

Challenges to measure kappa distributions in the terrestrial ionosphere

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Low energy ion distributions in the terrestrial ionosphere often show power-law tails with an exponential core, described by kappa distributions. For example, in the polar wind, a combination of the polarization electric field acceleration and the Coulomb collisions can produce the suprathermal tail (Barghouthi et al., 2001) because Coulomb collisions mainly affect low energy particles while the high energy particles are more efficiently accelerated by the upward directed ambipolar electric field. As another example, the ring beam relaxation (Moore and Khazanov, 2010) generated via perpendicular velocity diffusion can also produce kappa distributions. In the ionosphere, the transversely accelerated ions lower-hybrid wave activities (Andre et al., 1994) or ion pick-up processes. k-distribution-like tails have been observed in the vicinity of the space shuttle (Gurnett et al., 1988) and were attributed to the products by the water-group ion pick up processes. These mechanisms are ubiquitous in space plasmas, and it is important to characterize these suprathermal distributions in situ. However, there have been difficulties with making this observation.

Current state-of-the-art instruments to cover these low-energy ions from Low-Earth Orbit (LEO) are either Retarding Potential Analyzers (RPA) or Ion Drift Meter (IDM). RPA and IDM present a planar energy barrier to incoming supersonic charged particles and collect the charged particles that are able to overcome the barrier with a plate at the back of the instrument. When coupled with good spacecraft velocity data and attitude knowledge, analysis of the current-voltage (I-V) relationship provides the thermal ion flow speed in the direction of the spacecraft, the ion temperature and the fractional composition of the plasma. IDM can calculate the ion drift velocity by using split collector plates and the current ratio between plates. However, a fundamental shortcoming of this technique is determining the ionic concentrations (e.g., Knudsen et al., 1966). Thus, the suprathermal portions of lighter ions are always contaminated by heavier particle contributions. In addition, the precise determination of the ring distribution is impossible with the coarse angular distribution of IDM. In this paper we discuss new techniques to advance the study of ionospheric particles.

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