Magnetic reconnection induced by the Kelvin-Helmholtz vortex at the Earth’s magnetopause during southward IMF

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When the magnetic field is oriented nearly perpendicular to the direction of the plasma shear flow, the flow easily satisfies the super-Alfvénic unstable condition for the Kelvin-Helmholtz (KH) instability. This configuration is realized at the Earth’s low-latitude magnetopause when the interplanetary magnetic field (IMF) is strongly northward or southward. Indeed, clear signatures of the KH waves have been frequently observed during periods of the northward IMF. However, these signatures have been much less frequently observed during the southward IMF. In this work, we performed the first 3-D fully kinetic simulation of the KH instability at the magnetopause under the southward IMF condition. The simulation demonstrates that magnetic reconnection, with a typical fast rate on the order of 0.1, is induced at multiple locations along the vortex edge in an early non-linear growth phase of the KH instability. The reconnection outflow jet, which grows in the direction nearly perpendicular to the initial shear flow, significantly disrupt the flow of the non-linear KH vortex. On the other hand, the shear and vortex flow strongly bends and twists the reconnected field lines towards the direction out of the reconnection plane. The resulting coupling of the complex field and flow patterns within the magnetopause boundary layer leads to a quick decay of the vortex structure. These simulation results suggest that clear signatures of the KH waves are expected to be observed only for a limited phase during periods of the southward IMF, which may explain the difference in the observation probability of KH waves between northward and southward IMFs.