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Predicting nonresonant pressure-driven MHD modes in equilibria with low magnetic shear

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We introduce a new approach[1,2] for predicting unstable nonresonant MHD modes, which are demonstrated to be destabilised preferentially to any other resonant instability with the same toroidal mode number for $n > 1$ and thus play a decisive role in determining the overall MHD stability properties of equilibria with weak magnetic shear[2].

We establish a clear connection between the spectrum of unstable modes and certain rational approximations of the safety factor at the magnetic axis, for equilibria that are consistent with pre-crash profiles in sawtoothing tokamak plasmas in the large aspect ratio limit[2]. We discuss how these observations can potentially be used to reduce the uncertainty on q_0, as obtained from measurement or through analysis and reconstruction of experimental results[2].

In equilibria with extended regions of weak magnetic shear, including some tokamak scenarios and stellarators, nonresonant MHD modes can be unattractive for confinement since these instabilities displace substantial volumes of plasma and potentially lead to more efficient pressure gradient flattening in the nonlinear regime.

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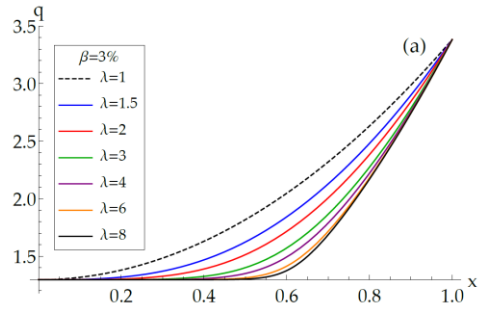
References

[1] A. M. Wright et al. "Predicting nonresonant pressure-driven MHD modes in equilibria with low magnetic shear", Physics of Plasmas 28.1 (2021): 012106. https://doi.org/10.1063/5.0032489

[2] A. M. Wright and N. M. Ferraro, "Mode spectrum characteristics and onset of the low-shear MHD stability regime", Physics of Plasmas 28.7, (2021): 072511. https://doi.org/10.1063/5.0053870



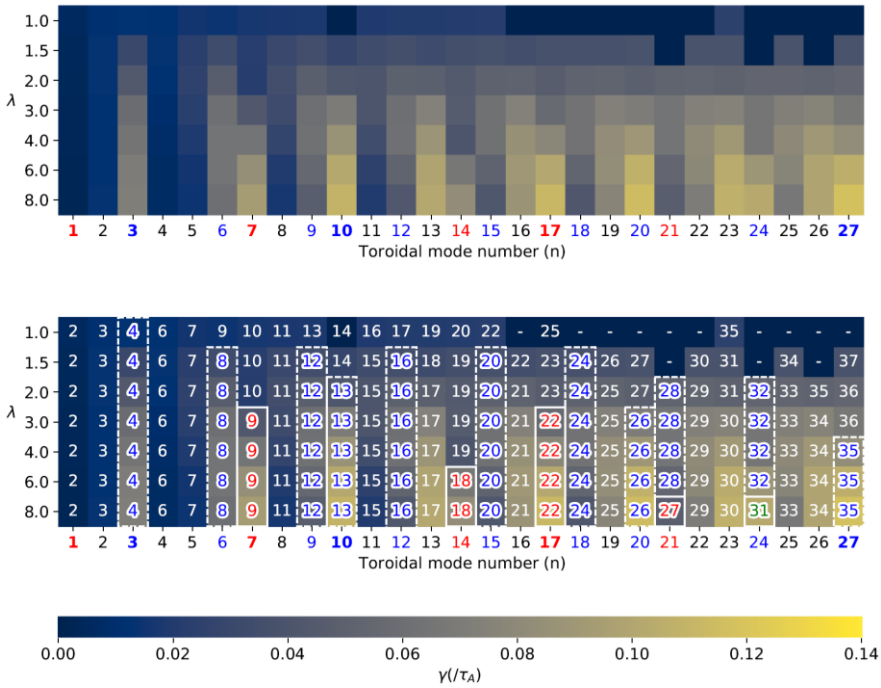


Figure 1 (left): (a) Equilibrium q-profiles and (b) toroidal current density profiles for $\beta = 3\%$ and $1 \leq \lambda \leq 8$, where λ controls the magnetic shear. The reference case, $\lambda = 1$ (dashed line), corresponds to a quadratic q-profile.
Figure 2 (right): (Top) The spectrum of the non-ideal linear growth rate, $\gamma(n)$, for $1 \leq n \leq 27$, computed using M3D-C[1] for each equilibrium profile in Figure 1. Increasing λ corresponds to decreasing shear. Blue (dashed box) and red (solid box) labels, respectively, denote modes in the resonant and nonresonant subsets of the spectrum associated with q_0. Modes associated with the fundamental harmonics are shown in bold on the horizontal axis. All other modes correspond to resonant instabilities not in the spectrum of q_0. (Bottom) For each (n, λ), the poloidal mode number of the fastest-growing mode is indicated. Both Figures 1 and 2 are taken from Ref. 2.