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Detailed Analysis of Upstream Ion Distributions Observed by Cluster-CIS

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Multispacecraft observations from Cluster of backstreaming ions upstream of the bow shock are presented. We will emphasize new features that have not been reported. Particularly, parallel and perpendicular reduced distribution functions of field-aligned beams and gyrating ions are presented in detail. For the purpose of a quantitative study, we used the functional $f(x) \sim exp(-\beta x^{\alpha})$ to fit the reduced distributions. We have found that the reduced ion distribution profiles associated with the field-aligned beams are strongly dependent upon θ_{Bn}, the angle that makes the ambient magnetic interplanetary field with the local shock normal. Above a critical value of θ_{Bn}^{c}, the distributions are remarkably well fit for $\alpha \leq 2$. When the beam speed decreases as θ_{Bn} decreases, a high energy tail appears, whereas the bulk of the distribution remains nearly Maxwellian. These energetic tails harden with decreasing θ_{Bn} angle. Moreover, the pitch angle distributions clearly indicate that the ions in the tail have a significant perpendicular velocity and the pitch angle is energy-dependent.

Similar features in the reduced distribution functions are also observed for gyrating ions typically at more oblique values of θ_{Bn}. The goal is to compare the non-Maxwellian part of field-aligned beams with the gyrating ions. These high energy tails do not result from electromagnetic instabilities occuring in the foreshock. If they are produced within the shock layer, the mechanism remains unknown.