Eo-025 Room: C510 Time: June 7 9:30-9:45

"Acceleration without energy dissipation" of preferential particles in collisionless plasmas

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One of nonlinear phenomena in the collisionless plasmas is a wave-particle interaction. We study the wave-particle interaction where waves exist in the 3 component plasmas that consist of electrons, protons, and alpha particles. We find that the alpha particles in the resonant velocity region that is determined by an injected wave are preferentially and orderly accelerated without random-walking and without energy dissipation. In addition to the numerical study we derive the theoretical equation for the movements of every preferential particle. It is very interesting that the preferential particles are orderly accelerated without energy dissipation in such system that many nonlinear actions complexly influence them.

One of nonlinear phenomena in the collisionless plasmas is a wave-particle interaction. This interaction has an important role for the acceleration and heating of particles in a shock, turbulence, solar wind, polar coronal holes and so on.

When waves exist in the 2 component plasmas that consist of electrons and protons, each particle random-walks through the wave-particle interaction. Hence the particles are diffused with energy dissipation. This nonlinear phenomenon has been discussed through a quasi-liner theory etc. We study the wave-particle interaction where waves exist in the 3 component plasmas that consist of electrons, protons, and alpha particles. In the 3 component plasmas there is the wave (Lp-mode) having very faster phase velocity and contrariwise slower group velocity than the Alfven velocity that is typical velocity for magnetohydrodynamic waves. We investigate the motion of the particles in Lp-mode and a normal magnetohydrodynamic wave using a test particle simulation. We find that the alpha particles in the resonant velocity region that is determined by an injected wave are preferentially and orderly accelerated without random-walking and without energy dissipation. In addition to the numerical study we derive the theoretical equation for the movements of every preferential particle. The preferential particle velocity for the perpendicular direction to an ambient magnetic field oscillates and the absolute value of the velocity for the parallel direction increase linearly because the wave having the fast phase velocity decouple a electric disturbance and a magnetic disturbance, and disturbances separately influence the particles. It is very interesting that the preferential particles are orderly accelerated without energy dissipation in such system that many nonlinear actions complexly influence them. We find that the conditions that the acceleration of the preferential particles without energy dissipation happens,

1; a wave having very faster phase velocity than Alfven velocity exists,

2; the length scale of disturbance except this wave is very smaller than that of this wave.

3; a magnetic disturbance except this wave is stronger than that of this wave and contrariwise an electric disturbance is weaker.

We research how such wave is excited. We performed liner analysis of beam instability for the wave propagating to the parallel direction. Excited waves are easily satisfied with the condition 1 and 3 at a time, but it is difficult to be satisfied 2 at a time. The beam instability for the wave propagating to the oblique direction and the parametric instability may excite such wave, so this is further study. Influences to the field by the orderly particles are neglected in the test particle simulation. We will perform a hybrid simulation that include this effect and will show the results.