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グローバルシミュレーションにおけるコヒーレントな磁気圏渦ダイナミックス

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Coherent Vortex Dynamics in Magnetospheric Flow

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In the northward IMF configuration, the energy transfer between the magnetosphere and solar-wind has been discussed based on Kelvin-Helmholtz (K-H) instability and its vortices.Unfortunately, no single precise definition of a vortex is currently universally accepted, despite the fact that many space plasma researchers claim that many observations have detected vortices (as Kelvin-Helmholtz vortices at/around the magnetopause).In the present report, we identify the 3D magnetic vortex structures by using various vortex identification criteria as follows: 1,The first criterion is Q-criterion that defines vortices as regions in which the vorticity energy prevails other energies; 2, the second criterion is the lambda_2-criterion that is related to the minus of the Hessian matrix of the pressure related term;3, the third criterion requires the existence of vortex-core-lines that is the Galilean invariance. We visualize (please see Figure) and identify vortex structures using these identification method and the coherent vortex dynamics can be summarized as follows: (1) The K-H vortices that are transverse to the flow grows in the shear layer generated between the solar-wind and magnetopause, and are quickly shed-off from the magnetopause shear layer after the Dawn-Dusk (DD) line; (2) The vortices move freely until reaching the stable configuration forming two vortex rows (i. e., Karman vortex street) inside/outside the velocity shear region across the magnetopause, which is a part of the large wake flow field of the magnetosphere; (3) They are developed into vortices that have spiral or helix structure; (4) The optimally aligned transverse vortex structures (Karman vortex street) inside the velocity shear region mentioned above gradually form the so-called longitudinal or transverse vortices [Kida, 2006]; (5) Both transverse and longitudinal vortex-cores form this ””grid”” structure, although the grid structure is highly unstable, and both the vortex-cores are broken into pieces by the instabilities (vortex-break-down and the flow become turbulent-like [Kida, 2006; Kida and Miura, 1998]); and (6) Finally, those scraped vortex-cores mainly in stream-wise move tailward, survive over long time-range, and form a large or global scale tail spiral motion (see Figure). This persisting stream-wise tail spiral motions will significantly contribute to the transfer of solar-wind energy into the magnetosphere [Kida, 2006].