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Direct measurements of the 3D plasma flow velocity in single-helical-axis RFP plasmas

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The first local velocity measurements of helical equilibrium plasmas in the RFP are made to characterize the equilibrium flow profile. In high current, low density MST plasmas, the island associated with the innermost resonant tearing mode can grow and envelop the magnetic axis, resulting in a saturated Single Helical Axis (SHAx) equilibrium. The process by which this self-organized transition occurs is not fully understood. Theory and modeling suggest that viscous dissipation or large flow or magnetic shear might stimulate the transition. Local, toroidally resolved non-axisymmetric velocity measurements are obtained with a CHERS diagnostic while using a resonant magnetic perturbation to control the orientation of the helical plasma. The axisymmetric part of the flow is a rigid-rotor-like poloidal flow and relatively flat toroidal flow. Outside of the core, r/a >0.5, the non-axisymmetric flow shows variations of order 10 km/s and more structure than a simple sinusoidal variation matching the helical variation of the magnetic axis. V3FIT ideal MHD 3D equilibrium reconstructions shows magnetic shear with respect to the minor radius (dq/dr) is strengthened in a region outside of the helical magnetic axis due to flux surface compression (ds/dr). The toroidally resolved helical flow shear measured by CHERS is less than the critical shear predicted to mute nonlinear coupling of tearing modes. Flow measurements are compared with preliminary NIMROD simulations of visco-resistive, single-fluid MHD in toroidal and cylindrical geometry with full and limited axial periodicity. Both measurements and toroidal simulations show stronger inboard flows relative to the outboard. In the experiment, the n = 5 component of the poloidal flow is phase shifted by ˜0.7 rad from the reconnection-like flow observed in the simulations, possibly due to decoupling of the ion and electron fluids over much of the plasma.