Error field detection in DIII-D by magnetic steering of locked modes

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Abstract. Optimal correction coil currents for the $n = 1$ intrinsic error field of the DIII-D tokamak are inferred by applying a rotating external magnetic perturbation to steer the phase of a saturated locked mode with poloidal/toroidal mode number $m/n = 2/1$. The error field is detected non-disruptively in a single discharge, based on the toroidal torque balance of the resonant surface, which is assumed to be dominated by the balance of resonant electromagnetic torques. This is equivalent to the island being locked at all times to the resonant $2/1$ component of the total of the applied and intrinsic error fields, such that the deviation of the locked mode phase from the applied field phase depends on the existing error field. The optimal set of correction coil currents is determined to be those currents which best cancels the torque from the error field, based on fitting of the torque balance model. The toroidal electromagnetic torques are calculated from experimental data using a simplified approach incorporating realistic DIII-D geometry, and including the effect of the plasma response on island torque balance based on the ideal plasma response to external fields. This method of error field detection is demonstrated in DIII-D discharges, and the results are compared to those based on the onset of low-density locked modes in Ohmic plasmas. This magnetic steering technique presents an efficient approach to error field detection and is a promising method for ITER, particularly during initial operation when the lack of auxiliary heating systems makes established techniques based on rotation or plasma amplification unsuitable.

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