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Nonthermal electron and ion acceleration by magnetic reconnection in large laser-driven plasmas

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Magnetic reconnection is a fundamental plasma process that plays a key role in the production of nonthermal particles in space physics and astrophysics. Experiments at high-energy-density facilities are starting to probe the microphysics of reconnection at high Lundquist numbers and large system sizes. We present kinetic particle-in-cell (PIC) simulations of particle acceleration from reconnection in large system sizes that may be produced with the most energetic laser drivers available, such as at the National Ignition Facility. In these conditions, we show the possibility of reaching the multi-plasmoid regime, where plasmoid acceleration becomes dominant. The transition from X point to plasmoid-dominated acceleration associated with the merging and contraction of plasmoids extends the maximum energy of the power-law tail of the particle distribution for electrons. We find for the first time a system size dependent emergence of nonthermal ion acceleration in driven reconnection, where the magnetization of ions at sufficiently large sizes allows them to be contained by the magnetic field and energized by direct X point acceleration. For experimentally feasible conditions, electrons and ions can attain energies exceeding their thermal energies by 2-3 orders of magnitude. Using PIC simulations with binary Monte Carlo Coulomb collisions we study the impact of collisionality on plasmoid formation and particle acceleration. We discuss the implications of these results for understanding the role reconnection plays in accelerating particles in space physics and astrophysics [1].

References

[1] S. Totorica, M. Hoshino, T. Abel, and F. Fiuza, "Nonthermal electron and ion acceleration by magnetic reconnection in large laser-driven plasmas", Physics of Plasmas 27, 112111 (2020).