Ion streaming instability and solitary structures associated with escaping planetary ions at Mars

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NASA's MAVEN spacecraft has been in orbit around Mars since September 2014. Its contentious measurements of the Martian plasma environment have confirmed the persistent presence of a stream of planetary ions (mainly O+ and O2+) that originate from the dayside ionosphere and flow outward, across the Martian induced magnetosphere, into the interplanetary space [Dong et a., 2015]. This stream of planetary ions combined with pick-up ions from the extended Martian corona forms what is sometimes referred to as the Martian "polar plume". Acceleration of the ions outside of the induced magnetosphere is attributed to the motional electric field of the solar wind. However, at altitudes closer to the ionosphere the dominant energization mechanism may be due to plasma waves and wave-particle interactions.

Here, we present new results, obtained by several wave and particle instruments onboard MAVEN, that establish the presence of intense plasma wave activity in conjunction with the initial stage of the ion energization inside the induced magnetosphere. The plasma waves are observed over a broad frequency range that extends from below the lower-hybrid frequency (~10 Hz) to the vicinity of the electron cyclotron (~ kHz) and ion plasma frequencies (~kHz). High-resolution electric field burst data, furthermore, show the presence of large-amplitude solitary structures including uni-polar electric field features that likely contain net parallel potential. At the time of the turbulence, strong response is sometimes observed in electron flux at energies close to 100--200 eV. We discuss the plasma wave observations in the context of lower-hybrid-type and ion-acoustic instabilities that emerge as a result of relative drifts between various plasma species originating from the ionosphere and the solar wind. The latter instability mechanism may be essentially the same process that is responsible for the generation of enhanced ion-acoustic waves sometimes detected by incoherent scatter radars in the F region of the Earth's auroral ionosphere.

References

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