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O^+ pickup ions outside of Venus' bow shock: Venus Express observation

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Abstract

Pickup ions are ions of planetary origin that become assimilated into the solar wind flow through their interaction with the solar wind magnetic and electric field. The speed of pickup ions varies between zero and twice the underlying plasma flow component perpendicular to magnetic field vector. For the unmagnetized planet Venus and Mars, oxygen (O^+) pickup ions are known to be important because they can modify the global configuration of planetary plasma environment and significantly contribute to the atmospheric O^+ loss [1].

Since the kinetic energy of an O^+ pickup ion can reach 64 times that of a co-moving proton, an instrument must be able to measure O^+ ions with energy of at least tens of keV to investigate the O^+ pickup ion distribution from planetary ionosphere to solar wind. The *in-situ* observations and simulations at Mars have shown that the energy of O^+ pickup ions can be 55-72 keV outside of the bow shock [2]. For Venus case, the plasma analyzer (OPA) onboard Pioneer Venus Orbiter (PVO), which was designed for solar wind monitoring, has an 8 keV energy limit for O^+ detection and the limited sampling and data rate [3]. Therefore, OPA can only measure the O^+ pickup ions in the sheath flow or inside the induced magnetosphere where the speed of ambient plasma flow is significantly lower than that of the unshocked solar wind outside of the bow shock.

The Ion Mass Analyzer (IMA), included in the Analyzer of Space Plasma and Energetic Atoms (ASPERA-4) package on board Venus Express (VEX), determines the composition, energy, and angular distribution of ions in the energy range ~10 eV/q to 30 keV/q. Note that an O^+ ion moving at the typical solar wind speed 400 km/s has kinetic energy 13.4 keV. Therefore, IMA has ability to measure the O^+ pickup ions outside of Venus' bow shock.

We have examined the IMA data during the solar minimum period 2006-2010, and identified about ten cases with clear signature of O^+ pickup ion. With these observations, we will determine the location and the scale height of the source region of O^+ pickup ions and describe the relationship between the behavior of these O^+ and the upstream solar wind condition. The results would provide new information for numerical simulation of plasma environment near Venus and contribute to estimation of total O^+ ion loss from Venus.

Reference:

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