MMS Observation of Inverse Energy Dispersion in Shock Drift Accelerated Ions

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The four Magnetospheric Multiscale (MMS) spacecraft observed a ~1 min burst of energetic ions (50-1000 keV) in the region upstream from the subsolar quasi-perpendicular bow shock on December 6, 2015.
The composition, flux levels, and spectral indices of these energetic protons, helium, and oxygen ions greatly resemble those seen in the outer magnetosphere earlier while MMS crossed the magnetopause and differ significantly from those simultaneously observed far upstream by ACE.
However, the event cannot be explained solely in terms of leakage from the magnetosphere. The strongly southward orientation of the interplanetary magnetic field (IMF) lines at the time of the event precludes any connection to the magnetosphere. This point is confirmed by the presence of energetic electrons, known to occur on magnetic field lines that graze the bow shock rather than connect to the magnetosphere.
We suggest that the ions gradient drifted out of the nearby quasi-parallel foreshock and into the quasi-perpendicular bow shock. Each of the ion species exhibited an inverse energy dispersion. As predicted by models for shock drift acceleration, the energies of the ions increased as Θ_{Bn}, the angle between the IMF and the shock normal, increased. Finally, we note that a similar event was observed a few minutes later in the subsolar magnetosheath, indicating that such events can be swept downstream of the bow shock.

