Simulations of particle acceleration in collisionless shocks for conditions relevant to NIF experiments

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Collisionless shocks are ubiquitous in astrophysical plasmas and are known to be important in magnetic field amplification and in the acceleration of both high-energy electrons and protons (cosmic rays). While the theory of diffusive shock acceleration (DSA) is well established, the details of particle injection into DSA remain a long-standing puzzle, particularly for electrons. Very recently, laser-driven high-energy-density experiments at the National Ignition Facility (NIF) have observed for the first time high-Mach number Weibel-mediated collisionless shocks and the associated nonthermal electron acceleration. We will discuss results from large-scale particle-in-cell simulations of counter-streaming plasma flows for the conditions of the NIF experiments. This study reveals that electrons can be effectively injected by multiple scatterings in small-scale turbulence produced within the shock front via a first order Fermi mechanism. We will present detailed analysis of the characteristic diffusion properties and energization associated with this mechanism, and discuss its relevance to electron injection in young supernova remnant shocks.