PIC simulation of quasi-parallel terrestrial bow shock

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Electromagnetic wave excitation and associated particle acceleration in collisionless shocks are fundamental issues in astrophysical and space plasma physics. In the quasi-parallel collisionless shock, some of the incoming ions are reflected at the shock and stream away from the shock along the upstream magnetic field. These field-aligned beams (FABs) generate electromagnetic waves far upstream, and they subsequently steepen during the plasma convection. Therefore, the turbulence extends to a large domain of the upstream region of the quasi-parallel shock. The kinetic self-consistent numerical simulation is one of the key tools to analyze detailed physics of the collisionless shock.

In this presentation, to model the quasi-parallel Earth's bow shock, we perform the full PIC simulation of a collisionless shock with Alfven Mach number 6.6, shock angle 20 degrees, and plasma beta 0.5 for both ions and electrons. Our findings are as follows. (1) generation of the FAB, (2) right-handed Alfven wave excitation through resonant mode instability, (3) generation of high-frequency whistler waves due to the steepening of low-frequency Alfven wave, (4) electron acceleration due to the whistler waves.