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Formation of reverse shocks in magnetized high energy density supersonic plasma flows[1]

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There has been considerable effort in developing experiments for studies of both collisionless and radiative shocks in high energy density plasmas (HEDP), but there is still very limited experimental information the concerning properties of HEDP shocks in the presence of a magnetic field. A new experimental platform, based on the use of supersonic ablation plasma flows in inverse wire array z-pinches, was developed for studies of shocks in magnetized HEDP plasmas in a well-defined and diagnosable 1-D interaction geometry. The mechanism of flow generation ensures that the plasma flow ($M_A \approx 5-6$, $V_{flow} \approx$ 100km/s, $n_i \approx 10^{17} cm^{-3}$) has a frozen-in magnetic field at a level sufficient to affect the shocks formed in the interaction with conducting obstacles. Experiments show that in addition to the formation of a "standard" reverse shock in a stagnated HEDP plasma, the presence of the magnetic field leads to the formation of an additional shock-like feature in the upstream plasma. This shock is triggered by the pile-up of magnetic flux diffusing into the upstream flow, despite a relatively small initial level of the frozen-in magnetic field (the flow ram pressure being much greater than the magnetic field pressure). The thickness of this shock is much smaller than the m.f.p. for the ion-ion collisions, the shock is formed at a distance of $\approx c/\omega_{pi}$ from the foil and remains stationary for the duration of the experiment (≈100ns). The plasma parameters in the flow and in the shock are measured using optical Thomson scattering, two-color laser interferometry, monochromatic X-ray radiography and miniature magnetic probes. The quantitative data from this experiment, especially the spatial profiles of the density and of the flow velocity measured simultaneously in the upstream and downstream of the shock, will allow detailed verification of MHD and PIC codes used by the HEDP community.

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