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Plasma Rotation Driven by Static Nonresonant Magnetic Fields[1]

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Recent experiments in high temperature DIII-D tokamak plasmas have reported the first observation of plasma acceleration driven by the application of static non-resonant error fields, with resulting improvement in the global energy confinement time. Toroidal rotation benefits tokamak experiments by flow shear stabilization of turbulence, screening of error fields, and stabilization of neoclassical tearing modes and resistive wall modes. However, a self-heated burning plasma will have little toroidal momentum injection. Toroidal momentum sinks will exist in a burning plasma, including torques from unavoidable magnetic field errors. Although the braking effect of static magnetic field asymmetries is well known, recent theory [A.J. Cole, et al., Phys. Rev. Lett. **99**, 065001 (2007)] predicts that they can lead instead to an increase in rotation frequency toward a "neoclassical offset" rate. We report the first experimental confirmation of this surprising result. When a large nonresonant $n = 3$ field is applied to a steady plasma with small neutral beam torque, the measured toroidal rotation of impurity ions and the calculated main ion toroidal rotation both increase in the electron diamagnetic drift direction. The magnitude, direction, and radial profile of the observed offset rotation are consistent with theory, as is the reduction of the rotation increase at low beta. The offset rotation rate is about 1% of the Alfvén frequency, more than double the rotation needed for stable operation at high beta above the no-wall kink limit in DIII-D. An important consequence is that the nonresonant field torque on a fusion plasma from high-n fields for ELM suppression may not represent a problem, but instead may generate a rotation rate sufficient to benefit confinement and stability.

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