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Experimental Study of Angular Momentum Transport in Astrophysically Relevant Flows[1]

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Rapid angular momentum transport in accretion disks is a longstanding astrophysical puzzle. Transport by molecular viscosity is inadequate to explain observationally inferred accretion rates. Since Keplerian flows are linearly stable in hydrodynamics, there exist only two main viable mechanisms for the required turbulence: nonlinear hydrodynamic instability or linear magnetorotational instability (MRI). The latter is regarded as a dominant mechanism for rapid angular momentum transport in hot accretion disks ranging from quasars and X-ray binaries to cataclysmic variables. The former is proposed mainly for cooler protoplanetary disks, whose Reynolds numbers are typically large. Despite their popularity, however, there is limited experimental evidence for either mechanism. In this talk, I will describe a laboratory experiment at Princeton in a short Taylor-Couette flow geometry intended to study these mechanisms. Based on the results from prototype experiments and simulations, the apparatus contains novel features for better controls of the boundary-driven secondary flows. The experiments in water have shown[3] that nonmagnetic quasi-Keplerian flows at Reynolds numbers as large as 2×10^6 are essentially laminar, through means of direct measurements of Reynolds stress via a synchronized, dual Laser Doppler Velocimetry. Scaled to accretion disks, rates of angular momentum transport lie far below astrophysical requirements. By ruling out hydrodynamic turbulence, our results indirectly support MRI as the likely cause of turbulence even in cool disks. The experiments in liquid gallium eutectic alloy have recently begun, and initial results on MRI as well as other related phenomena including numerical predictions will be also discussed if available.

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[2]In collaboration with E. Schartman, M. Nornberg, M. Burin, J. Goodman, and W. Liu.
[3]H. Ji, M. Burin, E. Schartman, & J. Goodman, Nature **444**, 343-346 (2006).