Measurement and modeling of three-dimensional equilibria in DIII-D

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Abstract

A detailed experiment-theory comparison reveals that linear ideal MHD theory is in quantitative agreement with magnetic measurements of the plasma response to externally applied non-axisymmetric fields over a broad range of beta and rotation. This result represents a significant step toward the goal of advancing the quantitative understanding of 3-D tokamak equilibria. Internal measurements, derived from a soft x-ray diagnostic viewing poloidal cross-sections of the plasma at three separate toroidal locations, indicate the plasma perturbation structure is qualitatively consistent with ideal MHD and increases linearly with the applied perturbation strength. The comparison also highlights the need to include kinetic effects in the MHD model once beta exceeds 80% of the kink mode limit without a conducting wall. Two distinct types of response fields are identified by the linear ideal MHD model: one that consists of localized currents at the rational surfaces that cancel the applied resonant field, and another that is excited by the components of the external field that couple to the kink mode. Numerical simulations show these two fields have similar amplitudes in ITER-shaped DIII-D discharges where $n = 3$ fields are used to suppress edge localized modes.

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