Geophysical Research Abstracts
Vol. 19, EGU2017-14629-1, 2017
EGU General Assembly 2017

The spatial evolution of the mixing layer in the Kelvin-Helmholtz instability at the Martian ionopause

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We investigate the growth of the mixing layer thickness in the Kelvin-Helmholtz instability (KHI) using an extended-local MHD model to estimate the ion loss rate from the Martian ionopause. The KHI is expected to play a major role in transporting mass, momentum and energy across the ionopause between the sheath flow and ionospheric plasmas. Since the mixing layer has a finite thickness between them, this layer has a potential for the removal of a huge amount of ions from Mars through its history. The recent MAVEN observation reported that the density ratio across the ionopause reaches as high as 100∼5000. With such a large density ratio, compressible effects are expected to modify the structure of the KH vortices and the evolution of the mixing layer by generating high-amplitude nonlinear fast-mode plane waves from ridges of the KH waves.

In order to reproduce Martian ionopause, we developed an extended-local MHD model with aperiodic boundary condition for the evaluation of traveling waves along the dayside Martian ionopause (∼6,000km). Spatial resolution is set with 3km to resolve the thin mixing layer. We find two factors that accelerate the growth of the mixing layer. Firstly, the KH wave with the fastest growing mode behaves like a wall to the leading vortex in the aperiodic condition. The sheath flow is stagnated by this wall-like structure and induces an enhanced vortex return flow, resulting in a deeper excavation of the ionospheric plasma. Secondly, fast-mode rarefaction waves generated by compressible effects make wall-like structures more effective by lowering pressure around antinodes of the KH waves. Such a pressure profile further accelerates the stagnation and the excavation. In addition, KH vortices are merging not one by one but also some vortices are merged together at time. Thus, the large wave like structure can be seen when the effect of compressibility is not so large. The mixing layer spread with the lapse of time and it depends on the density ratio, its relation can be described the function of the logarithm. Furthermore, we estimate the ion loss rate from our results and it agrees with the MAVEN observational results.