New Extended-MHD drift-tearing mode dispersion relations: implications and a tool for code verification

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The non-ideal tearing instability can produce magnetic islands that lead to degradation in tokamak core confinement. The linear, collisional, constant-ψ drift-tearing mode is analyzed for different regimes of the plasma-β, ion-skin-depth parameter space with an unreduced, extended-MHD model [1]. A well-known result from drift-reduced MHD is that the diamagnetic drift associated with the pressure gradient has a stabilizing influence [2]. New dispersion relations are found at moderate plasma β (PR2-4) and previous drift-results [2,3] are placed in context of these new results. The potential drift stabilization of the mode in the moderate-β regimes varies from non-existent (PR3) to weak (PR1) to complete (PR2).

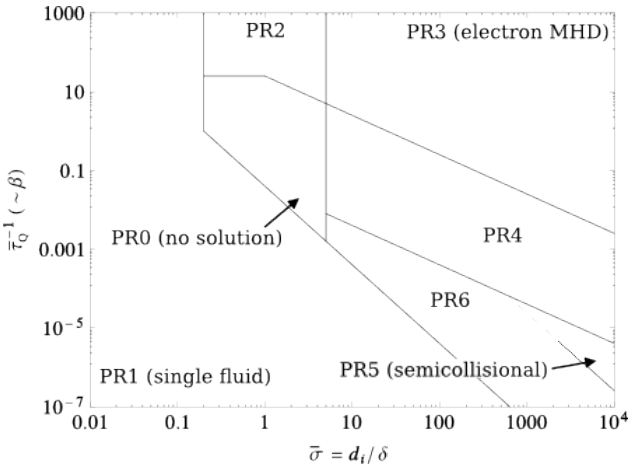

Figure 1: Drift-tearing mode dispersion relation solutions in normalized β – d_i parameter space.

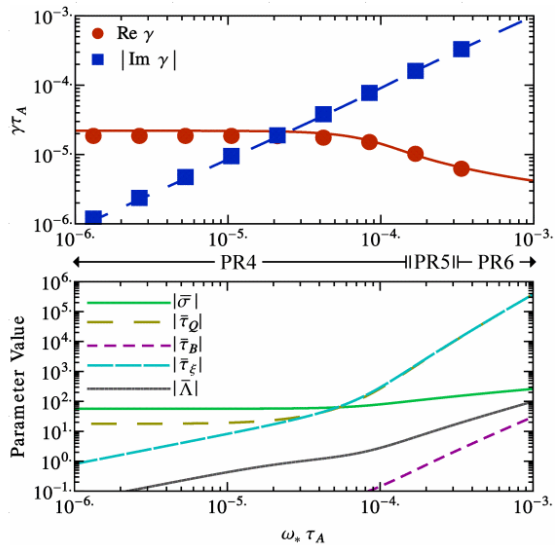

Figure 2: An example drift verification with a comparison of the dispersion relation for the analytics (lines) and NIMROD computations (discrete points).

Verification is most interesting in the experimentally relevant, moderate-β regimes. The new dispersion relations in these regimes are used to verify the extended-MHD implementation of the NIMROD code [Sovinec and King, J. Comput. Phys. 229, 5803 (2010)]. This analytic work broadens the extended-MHD tearing-mode dispersion relations without drifts [4] used in previous verification efforts to include drift effects.

The presentation focuses on the implications, not the derivation, of the results. In particular, we discuss limits of applicability of extended-MHD and reduced models in these regimes and the implications of these results for production level simulations for validation exercises.

[1] King and Kruger, PoP 21,102113 (2014)
[2] Coppi, PoF 7, 1501 (1964)
[3] Drake and Lee, PoF 20, 1341 (1977)
[4] Ahedo and Ramos, PPCF 51, 055018 (2009); Mirnov et al., PoP 11, 4468 (2004)

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