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Generation of hydrogen, helium and oxygen EMIC waves by fast magnetosonic shocks in the magnetosphere and in the solar wind

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Abstract

Electromagnetic ion cyclotron (EMIC) waves are often observed in the magnetosphere and in the solar wind. Here we propose a new generation mechanism for hydrogen, helium and oxygen EMIC waves associated with fast magnetosonic shocks in the magnetosphere and in the solar wind. In the magnetosphere, these shocks can be associated with either dynamic pressure enhancement or shocks in the solar wind and can lead to the formation of a “bunch” distribution of O+ ions in the perpendicular velocity phase space. The O+ bunch distribution can excite strong He+ EMIC waves and weak O+ and H+ waves. The dominant He+ EMIC waves are strong in quasi-perpendicular propagation and show harmonics in frequency spectrum of Fourier analysis. Further analysis by using Hilbert-Huang transform shows that these signals are similar to Duffing oscillations and exhibit frequency modulation in the instantaneous frequency spectrum. The proposed mechanism can explain the generation and some observed properties of He+ and O+ EMIC waves in the magnetosphere.

Strong fast magnetosonic shocks are often observed in the solar wind. In the shock downstream, the hydrogen and helium ions are strongly heated to achieve high ion beta and high temperature anisotropy. These conditions can lead to efficient generation of EMIC waves and mirror mode waves in the downstream, which are often identified in satellite observations in the solar wind. We find that the EMIC waves are generated both in the parallel and quasi-perpendicular directions. The parallel EMIC waves have been widely studied theoretically and observationally, while the excitation of quasi-perpendicular EMIC waves is usually overlooked. We also find coalescence of mirror waves as they drift with the plasma to further downstream.

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