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Plasma Waves and Solitary Structures in the Interaction Region of the Solar Wind and the Martian Upper Atmosphere

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NASA's MAVEN spacecraft has been in orbit around Mars since September 2014. Its extensive measurements have enhanced our understanding of the interactions of the solar wind with the Martian plasma environment, specifically how the transfer of energy and momentum from the solar wind to the planetary ions leads to heavy ion escape. Such energization of planetary ions is often attributed to processes that are represented in the generalized Ohm’s law---namely, the motional electric field of the solar wind, j × B force due to the magnetic shear stresses of the draped field lines, as well as the ambipolar electric field at lower energies.

Here, we present results obtained by several wave and particle instruments onboard MAVEN that establish the presence of intense plasma wave activity in conjunction with ion energization inside the Martian 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). The spectral characteristics suggest that instabilities involving the lower-hybrid and ion-acoustic branches are often present. Further, high-resolution electric field burst data show the presence of large-amplitude solitary structures, identified as ion phase-space holes and double layers associated, with the instabilities. Our goal here is to quantify the significance of the instabilities and the kinetic interactions in the transfer of energy and momentum from the solar wind to the planetary plasma. We will present case studies of MAVEN data along with results from linear stability analysis to identify the sources of the free energy for the instabilities, as well as results from kinetic simulations to quantify the extent of energy and momentum transfer between various particles facilitated by the waves.