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Electron Energy Spectrum Evolution during Magnetic Reconnection in Laser-Produced Plasma

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Abstract

Two-dimensional (2D) particle-in-cell (PIC) simulations are performed to investigate the evolution of electron energy spectrum during magnetic reconnection in laser-produced plasma. Two plasma bubbles surrounded with toroidal magnetic field are setted as the initial condition. The two bubbles expand and collide with each other, and then, magnetic reconnection occurs between them. Magnetic reconnection in laser-produced plasma can be divided into two stages, squeezing stage and reconnection stage. In the first stage, due to the expanding and squeezing of the two plasma bubbles, the toroidal magnetic field is enhanced, especially in the colliding region. The magnetic field enhancement lead to a large Alfven speed, which is responsible for the rapid reconnection in the second stage. During the first stage, electrons are heated by betatron mechanism due to the enhancement of the magnetic field. Meanwhile, non-thermal electrons are formed by bouncing between the two approaching plasma bubbles and getting energy through the inductive electron field when they are reflected by the magnetic field (Fermi-like acceleration). After these accelerations, the electron energy spectrum shows a Maxwellian distribution at low energy and a power-law distribution at high energy. The temperature of the Maxwellian part is in consist with the prediction by betatron mechanism through the magnetic field enhancement. The power-law formed due to the Fermi-like mechanism display a harder spectrum index for larger initial expanding speed of the plasma bubbles. During the second stage, electrons get further energization by the reconnection electric field. However, it is showed that for larger initial expanding speed, the Fermi-like mechanism is more important in producing non-thermal electrons than the magnetic reconnection.

References

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