DPP12-2012-001472

Abstract for an Invited Paper
for the DPP12 Meeting of
the American Physical Society

Stirring An Unmagnetized Plasma for Magnetorotational Instability Studies[1]

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The efficient outward transport of angular momentum in accretion disks is thought to be the result of turbulence generated by the magnetorotational instability (MRI). The MRI arises when a differentially-flowing, conducting fluid is permeated by a weak magnetic field. The instability has been the subject of extensive analytical and numerical investigations for several decades, yet experimental verification of the MRI remains elusive. Recently, a new method for stirring a hot (Te=10 eV), unmagnetized plasma has been demonstrated experimentally [RSI 83, 063502 (2012)], making it possible to study the MRI in a laboratory plasma for the first time. In the experiment, plasma is confined by a cylindrical, axisymmetric, multicusp magnetic field. Azimuthal flows (up to 6 km/s) are driven by JxB torque using biased, heated filaments at a single toroidal position in the magnetized edge. Measurements show that momentum couples viscously from the magnetized edge to the unmagnetized core, and that flow is axisymmetric [PRL 108, 115001 (2012)]. Collisional ion viscosity must overcome the drag due to ion-neutral collisions for the plasma to rotate. Additional electrodes at the inner boundary will create the sheared flow necessary for exciting the MRI. This experiment has already achieved magnetic Reynolds numbers of Rm$\sim$50 and magnetic Prandtl numbers of Pm $\sim$ 0.3-6, which are approaching regimes shown to excite the MRI in local linear analysis and global Hall-MHD numerical simulations [POP 18, 062904 (2011)]. Experiments characterizing the MRI will compare the onset threshold to theoretical and numerical predictions, look for altered velocity profiles due to momentum transport during nonlinear saturation, and identify two fluid effects expected to arise from the Hall term and plasma-neutral interactions (important in protoplanetary accretion disks).

[1]Work supported by NSF, DOE, CMSO, and CMTFO.