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Laboratory Studies of Angular Momentum Transport in Astrophysically Relevant Flows[1]

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Rapid angular momentum transport in accretion disks has been a longstanding astrophysical puzzle. Molecular viscosity is inadequate to explain observationally inferred accretion rates. Since Keplerian flow profiles are linearly stable in hydrodynamics, there exist only two viable mechanisms for the required turbulence: nonlinear hydrodynamic instability or 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 has been proposed mainly for cooler protoplanetary disks, whose Reynolds numbers are typically large. Despite their popularity, however, both candidate mechanisms have been rarely demonstrated and studied in the laboratory. In this paper, I will describe a laboratory experiment at Princeton in a short Taylor-Couette flow geometry intended for such purposes. 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 that nonmagnetic quasi-Keplerian flows at Reynolds numbers as large as 2×10^6 are essentially laminar [1]. 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. Initial results on MRI, using a liquid gallium eutectic, will be also discussed if available.

[1] H. Ji, M. Burin, E. Schartman, & J. Goodman, Nature 444, 343-346 (2006).

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[2]In collaboration with M. Burin, J. Goodman, W. Liu, M. Nornberg, and E. Schartman