Martian Electron foreshock: new results from MAVEN and comparison with terrestrial electron foreshock

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Observations upstream from the Martian bow shock have been obtained by the MAVEN Solar Wind Electron Analyzer (SWEA) and particularly in the foreshock, and can interestingly be compared with the terrestrial observations.
At Mars, significant flux enhancements associated with electrons in the energies 50-400 eV range are always observed when the MAVEN spacecraft is magnetically connected to the shock. The electron flux reaches a maximum near the shock surface.
A detailed examination of the pitch angle distribution shows that the enhanced fluxes correspond to electrons moving sunward away from Mars (foreshock backstreaming population). Also, the full 3-dimensional angular distributions show that the phase space density values are peaked at a non-zero pitch angle and that the electrons appear in a ring centered along the IMF direction. The gyrotropic feature is observed over a large range of the shock geometry from quasi-parallel to quasi-perpendicular. These signatures in the electron distribution function strongly suggest that the reflection off the shock is the main mechanism for the production of Martian foreshock electrons.
In addition, spikes of energetic electrons up to ~ 1.5 keV are detected near the Martian foreshock boundary. The spikes usually appear following a rotation of the interplanetary magnetic field (IMF). We show that they emanate from a narrow region at the tangency point of the IMF with Martian bow shock. The examination of their pitch angle distribution indicates that these spikes are also associated with electrons moving sunward. The 3-D angular measurements from MAVEN-SWEA detector show that for these spikes the values of phase-space density values are also maximum on a ring centered about the IMF. There is no clear evidence that the radius of the ring is energy dependent. These features have demonstrated for the first time that Mars acts as a fast magnetic mirror which can reflect solar wind electrons to produce high energy electron bursts. A quantitative analysis has been carried out and a higher bound of the cross-shock potential of Mars bow shock can be estimated.
Although striking differences exist between the Earth and Mars shock structures, these observations show strong similarities in both the Terrestrial and Martian electron foreshocks.