DPP08-2008-000657

Abstract for an Invited Paper
for the DPP08 Meeting of
the American Physical Society

First MHD Results of the Princeton MRI Experiment

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The accretion of gas, dust, and plasma orbiting a strong gravitational source is responsible for the observed luminosity of systems such as binary stars and active galactic nuclei. Accretion disk dynamics also set the timescale for star and planet formation in protostellar disks. The accretion rate is governed by how quickly angular momentum can be transported through the disk. Inferred accretion rates suggest that viscous transport is insufficient to explain observations. The proposed mechanism for turbulent transport in these disks is the magnetorotational instability (MRI), a linear instability caused by the Maxwell stress introduced by an ambient magnetic field coupled to the Keplerian sheared flow. The MRI is sufficiently generic that it should be observable in any hydrodynamically stable rotating shear flow with a radially-decreasing angular velocity for sufficiently high magnetic Reynolds number with an applied axial magnetic field. The Princeton MRI Experiment was designed to study the stability of rotating shear flow in a magnetized conducting fluid. The unique design of this experiment allows the generation of quiescent shear flow at high Reynolds number. The experiment has been filled with a gallium eutectic alloy and operated with an applied axial magnetic field of up to 5 kG. The most recent measurements show the emergence of nonaxisymmetric MHD modes from magnetized turbulent shear flow using an array of radially-aligned induction coils. The modes precess toroidally and have a frequency splitting proportional to the rotation speed, a characteristic of magnetocoreolis (MC) waves. The relationship between the MRI and MC waves and a method of identifying the MRI through observation of excited MC waves is illustrated though analytical analysis, experimental data, and comparison with simulations.