The impact of 3-D fields on tearing mode stability of H-modes

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Abstract. New processes have been discovered in the interaction of 3-D fields with tearing mode stability at low torque and modest β on DIII-D and NSTX. These are thought to arise from the plasma response at the tearing resonant surface, which theoretically is expected to depend strongly on plasma rotation and underlying intrinsic tearing stability. This leads to sensitivities additional to those previously identified at low density where the plasma rotation is more readily stopped, or at high β_N where ideal MHD responses amplify the fields (where β_N is the plasma β divided by the ratio of plasma current to minor radius multiplied by toroidal field). It is found that the threshold size for 3-D fields to induce modes tends to zero as the natural tearing β_N limit is approached. 3-D field sensitivity is further enhanced at low rotation, with magnetic probing detecting an increased response to applied fields in such regimes. Modeling with the MARS-F code confirms the interpretation with the usual plasma screening response breaking down in low rotation plasmas and a tearing response developing, opening the door to additional sensitivities to β and the current profile. Typical field thresholds to induce modes in torque-free $\beta_N \sim 1.5$ H-modes are well below those in Ohmic plasmas or plasmas near the ideal β_N limit. The strong interaction with the tearing mode β_N limit is identified through rotation shear, which is decreased by the 3-D field, leading to decreased tearing stability. Thus both locked and rotating mode field thresholds can be considered in terms of a torque balance, with sufficient braking leading to destabilization of a mode. On this basis new measurements of the principal parameter scalings for error field threshold have been obtained in torque free H-modes leading to new predictions for error field sensitivity in ITER. The scalings have similar exponents to Ohmic plasmas, but with seven times lower threshold at the ITER baseline β_N value of 1.8, and a linear dependence on proximity to the tearing mode β_N limit (~2.2 at zero torque). This reinforces the needs to optimize error field correction strategies in ITER, and implement sources to drive plasma rotation.

PACS Nos.: 52.55.Fa, 52.55.Tn, 52.35.Py