Measurement and Modeling of 3D Equilibria in DIII-D*

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A detailed experiment-theory comparison reveals that linear ideal MHD theory gives a quantitative description of the external magnetic plasma response to applied non-axisymmetric fields over a broad range of beta. This result represents a significant step toward the goal of advancing the quantitative understanding of 3-D tokamak equilibria. 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. Above the no-wall limit, the measured rotation dependence of the plasma response reveals evidence of resonances between the plasma perturbation and the trapped particle precession and bounce frequencies, providing the first direct evidence for the effect of kinetic resonances on 3-D equilibria. In these experiments, n=1 and n=3 magnetic fields were applied over a wide range of plasma parameters and field structures. Internal measurements, derived from toroidally distributed soft x-ray cameras, indicate the plasma perturbation structure is ideal and increases linearly with the applied perturbation strength. Ideal MHD modeling of the response field structure shows the plasma response simultaneously prevents reconnection by screening the applied resonant field at the rational surfaces, and amplifies the applied field components that excite the kink mode. Both effects are important when the applied perturbation has strong resonant components. These results elucidate the role of the plasma response in the measured variations of non-resonant magnetic field torques with plasma parameters, and uncover a dynamic response field in the regime relevant for suppression of edge localized modes by resonant magnetic perturbations.

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