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A Study of Magnetized Jet Stability Using High Energy Density Plasmas

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Astrophysical jets are ubiquitous structures observed in diverse environments, ranging in scale from young stellar objects to supermassive black holes. Most theories assume a gravitational engine to be responsible for generating the powerful axial flows of the jet from an accretion disk. However, the processes that maintain jet collimation and stability remain poorly understood. To understand the mechanisms at play, we propose to conduct a stability study of magnetized jets generated by pulsed-power drivers.

Though many orders of magnitude larger in size, astrophysical jets share the collimation, turbulence, and magnetic drag of high energy density plasma generated in the laboratory. Making an argument of magneto-hydrodynamic stability, we may justify our scaling of the system by matching dimensionless parameters of the plasma jet: the Reynolds number (Re), Magnetic Reynolds number (R_M), Mach number (M), and plasma beta (β). We may carefully control the properties of the magnetized jets generated in the laboratory, and then perturb them to quantitatively measure the stability conditions.

Our experiment will use a quasi-axisymmetric load, driven by 1MA and capable of producing a strongly collimated, magnetized plasma jet. We will then quantitatively study the jet's resilience to external perturbations from flows, magnetic fields, and localized heating.

We present results from simulations of the experimental geometry using the 3D extended MHD code PERSEUS, as well as some preliminary experimental results using the COBRA pulsed-power driver. After simulating several versions of the load with varying axial magnetic field strengths, we show that the scaling parameters for our setup indeed lie within the regimes of astrophysical jets: $Re > 10^3$, $R_M \sim 10^3$, $\beta \gg 1$, and $M > 1$.

Authors: HASSON, Hannah (University of Rochester); GOURDAIN, Pierre (University of Rochester)

Co-authors: Ms ADAMS, Marissa (University of Rochester); Dr HAMMER, Dave (Cornell Univeristy); Dr KUSSE, Bruce (Cornell University); SHAPOVALOV, Roman (University of Rochester); YOUNG, James (University of Rochester); EVANS, Matt (University of Rochester); GREENLY, John (Cornell University); WEST-ABDALLAH, Imani (University of Rochester)

Presenters: HASSON, Hannah (University of Rochester); GOURDAIN, Pierre (University of Rochester)

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