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Extrapolating Neoclassical Tearing Mode Physics to ITER – Physics Basis and Experimental Comparison[1]

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Neoclassical Tearing Modes (NTMs) represent one of the most serious concerns for baseline and hybrid scenario performance in ITER. Already on present devices they limit attainable β, degrading confinement and causing disruptions. The concern is increased for ITER where stabilising small island and rotation effects are likely to be reduced. In this paper we review the physics basis for NTM scalings, and compare to experimental behaviour, to deduce the key effects and impact on ITER prediction. The principal criteria for NTM onset is dictated by a competition between stabilising small island effects, and the drive from NTM-triggering MHD (eg. sawteeth). Typically the former arise from orbit and transport effects when island sizes are comparable to ion banana widths. This suggests a lowering of NTM β thresholds as ITER-like ρ_i^*s are approached. In addition, reduced plasma rotation will increase NTM coupling to other instabilities and decrease stabilising effects due to wall and rotation shear. New studies on JET and DIII-D have highlighted this with falls of ∼30% in both m/n=3/2 and 2/1 NTM β thresholds as momentum injection is removed. Indeed, a wide body of work confirms many aspects of the theory, particularly the expected small island effects and ρ_i^* scalings, while more detailed examinations, for example locally perturbing rotation with error fields, begin to distinguish particular physics mechanisms such as ion polarisation current effects. Thus consideration of the stabilising elements points to a lower metastability threshold for the NTM in ITER. Nevertheless, the triggering mechanisms provide grounds for optimism. For the most serious 2/1 NTM, onset in hybrid, and possibly baseline, scenario appears related to proximity to ideal β limits. Conversely, modes triggered by core MHD may be managed by proven control techniques for the core MHD itself.

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