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Direct Evidence of Magnetic Fluctuation-Driven Intrinsic Flow in a Toroidal Plasma[1]

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Exploiting fluctuation-driven torque is highly desirable for ITER where the efficiency of externally applied torque will likely be limited. Plasma pressure fluctuations, electric field fluctuations and magnetic field fluctuations have been long observed in various magnetic confinement configurations and can all play a role in intrinsic plasma flow. Electric and magnetic field fluctuations can act on plasma flow via the Reynolds stress or Maxwell stress, respectively. In addition, the interaction between plasma parallel pressure and magnetic field fluctuations can also generate a net torque (kinetic stress) that drives plasma flow parallel to magnetic field. This stress stems from the divergence of the magnetic-fluctuation-driven momentum flux. Direct experimental evidence of the kinetic stress and its relation to intrinsic flow has been observed in the MST reversed field pinch. Using advanced polarimetry and differential interferometry techniques, measurements of the torque amplitude, direction and spatial distribution are made in the plasma core. The magnitude of the force is approximately 0.5 N/m^3 at r/a$\sim$0.2 comparable to the observed flow acceleration. The stress is co-current directed in the core, and changes sign near mid-radius and the parallel flow profile has a similar shape. The correlated fluctuations generating the torque are related to tearing instabilities. The saturation mechanism of flow is qualitatively consistent with stochastic magnetic field induced damping. When magnetic fluctuations are suppressed by current profile control, the flow is also observed to decrease. These results strongly indicate the magnetic fluctuation-driven kinetic stress plays important role in plasma flow.

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