Characterization of quasi-Keplerian, differentially rotating, free-boundary laboratory plasmas

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We present results from pulsed-power driven differentially rotating plasma experiments designed to simulate physics relevant to astrophysical disks and jets. The experiments were conducted at the MAGPIE pulsed-power facility (1.4 MA, 240 ns rise-time). The goal is to interpret and model the rotation profile and pressure balance of differentially rotating plasmas inertially driven by the slightly off-radial inward-convergence of 8 magnetized plasma jets. In contrast to previous liquid metal and plasma experiments, rotation is not driven by boundary forces. Axial pressure gradients launch a rotating plasma jet upwards, which is confined by a combination of ram, thermal, and magnetic pressure of a surrounding plasma halo. The jet has subsonic rotation, with a maximum rotation velocity 23±3 km/s. The rotational velocity profile is quasi-Keplerian with a positive Rayleigh discriminant $\kappa^2 \propto r^{-2.8\pm0.8}$ rad^2/s^2. The plasma completes 0.5−2 full rotations in the experimental time frame (∼150 ns).