



Suprathermal ion populations upstream of interplanetary shocks

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Although energetic ion populations upstream of interplanetary (IP) shocks have been studied for decades, the majority of the studies reported observing only diffuse ions. There are only two exceptions (Viãs et al. 1984 and Tokar et al. 2000) but these works could not determine the details of ion distribution functions. Here we show for the first time that different types of suprathermal ion distributions may exist upstream of a single IP shock. The shock presented here was observed by ACE and the two ARTEMIS satellites on 8 October 2013. The ARTEMIS P1 and P2 spacecraft observed different ion populations arriving from the shock. They first observed field-aligned ions (P1) and gyrating ions (P2). These were followed by intermediate ions and later by a diffuse population. At the location of the P2 the shock exhibited an Alfvénic Mach number of $M_A=5.7$ and the angle between the upstream interplanetary magnetic field and the local shock normal was $\theta_{Bn}=47^\circ$, so the shock was marginally quasi-perpendicular. At P1 spacecraft the shock was weaker ($M_A=4.9$) and more oblique ($\theta_{Bn}=61^\circ$). The observed suprathermal ion and ultra low frequency wave properties were somewhat different. At P2 the ULF waves are more intense and extend farther upstream from the shock. The energies of field aligned and gyrating ions in the shock rest frame were ~ 20 keV, which is much more than in the case of the stronger ($M_A=6-7$) Earth's bow-shock, where they are less than 10 keV.