Progress toward fully-formed collisionless astrophysically-relevant shock experiments on OMEGA and the NIF

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Collisionless shocks, in which supersonic flows stagnate through coupling to electromagnetic fields rather than by Coulomb collisions, occur in a wide variety of astrophysical conditions and scales, including supernova remnants, gamma ray bursts, and protostellar jets. Scaled experiments using high-powered lasers are able to recreate the microphysics of these phenomena in the laboratory [1], allowing investigation of magnetic field generation by the Weibel instability and charged-particle acceleration by first- and second-order Fermi processes, which is a predicted source of high-energy cosmic rays [2]. Counterstreaming plasma flows generated by laser ablation have been probed on the Omega laser using proton radiography, showing the formation, growth, and merger of filamentary magnetic field structures associated with the Weibel instability in a collisionless regime [3]. Heating of the ions via both two-stream instability and collisional processes has been diagnosed by Thomson scattering [4]. Higher-energy experiments using the NIF laser demonstrate a scaling towards reduced collisionality with increased interaction length [5]. In the near-collisionless regime, proton radiographs of NIF experiments are consistent with the development of turbulent magnetic fields in the interaction region late in time, an expected effect of Weibel stagnation as demonstrated by comparison with particle-in-cell simulations. Experiments designed to probe the conditions of the stagnated plasma and record charged particle acceleration within a fully-formed collisionless shock on the NIF will be presented.

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