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Experiment on mass-stripping of interstellar cloud following shock passage[1]

J. FREDDY HANSEN, LLNL

The interaction of supernova shocks and interstellar clouds is an important astrophysical phenomenon which can lead to mass-stripping (transfer of material from cloud to surrounding flow, "mass-loading" the flow) and possibly increase the compression in the cloud to high enough densities to trigger star formation. Our experiments attempt to simulate and quantify the mass-stripping as it occurs when a shock passes through interstellar clouds. We drive a strong shock using 5 kJ of the 30 kJ Omega laser into a cylinder filled with low-density foam with an embedded 120 μm Al sphere simulating an interstellar cloud. The density ratio between Al and foam is $\sim$9. Time-resolved x-ray radiographs show the cloud getting compressed by the shock (t$\approx$5 ns), undergoing a classical Kelvin-Helmholtz roll-up (12 ns) followed by a Widnall instability (30 ns), an inherently 3D effect that breaks the 2D symmetry of the experiment. Material is continuously being stripped from the cloud at a rate which is shown to be inconsistent with laminar models for mass-stripping (the cloud is fully stripped by 80ns-100ns, ten times faster than the laminar model). We present a new model for turbulent mass-stripping that agrees with the observed rate and which should scale to astrophysical conditions, which occur at even higher Reynolds numbers than the current experiment. The new model combines the integral momentum equations, potential flow past a sphere, flat plate skin friction coefficients, and Spalding's law of the wall for turbulent boundary layers.

In collaboration with H. F. Robey, R. I. Klein, A. R. Miles, Lawrence Livermore National Laboratory; C. F. McKee, University of California Berkeley.

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