Wave-particle interactions with whistler precursor in the interplanetary shock upstream

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Abstract

The evolution of plasma entropy and the process of plasma energy redistribution at the collisionless plasma shock front are evaluated based on the high temporal resolution data from the four Magnetospheric Multiscale spacecraft during the crossing of the terrestrial bow shock. The ion distribution function has been separated into the populations with different characteristic behaviors in the vicinity of the shock: the upstream core population, the reflected ions, the gyrating ions, the ions trapped in the vicinity of the shock, and the downstream core population. The values of ion and electron moments (density, bulk velocity, and temperature) have been determined separately for these populations. It is shown that the solar wind core population bulk velocity slows down mainly in the ramp with the electrostatic potential increase, but not in the foot region, as it was supposed. The reflected ion population determines the foot region properties, so the proton temperature peak in the foot region is an effect of the relative motion of the different ion populations, rather than an actual increase in the thermal speed of any of the ion populations. The ion entropy evaluated showed a significant increase across the shock: the enhancement of the ion entropy occurs in the foot of the shock front and at the ramp, where the reflected ions are emerging in addition to the upstream solar wind ions, the anisotropy growing to generate the bursts of ion-scale electrostatic waves. The entropy of electrons across the shock does not show a significant change: electron heating goes almost adiabatically.

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