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Laboratory Study of the Shaping and Evolution of Magnetized Episodic Plasma Jets[1]

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The expansion of hot, dense plasma (100 eV, 10^{18} cm^{-3}) into vacuum occupied by a strong magnetic field ($\beta = P_{kinetic}/P_{mag} \approx 1$) along the expansion axis is a seemingly elementary physics problem, yet it is one that has scarcely been investigated. As well as being a fundamental problem in plasma physics, understanding such a situation is important to provide an explanation of large-scale jets observed in the formation of young stellar objects (YSO). Additionally, the ability to manipulate such a situation (e.g. to optimize x-ray emission) may be essential to the feasibility of recently proposed inertial confinement fusion (ICF) schemes with an imposed magnetic field. To investigate these situations, a CF_2 foil is irradiated with the ELFIE laser (10^{13} W/cm^2, 0.6 ns) in an external axial magnetic field of 20 T. As the plasma expands radially it is restricted by magnetic pressure that creates a cavity with a shock at the expansion edge. This shock redirects flow back on axis and creates a strong, stationary, conical shock that collimates the flow into a jet traveling over 1000 km/s and extending many centimeters. The effect of episodic heating (e.g. from variable mass ejection in a YSO, or pulse shaping in ICF) was investigated by irradiating the target with a precursor laser (10^{12} W/cm^2, 0.6 ns) at 9 to 19 ns prior to the main pulse. The addition of this relatively small addition of energy (<20% of the main pulse energy) changed the dynamics of the expansion dramatically by increasing the strength of the conical shock, reducing the forward expansion of the cavity and dramatically increasing emission. We also present MHD simulations that reproduce the experimental observables and help to understand dynamics of jet and cavity formation. Prepared by LLNL under Contract DE-AC52-07NA27344.

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