Macroscopic trends of linear and neoclassical tearing stability in high-field H-mode tokamak pilot plants

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Abstract

A new neoclassical tearing mode (NTM) stability metric - the minimum marginally stable island width wm - was compared across 14667 fully-inductive high-field tokamak pilot plant equilibria constrained by the requirement of producing 400MW fusion power. Larger devices with reduced elongation and/or increased minor radius demonstrated an order-of-magnitude increase in wm, primarily due to a reduction in bootstrap drive. This work is part of an ongoing effort to ensure passive NTM stability in high-field ARC-like tokamaks, which can't use localised electron cyclotron current drive to stabilise NTMs. The tokamak database was generated by Monte-Carlo sampling plasma geometries and calculating their corresponding equilibria over a range of plasma currents, before applying tearing analysis using the modified Rutherford equation to all poloidal and toroidal m, n modes up to n = 4. Single-helicity toroidal Δ' calculations in resistive DCON set the minimum marginally stable island width, and a simple modal scaling proportional to -m2n-1 was identified for high-m Δ' values. The dominant correlates of wm and Δ' across the database were analysed using interpretable machine learning techniques, to prepare for wm's application to an experimental tearing mode database.

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