Observations of shear flows in laser driven high-energy-density plasmas

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Shear layers containing strong velocity gradients appear in many high-energy-density (HED) systems and play important roles in mixing and the transition to turbulence. Yet few laboratory experiments have been carried out to study their detailed evolution in this extreme environment where plasmas are compressible, actively ionizing, often involve strong shock waves and have complex material properties. Many shear flows produce the Kelvin-Helmholtz (KH) instability, which initiates the mixing at a fluid interface. We present results from two dedicated shear flow experiments that produced overall subsonic and supersonic flows using novel target designs. In the subsonic case, the Omega laser was used to drive a blast wave along a rippled interface between plastic and foam, shocking both the materials to produce two fluids separated by a sharp shear layer. The interface subsequently rolled-upped into large KH vortices that were accompanied by bubble-like structures of unknown origin. This was the first time the evolution of a well-resolved KH instability was observed in a HED plasma in the laboratory [1]. We have analyzed the properties and dynamics of the plasma based on the data and fundamental models, without resorting to simulated values. In the second, supersonic experiment the Nike laser was used to drive a supersonic flow of Al plasma along a rippled, low-density foam surface. Here again the flowing plasma drove a shock into the second material, so that two fluids were separated by a shear layer. In contrast to the subsonic case, the flow is expected to developed shocks around the ripples in response to the supersonic flow of Al.

References

[1] E.C. Harding et al., *Phys. Rev. Lett.*, **103**, 045005 (2009)

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