



ULF waves in the Martian foreshock: MAVEN observations

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Foreshock ULF waves constitute a significant physical phenomenon of the plasma environment for terrestrial planets. The occurrence of these ULF waves, associated with backstreaming ions reflected and accelerated at the bow shock, implies specific conditions and properties of the shock and its foreshock. Using measurements from MAVEN, we report clear observations of this type of ULF waves in the Martian foreshock. We show from different case studies that the peak frequency of the wave case in spacecraft frame is too far from the local ion cyclotron frequency to be associated with local pickup ions taking into account the Doppler shifted frequency from a cyclotron resonance, the obliquity of the mode, resonance broadening and experimental uncertainties. On the opposite their properties fit very well with foreshock waves driven unstable by backstreaming field-aligned ion beams. The propagation angle is usually less than 30 degrees from ambient magnetic field. The waves also display elliptical and left-hand polarizations with respect to interplanetary magnetic field in the spacecraft frame. It is clear for these cases that foreshock ions are simultaneous present for the ULF wave interval. Such observation is important in order to discriminate with the already well-reported pickup ion (protons) waves associated with exospheric hydrogen in order to quantitatively use the later to study seasonal variations of the hydrogen corona.