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Supersonic, shockwave-driven hydrodynamic instability experiments at OMEGA-EP[1]

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Hydrodynamic instabilities play a dominant role in the transport of mass, momentum, and energy in nearly every plasma environment, governing the dynamics of natural and engineering systems such as solar convective zones, magnetospheric boundaries, and fusion experiments. In past decades, limitations in our understanding of hydrodynamic instabilities have led to discrepancies between observations and predictions. Since then, significant improvements have been made to our available experimental techniques, diagnostics, and simulation capabilities. Here, we present a novel experimental platform that can sustain a steady, supersonic flow across a precision-machined, well-characterized material interface for unprecedented durations

We applied this platform to a series of Kelvin-Helmholtz instability experiments. The Kelvin-Helmholtz instability generates vortical structures and turbulence at an interface with shear flow. In a supersonic flow, the growth rate is inhibited and the instability structure is altered. The data were obtained at the OMEGA-EP facility by firing three laser beams in sequence to produce a 12 kJ, 28 ns stitched laser pulse. The ablation pressure sustained a steady shockwave for $\sim$70 ns over a foam-plastic, single-mode or dual-mode interface. A spherical crystal imager was used to measure the evolution of these modulations with high-resolution x-ray radiography using Cu K_α radiation at 8.0 keV. The observed structure was reproduced with 2D hydrodynamic simulations.

References:

1. W.C. Wan, G. Malamud, et al., Physical Review Letters, 115, 145001, (2015).
2. G. Malamud, et al., High Energy Density Physics, 9, 672-686, (2013)

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