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Creating High Energy Density Jets in Laboratory Environments

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A new experimental platform for the investigation of high Mach-number, high energy-density jets has been developed at the University of Rochester's Omega laser facility. Assuming the scalability of the Euler equations, the resulting mm-sized jets should scale to astrophysical objects such as Herbig-Haro objects and jet-driven supernovae that may involve jets with similar internal Mach numbers. This scalability still holds in the presence of radiation as long as the relative importance of radiative cooling is similar. In these experiments, either direct or indirect laser drive is used to launch a strong shock into a 125 micron thick titanium foil target that caps a 700 micron thick titanium washer. After the shock breaks out into the 300 micron diameter cylindrical hole in the washer, a dense, well-collimated jet with an energy density of more than 0.1 MJ per cc is formed. The jet is then imaged as it propagates for 100s of ns down a cylinder of low-density polymer foam. The experiments are diagnosed by point-projection with a micro-dot vanadium backligher. The field of view is several mm and the resolution is 15 microns. The X-ray radiographs show the hydrodynamically unstable jet and the bow shock driving into the surrounding foam. Such complex experimental data provide a challenge to hydrocodes and so are being used to test the hydrodynamic simulations of these types of flows. Initial comparisons between the data and LANL and AWE simulations will be shown. However, the high Reynolds numbers of both the laboratory and astrophysical jets suggest that, given sufficient time and shear, turbulence should develop; this cannot be reliably modeled by present, resolution-limited simulations. Future work concerning the applicability of the Omega experiments to astrophysical objects and the quantitative study of turbulent mixing via subgrid-scale models will be discussed.