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Onset of turbulence and mixing induced by Kelvin-Helmholtz instability

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Recent in-situ observations often show the mixing of the solar wind and magnetospheric plasmas in the low latitude boundary layer (LLBL), in which the Kelvin-Helmholtz instability is considered to be unstable. Those suggest that LLBL is a candidate for a source of plasmas and the Kelvin-Helmholtz instability plays an crucial role in a new transport mechanism. Even though numerous theoretical and computational studies have challenged to explain it so far, no one succeeded in transport of plasmas over a K-H vortex size and diffusive process that explains the observations. Hence, the transport mechanism of the solar wind plasma into the Earth magnetosphere in the situation of northward IMF has been a hot topic in magnetospheric physics.

To elucidate the transport and the mixing of collision-less plasmas by K-H instability we carried out two dimensional MHD simulation of K-H instability in transverse uniform magnetic field with a inhomogeneous density profile. As a result, we find onset of strong turbulence that are generated after the development of the K-H vortex in the non-linear stage. Difference in density between the two media is a free energy for the turbulence. Examining in detail, we find that the onset of the turbulence is triggered not only by the secondary K-H instability but also by the Rayleigh-Taylor instability inside and at the edge of the normal K-H vortex. These two instabilities are caused by the velocity shear inside the normal vortex and the effective radial gravity force due to the rotating motion. The resulting turbulent flows enhance the mixing of the two media and transport plasmas deep inside the tenuous region. This mechanism will explain the existence of the broad mixing layer whose existence has been a long standing issue in magnetospheric physics.