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Plasma Response Measurements of Non-Axisymmetric Magnetic Perturbations on DIII-D[1]

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Measurements of three-dimensional (3D) perturbations due to the application of non-axisymmetric fields in DIII-D show experimental evidence of helical distortions that modify the tokamak boundary during edge localized mode (ELM) suppression experiments. Two distinct 3D features localized in minor radius are imaged via tangential filtered soft x-ray (SXR) emission in the X-point region: (i) the formation of lobes extending from the unperturbed separatrix at the plasma boundary with a low energy filter ($T_e \gtrsim 40\,\mathrm{eV}$), and (ii) helical kink-like displacements in the steep-gradient region inside the separatrix with a higher energy filter ($T_e \gtrsim 400\,\mathrm{eV}$). These measurements are used to test and to validate plasma response models, which are crucial for providing predictive capability of ELM control. In particular, vacuum and two-fluid resistive MHD responses are tested in the regions of these measurements. At the plasma boundary, measurements compare well to vacuum-field calculations that predict lobe structures created by intersecting manifolds based on a Hamiltonian formulation of the perturbed magnetic field line structure. This is corroborated by previous measurements of heat and particle flux strike-point splitting. Yet in the steep gradient region, displacement measurements agree better to calculations with the linear resistive two-fluid MHD code, M3D-C1. Displacements measured via Thomson scattering, poloidally and toroidally separated from the SXR imaging, also match this modeling. The calculations show partial resonant screening and non-resonant amplification compared to vacuum model, leading to a stronger kink response. This is largely dependent on rotational screening from large perpendicular electron flow. These results indicate that while the vacuum approach describes measurements in the edge region well, it is important to include two-fluid resistive MHD effects for the H-mode pedestal.

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