R009-P24
ポスター 4 ：11/26　AM1/AM2 （9:00-12:00）

#中村 勇貴 [1)], 関 華奈子 [2)], 吉田 辰哉 [3)], 寺田 直樹 [3)], 小山 俊吾 [4)], 堺 正太朗 [5)]
([1] 東大, [2] 東大理・地球惑星科学専攻, [3] 東北大・理, [4] 東北大, [5] 東北大・理・地球物理

Enhancement of hydrogen escape from the early Martian atmosphere induced by the precipitation of solar energetic particles

#Yuki Nakamura[1)], Kanako Seki[2)], Tatsuya Yoshida[3)], Naoki Terada[3)], Shungo Koyama[4)], Shotaro Sakai[5)]
([1]Graduate School of Science, The University of Tokyo, [2]Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, [3]Graduate School of Science, Tohoku University, [4]Tohoku University, [5]Graduate School of Science, Tohoku University

Hydrogen escape from the Martian atmosphere is crucial for understanding its redox state and water loss. The Jeans escape flux of hydrogen on Mars is regulated to be twice the nonthermal escape flux of oxygen, called self-regulation (e.g., McElroy and Donadue, 1972; Koyama et al., 2021).

Nakamura et al. (2023) suggested that the precipitation of solar energetic particles into the present-day Martian atmosphere enhances the production of H and OH pair due to cluster ion chemistry driven by SEP-induced atmospheric ionization. The flare observations of solar-type G stars by the Kepler mission suggested that our Sun should have been much more active, and intense SEP events could have hit the planetary atmospheres repeatedly 4 billion years ago (e.g., Shibayama et al. 2013; Lingam et al., 2018). Such a continuous precipitation of SEPs into the early Martian atmosphere could have enhanced the dissociation of water vapor and increased hydrogen escape.

In this study, we explored the impacts of SEPs on the escape rate of hydrogen from the early Martian atmosphere using an atmospheric ionization model based on continuous slowing down approximation and a one-dimensional photochemical model (Nakamura et al., 2023a, 2023b). We found that the dissociation of water vapor by SEP-induced ion chemistry is more than an order of magnitudes higher than the photolysis rate. In an atmosphere without H2 degassing, the precipitation of SEPs establishes a new steady state solution of atmospheric composition, and the hydrogen escape rate is no longer self-regulated. The escape rate of hydrogen increases proportionally to the energy flux of SEPs if the continuous SEP energy flux is more than ˜1 erg cmˆ-2 sˆ-1. Such an effect of SEPs on hydrogen escape suppresses as the H2 degassing rate increases.

References:

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