METASTABLE BETA LIMIT IN DIII–D*

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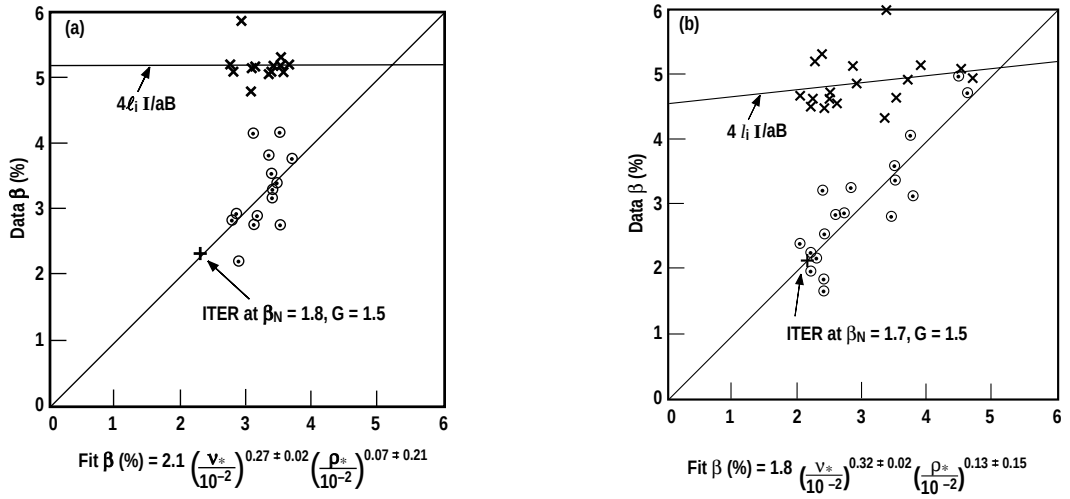
The long-pulse, slowly evolving single-null divertor (SND) discharges in DIII–D with H–mode, ELMs, and sawteeth are found to be limited significantly below (factor of 2) the predicted ideal limit $\beta_N = 4\,\ell_i$ by the onset of tearing modes. This is shown below for the onset of soft beta limiting m/n = 3/2 modes whose islands reduce τ_E by 10–20% and by hard beta limiting m/n = 2/1 modes whose islands lead to disruption. The critical beta depend on collisionality with dependence on local dimensionless parameters ν_* and ρ_*. The tearing modes are *metastable* and are explained by the neoclassical bootstrap current (high β_θ) destabilization of a seed island which occurs even if $\Delta' < 0$, i.e., otherwise stable. For sufficiently high β_θ, there is a region of the modified Rutherford equation such that $dw/dt > 0$ for w larger than a threshold value; the plasma is *metastable*, awaiting the critical perturbation which is then amplified to the much larger saturated island. Examination of the databases of ITER-like discharges in DIII–D shows: (1) the 3/2 mode becomes unstable following a sawtooth crash; (2) the 2/1 mode is triggered by an ELM. The metastable nature of the tearing modes may explain how a short pulse high beta near the ideal limit is attainable but not reproducibly sustainable. Operational techniques under investigation to raise the long-pulse beta limit in DIII–D are to: (1) remove or reduce the seed islands [q(0) > 1 removes sawteeth, high δ DND may lessen the size of the ELM perturbation] thus allowing a higher beta metastable state, (2) replace the perturbed (missing) bootstrap current in the seed island by application of modest radially localized electron cyclotron current drive (ECCD).



(a) Onset of 3/2 tearing (☉) and (b) of 2/1 tearing (☉) in DIII–D fitted to <u>local</u> parameters

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