability limits of the ITER baseline scenario," to be submitted to Nucl. Fusion (2014).
[3 K.E.J. Oloffson, *et al.*, "Array magnetics modal analysis for the DIII-D tokamak based on localised time-series modeling," submitted to Plasma Phys. Controlled Fusion (2014).
[4] R.J. La Haye, *et al.*, Nucl. Fusion **49**, 045005 (2009).

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