Trajectories of the solar wind He++ across the bow shock

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The recent Geotail observation on 30 March 2011 gives the profile of quasi-perpendicular bow shock crossing, where we find interesting features in the energy distribution of the solar wind subcomponent, He^{++}. When crossing the bow shock into the magnetosheath, the bulk solar wind (mainly proton) is normally heated and decelerated. On the contrary, from this observation, He^{++} did not undergo evident heating nor deceleration, rather showed an increase in energy across the shock. Detailed analyses indicate that the ring-type velocity distribution for He^{++} is correspondingly identified in the shock downstream.

In order to elucidate the physical mechanism of this observed profile, we perform one-dimensional hybrid simulations including both protons and He^{++} particles. We apply several parameter sets, which distinguish the shock properties such as its Mach number and normal angle, as well as the He^{++} density ratio to that of protons. We find that within the limited parameter ranges the ring distribution for He^{++} certainly forms in the shock downstream. Whether the ring forms or not mostly depends on the shock Mach number and the density ratio, the physical properties of which are focused on in this talk.

The value of the particles's Q/M (charge over its mass) characterizes its gyration scale. Therefore, in the case of the field variation scale comparable to it, particle species of different Q/M must exhibit different trajectories. Transition across the shock is one of the most abrupt variation and its scale is a few proton inertial lengths. Thus we suppose that the trajectories of He^{++} largely deviate from those of protons through the shock crossing. Some parameter sets regulate the shock strength such that the protons are sufficiently decelerated while He^{++} are not. The He^{++} bulk velocity consequently becomes different from that of protons. This process results in the ring formation in the He^{++} velocity space around the bulk proton flows, which well accounts for the present observation.