Particle acceleration in astrophysical and laser-driven plasmas

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The acceleration of non-thermal particles is critical for our understanding of explosive astrophysical phenomena, from solar flares to gamma ray bursts. Collisionless shocks and magnetic reconnection are often invoked as the dominant acceleration mechanisms, depending on whether the system energy is stored in flows or magnetic fields, respectively; however the microphysics underlying these processes and their ability to efficiently accelerate particles is not yet fully understood. The combination of first principles simulations and high-energy-density laser-driven plasma experiments can play an important role in the exploration of the microphysics of particle acceleration in collisionless plasmas.

By performing for the first time 3D particle-in-cell simulations of the interaction of both magnetized and unmagnetized laser-driven plasmas it was possible to identify the optimal parameters for observation of particle acceleration in the laboratory with current laser systems. I will show that efficient non-thermal acceleration of both electrons and ions can be reached in near-future laser-driven studies of collisionless shocks and magnetic reconnection [1-2]. The dominant mechanisms associated with energy dissipation and particle acceleration are identified as a function of the plasma conditions. Finally, I will discuss the requirements on the diagnostics to probe the microphysics of particle acceleration. These results open the way for the first experimental characterization of these important processes in the laboratory [3].

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