R009-24
A 会場 ： 11/25　AM2（11:05-12:35）
11:20～11:35:00

#坂田 遼弥 [1)], 関 華奈子 [1,2)], 寺田 直樹 [3)], 堺 正太朗 [4)], 品川 裕之 [5,6)]
([1] 東京大学先端科学技術研究センター, ([2] 東京大学大学院理学系研究科地球惑星科学専攻, ([3] 東北大学大学院理学研究科地球物理学専攻, ([4] 慶應義塾大学環境情報学部, ([5] 九州大学国際宇宙惑星環境研究センター, ([6] 情報通信研究機構

Eleven-ion multifluid simulation study on the effects of crustal magnetic fields at Mars

#Ryoya Sakata[1)], Kanako SEKI[1,2)], Naoki TERADA[3)], Shotaro SAKAI[4)], Hiroyuki SHINAGAWA[5,6)]
([1]Research Center for Advanced Science and Technology, The University of Tokyo, ([2]Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, ([3]Department of Geophysics, Graduate School of Science, Tohoku University, ([4]Faculty of Environment and Information Studies, Keio University, ([5]International Research Center for Space and Planetary Environmental Science, Kyushu University, ([6]National Institute of Information and Communications Technology

Mars lacks a global intrinsic magnetic field but has highly localized crustal magnetic fields, resulting in a unique configuration of the magnetosphere. The crustal magnetic fields also have complicated influences on ion outflow and escape. Numerous studies have investigated the effects of crustal magnetic fields, but they mainly focused on the dominant ion species in the ionosphere (O^+, $O_2{}^+$, $CO_2{}^+$). Some recent studies investigated distributions and outflows of minor ion species such as C^+ and NO^+. However, the detailed process of these ions' escape and the effects of the crustal magnetic fields remain poorly understood.

The purpose of this study is to investigate the escape of carbon- and nitrogen-bearing ions (C^+, CO^+, HCO^+, N^+, $N_2{}^+$, NO^+) and the effects of the crustal magnetic fields using a three-dimensional global multifluid MHD model, MAESTRO (Sakata et al., 2024). We implemented photochemical and collisional processes for these ions, extending the original set of five ions (H^+, O^+, $O_2{}^+$, $CO_2{}^+$, $H_{SW}{}^+$) to eleven in total. We conducted eleven-ion multifluid simulations under typical solar wind conditions (n = 3 cm^{-3}, V = 400 km s^{-1}, B = 2.5 nT), with both "away" and "toward" sectors of the Parker spiral interplanetary magnetic field (IMF) considered. The strongest crustal magnetic field region at around 180-degree longitude was placed at four local times (noon, dusk, midnight, dawn). A simulation without crustal magnetic fields was also conducted for comparison.

The results show that the crustal magnetic fields reduce ion escape except for $O_2{}^+$, and the dependence on the crustal field location is different among ion species. NO^+, which is abundant in the nightside ionosphere, shows a unique trend compared to other ions. The IMF polarity also influences the escape rate because it controls the direction of the solar wind convection electric field. The effects are also seen in the magnetotail, as the current sheet twist significantly weakens under specific conditions of the crustal field and IMF polarity. These results suggest a role of magnetic reconnection in regulating the magnetospheric configuration and ion escape. On average, the six additional ions account for approximately 10% of the total escape rate. Notably, the C^+ escape rate is about 70% higher than that of $CO_2{}^+$, implying that "minor" ion species have a non-negligible contribution to atmospheric escape from Mars.

References

Sakata, R., Seki, K., Terada, N., Sakai, S., & Shinagawa, H. (2024). Effects of an Intrinsic Magnetic Field on Ion Escape From Ancient Mars Based on MAESTRO Multifluid MHD Simulations. Journal of Geophysical Research: Space Physics, 129(5).