磁気圏シース領域の磁場極小におけるホイッスラーモード波動の空間スケール

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Spatial scale of whistler mode waves in magnetic dips in the magnetosheath

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In the terrestrial magnetosheath, intense whistler mode waves, called 'Lion roars', are often detected around minima of semi-periodic fluctuations of magnetic field intensity. The whistler mode waves are efficiently generated near a local minimum of magnetic field intensity along a field line due to the smallest resonance velocity. If a spacecraft passes through the effective source region along the magnetic field direction, a reversal of the field-aligned component of Poynting flux is observed. One of the important but not well-understood characteristics of wave is the spatial scale of the wave. Especially, because a single plain wave approximation is one of the important assumptions for analyses of waves, it is important to understand the spatial scale for which the plain wave approximation is valid. In the present study, spatial scales of whistler mode waves in and around such Poynting flux reversals are studied using the data obtained by the four MMS (Magnetospheric Multiscale) spacecraft. Using the data during ~7 km separation, which corresponds to ~5-10 gyro radii of electrons with energies comparable to the temperature, the observed phase difference of the whistler mode waves among the four spacecraft were compared with the prediction by the dispersion relation of plasma waves under the cold plasma approximation using the direction of the Poynting flux and the minimum variance direction of the wave magnetic field, which corresponds to the direction of wave number vector and was calculated for each rotation of the right-hand polarized wave in the plain perpendicular to the background magnetic field. Although the agreement between the predictions and observed phase differences were good out of the Poynting flux reversal, the phase differences frequently deviated from the predictions in the Poynting flux reversal regions. This would be due to the co-existence of forward and backward propagating waves in the Poynting flux reversal regions. On the other hand, in 9 wave events with Poynting flux reversals during the interval of ~40 km separation, the correlation of phase and amplitude among spacecraft were unclear and unstable. Thus, a few tens of electron gyro radii would be the upper limit of the spatial scale that the plain wave approximation is valid for the whistler mode waves in the magnetosheath even in the cases where the background magnetic field do not have significant small-scale structures in much larger ion-scale magnetic dips.