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Experimental Observation of Shock-front Separation in Multi-ion-species Collisional Plasma Shocks[1]

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In the context of inertial-confinement-fusion and high-energy-density experiments, shock-driven ion species separation in the fuel potentially leads to neutron yield degradation [1], and this has in part motivated the recent strong interest in studying multi-species plasma transport and shocks. In this work, we directly observe shock-front separation and species-dependent shock widths in collisional plasma shocks. The shock-front is produced by obliquely merging plasma jets with initial 97%-He and 3%-Ar atomic concentrations on the Plasma Liner Experiment [2]. Cameras with narrow bandpass filters directly observe line emission from the distinct ion species. We experimentally infer both shock-front separation and individual shock widths (for the He and Ar) to be of order several tens of post-shock thermal ion-ion mean free paths. These observations agree reasonably with results from 1D multi-fluid simulations using the Chicago code [3]. Moreover, the experimental and simulation results are consistent with first-principles theoretical predictions [4] that the lighter He ions diffuse farther ahead (toward the pre-shock region) within the overall shock-front than the heavier Ar ions. Our fundamental experimental data can be used to benchmark first-principles-based multi-fluid or kinetic simulations of multi-ion-species collisional plasma shocks, for which there have been recent known discrepancies between models [5].

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