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A quantitative test of the self-organization in the magnetopause Kelvin-Helmholtz instability as an inverse problem

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The self-organization hypothesis of the magnetopause Kelvin-Helmholtz (K-H) instability is tested against observations by 2-D MHD simulations for two different initial seed perturbations. The linear relationships are obtained by the simulations between the period of the magnetopause oscillation caused by the instability and the distance along the magnetopause from the subsolar point. The comparison of the linear relationships with that obtained from observations of the magnetopause oscillations gives a reasonable thickness of the velocity shear layer near the subsolar point and a reasonable average magnetosheath flow speed. This suggests that the self-organization in the K-H instability, i.e., the successive pairings of vortices, really occurs along the magnetopause.

It has recently been demonstrated by two-dimensional (2-D) MHD simulations that successive pairings of vortices occurring in the nonlinear stage of the Kelvin-Helmholtz (K-H) instability is a self-organization process, in which the total kinetic energy is nearly conserved but the enstrophy decreases rapidly by the numerical viscosity. This suggests that small-scale vortices excited by the instability near the subsolar magnetopause evolve into global scale vortices in the tail of the magnetosphere.

In the present study this self-organization hypothesis of the magnetopause K-H instability is tested against observations by 2-D MHD simulations for two different initial seed perturbations. The linear relationships are obtained by the simulations between the period of the magnetopause oscillation caused by the K-H instability and the distance along the magnetopause from the subsolar point based on the fact that the vortices excited by the K-H instability at the magnetopause move tailward with a velocity of a half of the magnetosheath flow speed. The comparison of the linear relationships with that obtained from reported observations of the period of the magnetopause oscillations gives a reasonable thickness of the velocity shear layer near the subsolar point of 1570km-3010km and a reasonable average magnetosheath flow speed along the magnetopause of 399km/sec-766km/sec. This suggests that the self-organization of the magnetopause K-H instability, i.e., the successive pairings of vortices, really occurs along the magnetopause and that small-scale vortices excited by the instability near the subsolar magnetopause evolve into global scale vortices in the tail of the magnetosphere. This means that the transport of momentum and energy across the magnetopause associated with the K-H instability occurs on a global scale in the tail of the magnetosphere. The present comparison of the simulation results with the observations of the magnetopause oscillations provides, as an inverse problem, a useful method to determine the thickness of the velocity shear layer near the subsolar point, which is important for understanding the structure of the magnetopause.