The solar wind interaction with the non-magnetized planets: IMF penetration into the ionosphere

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Since Mars and Venus do not have a global intrinsic magnetic field, the solar wind directly interacts with the ionosphere of these planets. PVO (Pioneer Venus Orbiter) discovered that the IMF sometimes penetrates into the Venus ionosphere and recently MGS (Mars Global Surveyor) also observed the IMF penetration into the Martian ionosphere. The IMF forms both large-scale and small-scale fields in these ionospheres. The large-scale field is very important for ionospheric structures. For example, it is reported that the observed profile of ionospheric temperature is significantly influenced by the existence of the large-scale field.

The mechanism responsible for the IMF penetration into the ionosphere has been one of the biggest problems in the solar wind- Mars/Venus interaction. According to the PVO observation, when dynamic pressure of the solar wind does not exceed thermal pressure of the ionosphere, ionopause is clearly formed between the shocked solar wind and the ionosphere. But in the case where the solar wind dynamic pressure is large, ionopause becomes rather obscure with its altitude lower and its thickness thicker. During this phase, a large-scale field is observed in the subsolar region of the ionosphere. Therefore, we can expect that the IMF penetration may be related to photochemical reactions and/or magnetic dissipation due to collisions among particles in the lower ionosphere. We also expect that turbulence produced by macro-instabilities such as Kelvin-Helmholtz instability may play an important role in the penetration process.

We study the solar wind-Mars/Venus interaction by using a global MHD simulation model which includes photochemical reactions in the ionosphere. Kelvin-Helmholtz wave-like structures are reproduced on the boundary between the shocked solar wind and the region filled with ionospheric plasma, even in the case of lower solar wind dynamic pressure. We discuss the problem of IMF penetration mechanisms, mentioning the effects of macro-turbulence, collisions, and photochemical reactions.