ジオテイル衛星で観測された地球バウショックの上流ホイッスラーモード波動の統計解析

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Statistical analyses on upstream whistler-mode waves of terrestrial bow shock observed by Geotail

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Upstream whistler-mode waves have been observed in the upstream region of various solar system bodies and have been studied over four decades. The upstream whistler-mode waves are categorized into two types: left-hand polarized narrowband waves in the frequency range near 1 Hz and right-hand polarized broadband waves in the frequency range around the lower hybrid resonance frequency. To reveal the generation and propagation processes of these waves, we perform statistical analyses for these waves detected by the fluxgate magnetometer aboard Geotail in the upstream region of the terrestrial bow shock from February 1995 to December 1998 and from January 2007 to May 2012.

The results indicate that the condition to observe these waves are obviously restricted by the interplanetary magnetic field (IMF) direction; the narrowband waves are observed when IMF is nearly parallel to the solar wind flow, and the broadband waves are observed when IMF is nearly perpendicular to the solar wind flow. The dependences on the magnetic field direction, signatures of the observed frequency, spectral shape, and wave vector direction of the narrowband waves can be explained by the group-standing effects [Tsugawa et al., JGR 2014]. Considering the effects, we suggest that the narrowband waves are group-standing whereas the broadband waves are not group-standing and that these waves are generated in the same source region. Since most of properties of the narrowband waves are restricted and determined by the group-standing effects, the properties of the broadband waves should be investigated in order to understand their generation processes. We find that the amplitude of the broadband waves becomes large near the perpendicular shock region and the nose region, suggesting that these whistler-mode waves are mainly generated through the instability driven by particles reflected from the bow shock parallel to the magnetic field direction.