Impact of plasma response on plasma displacements in DIII-D during application of external 3D perturbations

A. Wingen[1], N.M. Ferraro[2], M.W. Shafer[1], E.A. Unterberg[1], T.E. Evans[2], D.L. Hillis[1] and P.B. Snyder[2]

[1]Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

[2]General Atomics, PO Box 85608, San Diego, California, 92186-5608, USA

E-mail: wingen@fusion.gat.com

Abstract. The effects of applied 3D resonant magnetic perturbations (RMPs) are modeled with and without self-consistent plasma response. The plasma response is calculated using a linear two-fluid model. A synthetic diagnostic is used to simulate soft x-ray (SXR) emission within the steep gradient region of the pedestal, $0.98 > \psi > 0.94$. Two methods for simulating the SXR emission given the perturbed fields are considered. In the first method, the emission is assumed to be constant on magnetic field lines, with the emission on each line determined by the penetration depth into the plasma. In the second method, the emission is taken to be a function of the perturbed electron temperature and density calculated by the two-fluid model. It is shown that the latter method is more accurate within the plasma, but is inadequate in the scrape-off layer due to the breakdown of the linearized temperature equation in the two-fluid model. The resulting synthetic emission is compared to measured SXR data, which show helical $m = 11 \pm 1$ displacements around the 11/3 rational surface of sizes up to 5 cm, depending on the poloidal angle. The helical displacements around the 11/3 surface are identified to be directly related to the kink response, caused by amplification of non-resonant components of the magnetic field due to plasma response. The role of different plasma parameters is investigated, but it appears that the electron rotation plays a key role in the formation of screening and resonant amplification, while the kinking appears to be sensitive to the edge current density. It is also hypothesized that the plasma response affects the edge-localized-mode stability, i.e. the discharge's operational point relative to the peeling-ballooning stability boundary.