Reduced magnetohydrodynamic analysis of the magnetosphere-ionosphere coupling system

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Macroscopic phenomena in the magnetosphere associated with auroral activities are coupled with ionospheric responses through the shear Alfven waves carrying field-aligned currents. The feedback instability, which has been considered as a possible mechanism for explaining growth of auroral arcs, is one of the typical examples. The reduced magnetohydrodynamic (MHD) equations, which have been applied to the feedback instability analysis, are quite useful for modeling of the magnetosphere-ionosphere (M-I) coupling system.

Typical magnetospheric perturbations in a near Earth region, with a frequency range lower than the ion cyclotron one, tend to have much longer parallel wavelengths than those in the perpendicular direction to the magnetic field. This is attributed to the fast propagation speed of the shear Alfven wave along field lines. The physical situation satisfies the so-called shear Alfven law considered in theoretical analyses of the magnetically confined fusion plasmas, where the reduced MHD equations are widely employed not only for linear stability analyses but also for nonlinear simulations. The reduced models have several benefits, such as scale separation in parallel and perpendicular directions (flute reduction), simplified geometrical effect, removal of compressional modes, and so on.

The reduced M-I coupling model is first applied to the feedback instability analysis, where the linear initial value problem is investigated in detail along with nonlinear simulations. The reduced model can also be extended to involve pressure gradients and diamagnetic effects which may become important at the inner edge of the plasma sheet.

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