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Formation of a broad plasma mixing layer by forward and inverse energy cascades of the Kelvin-Helmholtz instability

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The formation mechanism of the LLBL in the magnetosphere is a long standing issue in the magnetospheric physics and the Kelvin-Helmholtz instability (KHI) is one of the candidate mechanisms responsible for its formation. In this presentation, 2D MHD simulation of the KHI in a highly asymmetric density layer shows that rapid formation of a broad plasma mixing layer can be achieved by forward and inverse energy cascades of the KHI. The forward cascade is triggered by the growth of the secondary Rayleigh-Taylor instability [Matsumoto and Hoshino, JGR, 2006] excited during the nonlinear evolution of the KHI. The resultant turbulent evolution enhances the mixing process. The inverse cascade is accomplished by nonlinear mode couplings among the KH unstable modes. Due to the nonlinear mode couplings, the growth of the largest vortex allowed in the system reached 3.7 times the linear growth rate. By a combination of the secondary instability and the rapid growth of the large scale vortex, we show that a plasma mixing layer of a spatial scale of 7 R_E is formed within 10 minutes, when 1000 km and 400 $km\ s^{-1}$ are adopted for the shear half width and the solar wind flow speed, respectively. The results suggest that the mechanism proposed here can be responsible for the formation of the LLBL in the magnetosphere for a purely northward IMF case.