Ion heating and energization by the ion beam instability and magnetic reconnection in the Earth's quasi-parallel bow shock

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Abstract

We investigate roles of the ion beam instability and magnetic reconnection on the ion heating and energization in the Earth's quasi-parallel bow shock, by means of 2D particle-in-cell simulation. In a high Alfven Mach number ($M_A > 10$) quasi-parallel shock, the non-resonant ion-ion beam mode is excited and it propagates downstream of the shock. Magnetic field lines are bent by the wave, and many current sheets are produced. Magnetic islands are generated due to reconnection, and the ion temperature in those islands becomes higher than that in the surrounding regions. We demonstrate that the increase of the ion temperature inside those islands is due to (1) the reduction of the cold incident ions and (2) actual heating in the reflected ions. In the ion-ion beam mode, a density fluctuation grows because the wave contains electrostatic fluctuations. The reduction of the incident ions causes the ion temperature enhancement. Further ion heating occurs due to reconnection, and unmagnetized ions that pass through reconnection regions and islands can gain energy. In a 2D PIC simulation, we investigate the trajectories of energetic ions, and we present how ions gain energy in the shock transition region.

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