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Spinning Unmagnetized Plasma for Laboratory Studies of Astrophysical Accretion Disks & Dynamos

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A technique for creating a large, fast-flowing, unmagnetized plasma has been demonstrated experimentally. This marks an important first step towards laboratory studies of phenomenon such as magnetic field generation through self-excited dynamos, or the magnetorotational instability (MRI), the mechanism of interest for its role in the efficient outward transport of angular momentum in accretion disks. In the Plasma Couette Experiment (PCX), a sufficiently hot, steady-state plasma is confined in a cylindrical, axisymmetric multicusp magnetic field, with Te<10 eV, Ti<1 eV, and $n<10^{11}$ cm^{-3}. Azimuthal flows are driven by JxB torque using toroidally localized, biased hot cathodes in the magnetized edge region. Measurements show that momentum couples viscously from the magnetized edge to the unmagnetized core, and the core rotates when collisional ion viscosity overcomes the drag due to ion-neutral collisions. Torque can be applied at the inner or outer boundaries, resulting in controlled, differential rotation. Maximum speeds are observed (He $\sim$ 12 km/s, Ne $\sim$ 4 km/s, Ar $\sim$ 3.2 km/s, Xe $\sim$ 1.4 km/s), consistent with a critical ionization velocity limit reported to occur in partially ionized plasmas. PCX has achieved magnetic Reynolds numbers of Rm $\sim$ 65 and magnetic Prandtl numbers of Pm $\sim$ 0.2-10, which are approaching regimes shown to excite the MRI in a global Hall-MHD stability analysis. Ion-neutral collisions effectively add a body force that undesirably changes the flow profile shape. Recent upgrades have increased the ionization fraction with an additional 6 kW of microwave heating power and stronger magnets that reduce loss area and increase plasma volume by 150%. In addition, an alternative scheme using volume-applied JxB force will maintain the shear profile and destabilize the MRI at more easily achievable plasma parameters.