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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 [1, 2, 3]. In these experiments, angular momentum is injected by the ram pressure of the ablation flows from a wire array Z pinch. The goal is to interpret and model the rotation profile and pressure balance of differentially rotating plasma flows, and study their stability and overall evolution.
The data show that rotating plasmas have a hollow density structure and are radially confined by the ram pressure of the ablation flows. A combination of axial thermal and magnetic pressure launches an axial, supersonic jet with a velocity 100 km/s (M > 5) which transports angular momentum. The axial jet is collimated by a hot ($T_i \sim 250$ eV) surrounding plasma halo. It is inferred that the plasma halo is magnetized by a ~ 3 T magnetic field. We will discuss the thermal and possible magnetic structure of the halo and its impact on jet collimation. Finally, the rotation velocity radial distribution is such that angular frequency decreases with radius, as the opposite happens to specific angular momentum. The calculated squared epicyclic frequency (Rayleigh determinant) of the flow is estimated to be $\kappa^2 \sim r^{-2.8} > 0$. This implies that the plasma flows are quasi-Keplerian and share stability properties of gravitationally driven accretion disks.

References

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[3] D. D Ryutov Astrophys. Space Sci. **336**, 21 (2011)