Particle acceleration in laser-driven magnetic reconnection

S. R. Totorica[1,2,3], T. Abel[1,2,4], F. Fiuza[3]

[1] Kavli Institute for Particle Astrophysics and Cosmology, Stanford University, Stanford, California, USA
[2] Department of Physics, Stanford University, Stanford, California, USA
[3] High Energy Density Science Division, SLAC National Accelerator Laboratory, Menlo Park, California, USA
[4] SLAC National Accelerator Laboratory, Menlo Park, California, USA

Magnetic reconnection is a fundamental plasma process that is thought to play a key role in the production of nonthermal particles associated with explosive astrophysical phenomena. Experiments at high-energy-density facilities are starting to probe the microphysics of reconnection at high Lundquist numbers and in strongly driven regimes. Using two- and three-dimensional particle-in-cell (PIC) simulations that match the conditions and geometries of current and future experiments, we explore the possibility of using laser-driven plasmas to study particle acceleration from reconnection in astrophysically relevant regimes. For the conditions of recent experiments, we find that direct acceleration by the reconnection electric field at the X-points can produce a nonthermal component of electrons resembling a power-law energy spectrum [1,2]. We have also explored particle acceleration in larger system sizes that may be produced with a more energetic laser-drive, such as at the National Ignition Facility. In this case, we show the possibility of exploring the multi-plasmoid regime, where plasmoid acceleration becomes dominant. We will discuss the transition between X-point and plasmoid-dominated acceleration, and how the maximum energy depends on the system size and plasma parameters. Finally, we will discuss the role of collisionality and how it can impact plasmoid formation and particle acceleration in these experiments.

[1] S. R. Totorica, T. Abel, and F. Fiuza, Phys. Rev. Lett., 116, 095003 (2016).
[2] S. R. Totorica, T. Abel, and F. Fiuza, Phys. Plasmas, 24, 041408 (2017).