Study on particle acceleration mechanism due to interaction between one-dimensional fast plasma flow and perpendicular magnetic field

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Acceleration mechanisms of non-relativistic charged particles is an important issue for understanding generation processes of cosmic rays (CRs). CRs are generated by the interaction between a fast plasma flow and electromagnetic fields in collisionless shocks. Diffusive shock acceleration (DSA) has been widely accepted as a standard model for the energy growth process of relativistic particles because DSA explained the non-thermal energy distribution with the power-law spectrum of CRs [1]. On the other hand, the initial acceleration process in non-relativistic region for generating non-thermal particles and for driving DSA has been discussed by many previous works [2].

To obtain a fast plasma flow in a laboratory scale experiment with the similarity for the space plasma, we have developed a tapered cone plasma focus device (TCPFD) [3]. The behavior of the plasma flow generated by the TCPFD in a perpendicular magnetic field has been investigated. The experimental results and the numerical results showed the particle acceleration phenomenon via the interaction between the one-dimensional fast plasma flow and the perpendicular magnetic field [4].

In this study, we have investigated the particle acceleration mechanism due to the interaction between the one-dimensional plasma flow and the perpendicular magnetic field by using a numerical simulation. The numerical simulation based on an electromagnetic hybrid particle-in-cell method was carried out in four-dimensional phase space (x, v_x, v_y, v_z). The flow direction of the plasma is x, and the magnetic field B_z is applied in the perpendicular direction to the plasma flow. The numerical result indicated the existence of the accelerated ions [4]. The magnetic field is compressed with the propagation of the plasma flow, and the spatial gradient of the magnetic field is formed. The gradient of the magnetic field induces the electron current J_{ey} on y-direction, and the Lorentz force due to $J_{ey} \times B_z$ affects the behavior of the ions.

References

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