Laboratory experiments to study astrophysical collisionless shocks

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Collisionless shocks are considered to be sources of high-energy particles or cosmic rays, and occur when a coulomb mean-free-path is longer than the shock-front thickness. In such plasmas wave-particle interactions and collective effects play an essential role in the shock formation. In addition to local observations of spaces plasmas by spacecraft and global emission measurements of astrophysical plasmas, a laboratory experiment can be an alternative approach to study the formation of collisionless shocks. In this paper, we investigate the formation of collisionless shocks in counter-streaming plasmas produced by large-scale intense lasers, such as Gekko XII HIPER (Japan), LULI2000 (France), and OMEGA (USA). Shock structures are measured by optical diagnostics (interferometry, shadowgraphy, self-emission); collective Thomson scattering diagnostics provide electron density, electron and ion temperatures, flow velocity, and Mach number in the upstream and downstream regions of a shock; and electric and/or magnetic fields are obtained by proton-radiography. We also investigate experimental plans to demonstrate the formation of Weibel-instability mediated collisionless shocks using the NIF (USA).