Solar wind entry process during a quiet geomagnetic activity

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An appearance of cold and dense (low entropy) plasma at geosynchronous orbit is one of the characteristic natures after a prolonged northward IMF duration. This cold dense material can contribute to the enhancement of the ring current density, which results a further declination of Dst. Therefore investigating the origin, path and fate of the cold dense plasma is important to understand how it preconditions the magnetosphere during a quiet interval before storm [Borovsky and Steinberg, 2006]. Observational evidences have shown that the cold dense material builds up during the northward IMF intervals in the flanks of the magnetosphere [e.g., Wing and Newell, 2002] which is referred to as the low latitude boundary layer (LLBL). The entry process of the solar wind plasma into the magnetosphere during the northward IMF conditions has been controversial in contrast to the Dungey's reconnection model for the southward IMF cases. The major candidate processes are the double lobe reconnection model [Song et al., 1999], in which newly closed magnetic field lines on the dayside magnetopause capture the solar wind plasma, the anomalous transport by the kinetic Alfven waves [Johnson and Cheng, 1998; Chaston et al., 2007] and the Kelvin-Helmholtz instability (KHI) driven by the fast solar wind flow.

Mixing and transport processes by the KHI itself are determined by the time and the spatial scale of the vortex. Thus one may wonder weather it will be responsible for the broad mixing layer, LLBL. The recent theoretical progresses on the nonlinear evolution of the KHI have suggested some possibility explaining such a broad mixing layer. Those can be grouped into two scenarios. The one was proposed by introducing magnetic reconnection [Brackbill and Knoll, 2002; Nykyri and Otto, 2002; Nakamura and Fujimoto, 2006]. When there was a magnetic filed component parallel to the flow, the KHI excites the magnetic reconnection inside a vortex. Eventually, the magnetic island captured the solar wind origin and transport into the magnetosphere [Nykyri and Otto, 2002]. On the other hand, Matsumoto and Hoshino [2004, 2006] showed a turbulent transport mechanism which is a natural consequence of the nonlinear development of the KHI through the secondary Rayleigh-Taylor instability, if there is a large density difference between the two media. The mechanism is fundamentally two-dimensional and therefore we term it the 2-D secondary instability. We also showed that the turbulent development greatly contributes to the solar wind plasma transport deep into the magnetosphere. Based on the previous 2-D studies, the 3-D nonlinear evolution of the KHI is studied by performing MHD simulation. Starting with a uniform background field configuration and a velocity shear layer, we obtained a unique feature which arose due to the three-dimensionality: The KH vortex is susceptible to the 3-D secondary instability which converts the rotating energy into the magnetic energy by generating large amplitude Alfvenic fluctuations. Once the 3-D secondary instability is excited, the mode cascade starts after the amplitude of the fluctuation reaches to a certain level compared to the background field. In this presentation, we show recent progress on the nonlinear nature of the KHI responsible for the formation of LLBL and its impact on the geomagnetic activity just after the appearance of the low entropy plasma transported from the LLBL.