Small scale whistler mode waves near the magnetic field intensity minimum in the magnetosheath

*Naritoshi Kitamura[1], Takanobu Amano[1], Yoshiharu Omura[2], Satoko Nakamura[2], Chika Umegaki[1], Scott A Boardsen[3,4], Narges Ahmadi[5], Robert E Ergun[5], Olivier Le Contel[6], Per-Arne Lindqvist[7], Yoshifumi Saito[8], Shoichiro Yokota[9], Daniel J Gershman[3], Barbara L Giles[3], Thomas E Moore[3], William R Paterson[3], Craig J Pollock[10], Christopher T Russell[11], Robert J Strangeway[11], James L Burch[12]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2. Research Institute for Sustainable Humanosphere, Kyoto University, 3. NASA Goddard Space Flight Center, 4. University of Maryland, 5. Laboratory for Atmospheric and Space Physics, University of Colorado, 6. Laboratoire de Physique des Plasmas, UMR7648 CNRS/Ecole Polytechnique/UPMC/Université Paris-Sud/Observatoire de Paris, 7. Royal Institute of Technology, 8. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 9. Department of Earth and Space Science, Graduate School of Science, Osaka University, 10. Denali Scientific, 11. Institute of Geophysics and Planetary Physics, University of California, Los Angeles, 12. Southwest Research Institute

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. In the terrestrial magnetosheath, intense whistler mode waves, called 'Lion roars', are often detected by spacecraft around minima of semi-periodic fluctuations of magnetic field intensity due to mirror mode structures and motion of the structures. It is expected that whistler mode waves are efficiently generated near a local minimum of magnetic field intensity due to the smallest cyclotron resonance velocity. We report the detailed characteristics of such whistler mode waves using the data obtained by the four MMS (Magnetospheric Multiscale) spacecraft. Because reversals of field-aligned component of Poynting flux around minima in mirror mode structures correspond to reversals of gradient of magnetic field intensity along the magnetic field, whistler mode events with reversals of the field-aligned component of Poynting flux are good candidates of observations of effective wave generation regions along field lines. Even in such events, phase difference and change of amplitude of whistler mode waves observed by the four spacecraft do not have a clear correlation in cases of ~40 km separation, which is much smaller than the spatial scale of magnetic field depression due to mirror mode structures and is even smaller than the local thermal ion gyro scale. This result indicates that the coherent whistler wave generation in mirror mode structures has very limited spatial scale across field lines and is probably affected by any electron scale process. A plane wave approximation can be usable only in a very small scale. Because some events in cases of ~7 km separation showed good correlation among four spacecraft, the typical scale of coherent whistler wave across field lines can be at least an order of 10 km in mirror mode structures in the terrestrial magnetosheath. The whistler mode waves observed by a spacecraft in a mirror mode structure are a cluster of waves from multiple spatially small sources.

Keywords: Whistler mode wave, Plasma wave, MMS spacecraft, Wave-particle interaction

