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Progress in understanding error-field physics in NSTX spherical torus plasmas[1]

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The low aspect ratio, low magnetic field, and wide range of plasma beta of NSTX plasmas provide new insight into the origins and effects of magnetic field errors. An extensive array of magnetic sensors has been used to analyze error fields (EFs), to measure error field amplification (EFA), and to detect resistive wall modes (RWMs) in real time. The measured error-field threshold for the onset of locked modes shows a linear scaling with plasma density, a weak dependence on B_T, and a positive scaling with magnetic shear. These results extrapolate to a favorable threshold $\delta B_{21}/B_T > 1\times10^{-4}$ for ITER. For these low-beta locked-mode plasmas, perturbed equilibrium calculations find that the plasma response must be included to explain the empirically determined optimal correction of NSTX error fields [1]. In high-beta NSTX plasmas exceeding the n=1 no-wall stability limit where the RWM is stabilized by plasma rotation, active suppression of n=1 EFA and correction of newly discovered n=3 error fields have led to sustained high rotation and record durations free of low-frequency core MHD activity. For sustained rotational stabilization of the RWM, both the rotation threshold and magnitude of EFA are important. At fixed normalized dissipation, kinetic damping models predict rotation thresholds to scale nearly linearly with particle orbit frequency. Studies for NSTX find orbit frequencies at large minor radius are a factor of two higher than used in the present kinetic damping theory derived in the limit of high aspect ratio and circular plasma cross-section. Such discrepancies may explain the recent observation of kinetic damping models under-predicting the critical rotation [2].

[1] J.K. Park, et al., "Correction of magnetic field errors in tokamaks", submitted to PRL (2007)
[2] H. Reimerdes, et al., Phys. Rev. Lett. 98, 055001 (2007)

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