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オーロラ乱流の発生とそのスペクトル特性
Generation of Auroral Turbulence and its Spectral Characteristics

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Formation of auroral arc structures and their dynamics have been investigated from a point of view of interactions between the magnetospheric and ionospheric plasmas via the shear (or kinetic) Alfven waves. The feedback instability, of which energy source is an input Poynting flux through a large-scale electric field driving the convection ExB flow in the magnetosphere, is considered as a possible mechanism to explain self-excitation of the arc structure with enhancement of perturbations in the ionospheric density, the field-aligned current, and the polarization electric field. If the convection flow exceeds a critical value, the arc structure can grow with amplification of the upward and downward propagating Alfven waves. Thus, nonlinear interactions of the conter propagating waves are expected to induce Alfvenic turbulence, if they could grow to a large amplitude through the feedback instability. The Alfvenic turbulence is also observed by spacecraft in the auroral region. Here, we call it auroral turbulence as it would be related to turbulent behaviors of auroras in the ionosphere. In this study, we have investigated generation process of the auroral turbulence, and its characteristics by means of a simulation model of the magnetosphere-ionosphere (M-I) coupling.

The M-I coupling model consists of the reduced magnetohydrodynamic (MHD) equations for the magnetospheric plasma and the height-integrated two-fluid equations for the ionospheric plasma. Our previous study [1] reveals the Kelvin-Helmholtz (K-H) type modes are secondarily destabilized when the feedback instability has grown beyond a critical amplitude. This is because the auroral structures with short perpendicular wavelengths are accompanied with velocity shear which is enhanced as the instability grows. A nonlinear simulation of the feedback instability clearly indicates development of a vortex structure in the magnetosphere [see Fig. 1 (b)]. As the secondary K-H instability grows, the M-I coupling system enters into a turbulent state, showing strong deformation of vortex structures and generation of fine-scale fluctuations [see Fig. 1 (c)]. When the large-scale convection flow is constantly driven, a steady turbulent state is realized in later time [see Fig. 1 (d)], where we have also found a turbulent spectrum of Alfvenic fluctuations.

In the M-I coupling system considered here, the counter propagating shear Alfven waves cause the nonlinear interaction which has been discussed as a key mechanism of the Alfvenic turbulence cascade [2]. A power law spectrum observed here is also similar to the theoretical prediction of $k^{-5/3}$, of which details will be discussed at the conference.

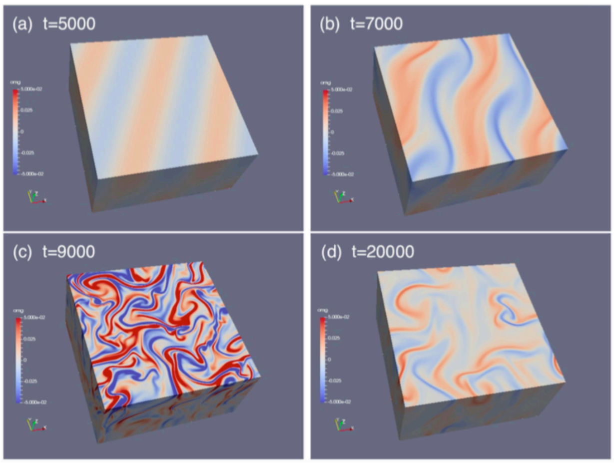

Fig. 1: Snapshots of vorticity distribution found in a MHD and two-fluid hybrid simulation of the feedback instability in the M-I coupling [1].

References

[1] T.-H. Watanabe, et al.: New J. Phys. **18** (2016) 125010.

[2] P. Goldreich and S. Sridhar: Ap. J. **438** (1995) 763.