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Feedback instability in magnetosphere-ionosphere coupling system: revisited

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Feedback instability in the magnetosphere-ionosphere (M-I) coupling system is proposed by Sato (1979) as a possible mechanism for explaining excitation and growth of auroral arcs [1], where fluctuations of density and electrostatic field in the ionospheric E-region are coupled with the shear Alfven waves in the magnetosphere. Its energy source is given by the background electric field. The so-called transmission line analysis shows that the system with the inductive magnetospheric response is destabilized if the background electric field is strong enough to overcome the stabilization effect of the recombination loss.

For simplicity, we consider a rectangular M-I coupling model with uniform external magnetic and electric fields and density distribution. The bottom and upper planes correspond to the hight-integrated E-region and the magnetic equatorial plane, respectively. Side boundaries are periodic with the assumption that typical scale length of the background components are much longer than the horizontal wave length. Starting from the magnetohydrodynamic (MHD) equations for the magnetosphere with suitable ordering, we obtained a set of reduced MHD equations which are coupled with continuity equations for the ionospheric density and current. The linear analysis leads to a dispersion relation similar to that given by Sato. However, the obtained eigenfunction consists of sin or cos functions in hight, which are assumed in the transmission line analysis, multiplied by exponential functions of the linear growth rate. Furthermore, the linear analysis for a case with dissipation terms is straightforward in the framework given here.

In order to study nonlinear evolutions of the feedback instability described by the above set of equations, we have developed a numerical simulation code. Although previous simulation studies on the feedback instability [2] are focused on global features for excitation of auroral arcs, local nonlinear evolutions have not been fully investigated yet. Our present three-dimensional simulation reveals that a secondary instability largely deforms the density, vorticity, and field-aligned current patterns which are initially excited by the feedback instability. It is considered that the Kelvin-Helmholtz instability is induced by local enhancement of the velocity shear accompanied with the auroral arcs. A more detailed analysis on the nonlinear evolutions of the feedback instability is currently in progress as well as investigating effects of the equilibrium distribution.

[1] T.Sato, J.Geophys.Res., vol.83, 1042 (1979).

[2] A.Miura and T.Sato, J.Geophys.Res., vol.85, 73 (1980); K.Watanabe and T.Sato, Geophys.Res.Lett., vol.15, 717 (1988); T.Watanabe, H.Oya, K.Watanabe, and T.Sato, J.Geophys.Res., vol.98, 21391 (1993).