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Electron heating influenced by Whistler wave packets at quasi-parallel shock waves

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The plasma wave receiver onboard Geotail spacecraft revealed that the plasma waves observed around the Bow shock region are closely related to electron dynamics and that they are the results of the nonlinear processes. In order to investigate the plasma dynamics and wave-particle interactions around the Bow shock, we have carried out a one-dimensional full particle computer simulation concerning quasi-parallel shock waves.

The plasma wave receiver onboard Geotail spacecraft revealed that the plasma waves observed around the Bow shock region are closely related to electron dynamics and that they are the results of the nonlinear processes. In order to investigate the plasma dynamics and wave-particle interactions around the Bow shock, we have carried out a one-dimensional full particle computer simulation concerning quasi-parallel shock waves. The electromagnetic simulation code we used is based on the KEMPO, in which the equations of motion of both ions and electrons, and Maxwell's equation are solved selfconsistently by using the PIC method. We treated plasma particles as superparticles. The shock wave is driven by the magnetic piston method in our model. The Mach number of shock waves can be adjusted freely by changing the amplitude of the magnetic piston. In the case of low Mach number, the electromagnetic wave with the large amplitude can be excited in the transiton region and propagate towards the upstream region. It is found that this large amplitude wave results from the nonlinear evolution of the Whistler wave excited by the ion beam instability, which is caused by the ions reflected at the shock surface. On the other hand, we cannot see the wave packets in the case of high Mach number because the resonance condition between the wave and the reflected ions does not become satisfied. We also focus on the acceleraton of electrons along the magnetic field due to the electric field generated by both the shock potential and the Whistler wave packets in the transition region. The field-aligned velocity of electrons becomes high as the Mach number increases in the case of low Mach numbers, where the Whistler wave packets exists. We cannot see, however, the dramatic increase of the field-aligned velocity of electrons in the case of high Mach numbers because the field-aligned electric field is caused only by the shock potential. The difference of drift velocities of electrons and ions along the magnetic field can induce the ion-acoustic instability. The electrons are heated up by the instability in the downstream region. We can see the anisotropic tendency of electron temperature in this region. It is also found that the velocity distribution of electrons becomes flat-topped, which is consistent with the observational results.