Plasma Jet Studies in a Flow Z-Pinch Experiment

U. Shumlak, B.A. Nelson, and B. Balick
Aerospace and Energetics Research Program, University of Washington, Seattle,
shumlak@u.washington.edu

The ZaP Flow Z-Pinch Experiment at the University of Washington produces plasma jets that are remarkably similar to many plasma jets from Herbig-Haro (HH) objects and planetary nebulae (PNe). The experimental plasmas are long-lived, stable jets with large aspect ratios and occasionally produce propagating "knots". The axially flowing plasma Z-pinch or jet is generated with a coaxial accelerator coupled to a Z-pinch assembly chamber. The plasma exits the assembly chamber and expands without a confining magnetic field in a manner that resembles plasma structures associated with PNe. Experimental diagnostics measure the evolution of the plasma equilibrium, including velocity profile, and of the plasma stability. The plasma is magnetically confined for an extended quiescent period where the mode activity is significantly reduced and a stable plasma jet is observed. A large, sheared flow is observed during the quiescent period and low shear profiles during periods of high mode activity, in agreement with computational predictions [1]. This quiescent period lasts up to 2000 times longer than the MHD kink growth time. Multichord interferometry measures a Z-pinch plasma with a peaked radial profile during the quiescent period. Internal magnetic fields have been recently determined by measuring the Zeeman splitting of impurity carbon emission. The measurements are consistent with a well-confined pinch plasma. Similarity criteria for plasma evolution [2] are within the range of values for HH objects. The supersonic jets can impinge upon neutral gas, producing shock fronts, as seen in HH objects and PNe. Further experiments investigating background gas entrainment into the jet can also be performed. The details of experimental jet and shock evolution can be compared with astrophysical jets under the similarity constraints. Results can further be compared with observations, theory, and numerical simulations of astrophysical jets.

References

[1] U. Shumlak and C.W. Hartman, Phys. Rev. Lett. 75, 3285 (1995)
[2] D.D. Ryutov and B.A. Remington, Phys. Plasmas 8, 1804 (2001)