Magnetosonic waves driven by proton ring distributions in the Martian magnetosphere

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We present MAVEN observations of magnetosonic waves at the local proton cyclotron frequency in the Martian magnetosphere. As a consequence of the lack of a global magnetic field of internal origin, the upper atmosphere of Mars directly interacts with the solar wind, thereby forming an induced magnetosphere. The majority of the solar wind plasma diverts around the obstacle, but some fraction of the hot magnetosheath protons have access to the upper ionosphere of Mars due to their large gyroradii with respect to the size of the induced magnetosphere. As a result, ring/shell-like proton velocity distribution functions are formed just below the induced magnetospheric boundary in the presence of cold, dense protons of ionospheric origin.

Below the induced magnetospheric boundary, MAVEN detected narrowband compressional waves at the local proton cyclotron frequency (and its harmonics for some cases) typically in the presence of both hot ring protons and cold ionospheric protons. The occurrence of the waves at the local proton cyclotron frequency is strongly controlled by solar extreme ultraviolet (EUV) conditions, showing a distinct preference for high EUV. The wave properties and their dependence on local and upstream conditions can be mostly explained by a proton Bernstein mode instability driven by a positive perpendicular slope in proton velocity distribution functions. The wave properties and their association with ring protons exhibit striking similarities to the magnetosonic waves observed in the terrestrial inner magnetosphere. These "Martian magnetosonic waves" potentially facilitate energy transport from the precipitating hot protons of magnetosheath origin to the cold ionospheric protons.

Keywords: Mars, magnetosonic waves, proton ring distributions