Plasma Rotation Driven by Static Nonresonant Magnetic Fields*

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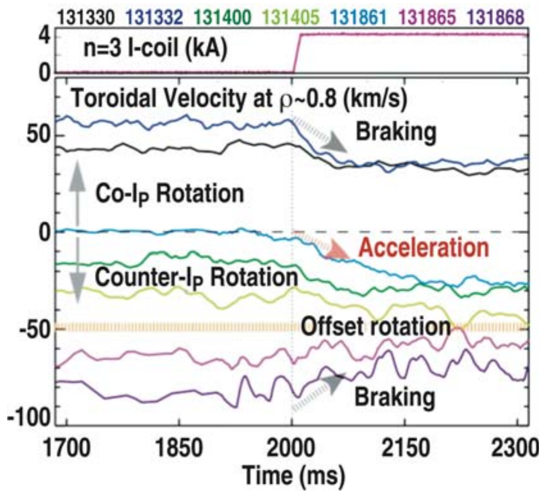
Recent experiments in high temperature DIII-D tokamak plasmas have reported the first observation of plasma acceleration driven by the application of static nonresonant magnetic fields (NRMFs), with resulting improvement in the global energy confinement time [1].

Toroidal rotation benefits tokamak plasmas by flow shear stabilization of turbulence and suppression of macroscopic plasma instabilities. However, a self-heated burning plasma will have little or no toroidal momentum injection. On the other hand, toroidal momentum sinks will exist in a fusion reactor plasma, including the well known braking effects from unavoidable magnetic non-axisymmetries. A less known effect, predicted by neoclassical theory, is that magnetic asymmetries can, in some cases, lead to an increase in rotation toward a "neoclassical offset" rate. We report the first experimental confirmation of this surprising result.

Nonresonant magnetic fields of toroidal mode number $n = 3$ were applied using the DIII-D I-coil to plasmas prepared with a variety of initial plasma rotation conditions (figure). When the n=3 field was applied to a steady plasma with slow counter rotation, the flow accelerated toward an offset rotation with magnitude and direction in accord with the neoclassical theory predictions. This observed offset rotation is about 1% of the Alfvén frequency, i.e. a rotation which might be adequate in ITER and in a fusion plant for providing good energy confinement and stable operation at high β_N above the $n = 1$ no-wall kink limit.



Amplitude of n=3 I-coil current producing the nonresonant magnetic field, and toroidal rotation evolution measured at fixed location inside the plasma for discharges with different initial rotation (different color lines).

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