Competing Process between Mirror Instability and L-mode Electromagnetic Ion Cyclotron Instability in the Earth's Magnetosheath

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Spacecraft observations show that the mirror instability dominates over the L-mode electromagnetic ion cyclotron (EMIC) instability in the magnetosheath (see Figure 1), although the theoretical linear growth rate of the L-mode EMIC wave is higher than that of the mirror mode waves [1]. This has been a long-standing puzzle. To analyze the competing processes between the L-mode EMIC and mirror instabilities, we performed one-, two- and three-dimensional (1D, 2D and 3D) hybrid simulations, assuming anisotropic energetic ions[2].

In the 2D model, the energy of the L-mode waves is higher in the initial stages because their linear growth rate is larger than that of the mirror mode. In the 3D model, however, the energy of the mirror mode waves is larger than that of the L-mode waves for all times. This is because there are more directions of the wavenumber vectors of the mirror mode waves (degrees of freedom) in the perpendicular direction to the ambient magnetic field.

After the saturation of these instabilities, inverse cascading of L-mode EMIC waves and coalescence of the mirror mode waves take place in both models. We also developed a new 2D model to analyze the coalescence of monochromatic mirror mode structure. At this stage, the coalescence is slower process than the inverse cascading, and thus the temperature anisotropy of the protons is controlled by the inverse cascading process. Through the coalescence, the scale size of the mirror mode structure in the transient coalescence process of the 3D model (~ 40 ion inertial lengths) becomes in good agreement with planetary magnetosheath observations.

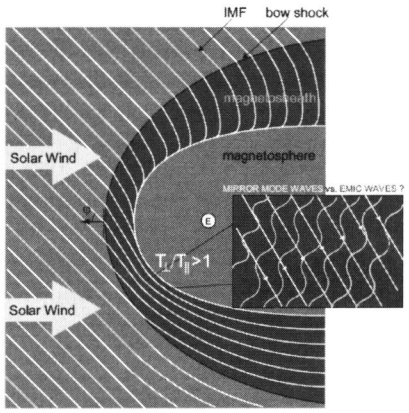

Figure 1. The logo of Kyoto University. The figure caption should be under the figure.

Furthermore, we analyzed the relation between the mirror instability and the magnetic peaks/dips which are observed in the magnetosheath. The 3D simulation result indicates that the mirror instability contributes only to the magnetic peaks actually observed in the magnetosheath.

Acknowledgements

Computation in the present study was performed with the KDK system of Research Institute for Sustainable Humanosphere (RISH) and Academic Center for Computing and Media Studies at Kyoto University as a collaborative research project.

References

[1] Tsurutani, B. T., E. J. Smith, R. R. Anderson, K. W. Ogilvie, J. D. Scudder, D. N. Baker, and S. J. Bame, "Lion roars and nonoscillatory drift mirror waves in the magnetosheath," *J. Geophys. Res.*, vol. 87, no. A8, pp. 6060-6072, 1982.

[2] Shoji, M, Y. Omura, B. T. Tsurutani, O. P. Verkhoglyadova, and B. Lembege, "Mirror instability and L-mode Electromagnetic Ion Cyclotron Instability: Competition in the Earth's Magnetosheath, *submitted to J. Geophys. Res.*