磁気圏シース領域のミラー構造内磁場極小付近でのホイッスラーモード波動の観測

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Observation of whistler mode waves near the local minimum of magnetic field intensity in the magnetosheath mirror structures

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Wave-particle interactions are thought to play a crucial role in energy transfer in collisionless space plasmas in which the motion of charged particles is controlled by electromagnetic fields. However, in general, it is not easy to discriminate whether a spacecraft which observed waves had been in an effective wave generation region or outside of it at the time of observation. In the terrestrial magnetosheath, intense whistler mode waves, called 'Lion roars', are often detected around minima of semi-periodic fluctuations of magnetic field intensity. It is expected that whistler mode waves are efficiently generated near a local minimum of magnetic field intensity due to the smallest resonance velocity. We report the detailed characteristics of such whistler mode waves using the data obtained by the four MMS (Magnetospheric Multiscale) spacecraft. Using four spacecraft magnetic field data, we can derive magnetic field gradient. From limited amount of burst data of whistler mode waves with clear semi-periodic fluctuations of magnetic field intensity in the intervals of appropriate spacecraft separations (~25 or ~40 km) in Phase 1A, we found that reversals of gradient of magnetic field intensity along the magnetic field correspond to reversals of field-aligned component of Poynting flux around minima of semi-periodic fluctuations of magnetic field intensity. Such a characteristic is consistent with the idea that the whistler mode waves are efficiently generated near the local minima of magnetic field intensity and propagate toward regions of larger magnetic field intensity along the magnetic field lines on both sides. This result confirms that reversals of the field-aligned component of Poynting flux that is measurable even by a single spacecraft is useful to find good candidates of effective wave generation regions along field lines. In such regions, electron distribution functions have characteristics which are consistent with those near the centers of mirror mode structures. Since anisotropy depends on energy, simple approximation of bi-Maxwellian distributions is not usable to estimate linear growth rates at such locations. Pancake or an outer edge of butterfly electron distributions from ~100 to ~400 eV are good candidates for effective wave generation at the local minima of magnetic field intensity along field lines.