Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PCG31-12 会場:301A 時間:5 月 23 日 12:00-12:15

DSMC モデルによる過去の火星外気圏に関するシミュレーション研究
A simulation study of the ancient Martian exosphere of Mars with a DSMC model

寺田 香織 [1*], 寺田 直樹 [1]
Kaori Terada[1*], Naoki Terada[1]

[1] 東北大学大学院理学研究科
[1]Graduate School of Science, Tohoku University

In this paper, we investigate the ancient oxygen and hydrogen exosphere of Mars using a one-dimensional multi-species direct simulation Monte Carlo (DSMC) model. The evolution of thermal and non-thermal escape rates depends on the history of the solar EUV intensity. The astronomical observations of stars that are analogous to the sun shows the solar EUV luminosity is gradually decreasing. 3.7 billion years ago, from which the loss mechanisms that still active today are dominant, the solar EUV luminosity is estimated to have been about 7 times the present one. We estimate the exobase altitude and the temperature at the exobase level, and the rates of oxygen escape due to the dissociative recombination of O_2^+ and atomic hydrogen Jeans escape for three different solar EUV intensity cases, which correspond to 1, 3, and 6 times the present low solar activity.

We use an upper thermosphere-exosphere full-particle model using a DSMC method coupled with a photochemical model. The DSMC method is a method of solving the Boltzmann equation and a common and effective approach for simulation of rarefied gas flow dynamics. Traditionally, a one-fluid approximation is used for modeling of thermosphere. But a one-fluid approximation is not sufficiently adequate at upper-thermosphere where the Knudsen number is larger than 0.01. In such a transition domain (between collision and collision less domains), the collision frequency is not high enough that the commonly used thermal conductivity coefficient is adequate and that physical quantities of each species are equal to each other.

The computed exobase temperature of H is lower than that of the other species (O, N_2, CO_2). A hydrostatic equilibrium of H is not established owing to thermal escape of H. It produces an upward flow and a thermal energy is converted to a flow energy. Even the exobase temperatures of O, N_2, and CO_2 are significantly lower than those of previous studies. The differences are mainly caused by the difference in an approach of molecular thermal conductivity.