Atmospheric effects on the formation of Magnetic Pile-up Boundary

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The solar wind interaction with the Martian atmosphere is often regarded as the same category as that of Venus, since the planetary ionosphere directly interacts with the solar wind at both the planets. However, some comet-like features have also been observed at Mars. Recent observations revealed the existence of the Magnetic Pile-up Boundary (MPB), a sharp rise in the magnetic field as well as a sudden change in

the electron energy spectra, in the inner magnetosheath at Mars. Such a structure has originally been detected at comets (Comet Halley and Grigg-Skjellerup), but has never been detected at Venus.

Since Mars, like comets, has an extended atmosphere due to its small gravity, the formation of the MPB may have some relation to the large atmospheric extension. In order to examine this, we carried out some MHD simulations of Mars-SW interaction. Especially, we focused on the roles of charge exchange (CE) and electron impact ionization (EII), between the solar wind ions/electrons and the planetary atoms, on the MPB formation.

The 2D MHD model was coupled to Monte-Carlo simulations in order to incorporate the CE and EII reaction rates properly. The simulation results suggest that an enhancement of magnetic field magnitude occurs in the inner magnetosheath mainly due to the CE energy relaxation effect at the solar minimum and to the EII effect at the solar maximum. We also found that EII decelerates the solar wind significantly through the mass-loading effect, which lengthens the interaction time between the solar-wind plasma and the exospheric atoms, resulting in an additional enhancement of magnetic field magnitude both at the solar minimum and maximum.