地球定在衝撃波における粒子加速:空間依存性

Particle acceleration at the earth's bow shock: Spatial dependence

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We present Geotail observations of diffuse ions (several keV/q - 40 keV/q) in the upstream region of the bow shock, covering from the nominal upstream region (X \ge 0 Re) to the predawn upstream region (X \ge ~-120 Re). The intensity of the diffuse ions is highest in the nose upstream region (XGSE \ge ~+10 Re), and becomes weaker as XGSE reduces. While in the nose upstream region these ions are more or less isotropic and have characteristic e-folding energies of ~ 20-30 keV, in the pre-dawn upstream region they have anisotropic pancake distributions (perpendicular \gt parallel) around the IMF and much smaller e-folding energies (\lt ~10 keV). The intensity of the diffuse ions in the pre-dawn region is controlled by the direction of the interplanetary magnetic field (IMF) and is maximized when the IMF is around the nominal spiral direction. These observations are consistent with the model that the diffuse ions are predominantly produced in the nose upstream region and transported by the solar wind flow mainly in the direction perpendicular to the IMF (namely, transport with the ExB drift motion). Note that the above model was originally suggested from the early ISEE-3 observations of diffuse ions in the pre-dawn upstream region (Terasawa et al., 1985), but has been unconfirmed since the early observations lacked complete energy and angular coverage of diffuse ions. With the new Geotail data, we have finally obtained the confirmation of the model.

While standard shock acceleration theory has been developed for the plane shock geometry with an infinite lateral extent, any realistic astrophysical shocks should have finite extents. For example, interplanetary CME shocks have limited spatial sizes and is expected to be strongest around the 'nose' of the ejecta where the acceleration of energetic particles is most efficient (e.g., Reams et al.). We will discuss implications of the bow shock observations in the general context of acceleration problems with shocks of finite spatial extents.