R009-24
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9:15〜9:30

Numerical experiments of exospheric retrieval for isotope ratio measurements by MSA onboard MMX

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Mars has experienced a massive atmospheric escape and climate change over the past 4.6 Gyr. The main component of Martian atmosphere is carbon dioxide (CO_2) and how much CO_2 has escaped to space is significant for understanding the climate change on Mars. The isotope ratio is one of the important key parameters to understand the atmospheric evolution. Jakosky et al. (2017) suggested from measurements of argon isotope ratio ($^{38}Ar/^{36}Ar$) based on observations by the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft that one bar or more of oxygen (O) has been lost to space, assuming that the lost O comes primarily from CO_2, but these estimations were not based on direct observations of CO_2. Evolution of O and carbon (C) isotope ratios ($^{16}O/^{18}O$ and $^{12}C/^{13}C$) between the surface and upper atmosphere are suitable for understanding the CO_2 loss process, but no observational constraints on these isotope ratios in the upper atmosphere have been made until this point. Note that Curiosity identified the isotope ratios of $^{16}O/^{18}O$ ˜476 and $^{12}C/^{13}C$ ˜85 near the surface (e.g., Mahaffy et al., 2013), and the Atmospheric Chemistry Suite onboard Trace Gas Orbiter (TGO) found the isotope ratio of $^{16}O/^{18}O$ ˜420 in the middle atmosphere below 60 km altitude (Alday et al., 2019). Japanese future sample return mission ”Martian Moons eXploration (MMX)” is a candidate of this observation. Mass Spectrum Analyzer (MSA) onboard MMX can measure the escaping ions with a high mass resolution of M/dM $>$100. MSA enables us to measure isotope ratios in the escaping atmosphere for the first time, and in addition, it can estimate isotope ratios in the exosphere by retrieving the neutral atmosphere of each isotope from the ion observations. As a first step toward future MMX observations, this study investigates the distribution and energy of ions ($^{16}O^+$ and $^{18}O^+$) seen at midnight around the Phobos’ orbit, as well as their sources, using test particle simulations under electric and magnetic fields obtained from magnetohydrodynamic simulations (e.g., Sakai et al., 2021). The particle simulations are conducted under certain interplanetary magnetic field conditions. The ions that reach Phobos’ orbit at midnight are picked up in the induced magnetosphere or the solar wind region. Most of the ions come from the induced magnetosphere around 2000 km altitude, and the energy is as low as several eV. The ions coming from the solar wind reach several keV because of the acceleration by the solar wind electric field. The simulations also show that there is a proportional relationship between the energy and the distance from the Phobos’ orbit to the pickup position, and that the gradient significantly depends on the electric field. Establishing a retrieval method would enable us to determine the pickup position from the ion energy around the Phobos’ orbit in MMX. Finally, the radial $^{16}O^+$ and $^{18}O^+$ fluxes around the Phobos’ orbit are 10^5 - 10^7 cm^{-2} s^{-1} and 10^3 - 10^4 cm^{-2} s^{-1}, respectively. The $^{16}O^+$ flux from the simulations is consistent with the previous study (Curry et al., 2013). Multiple measurements of isotope ratios at different altitudes by MMX, Curiosity, and TGO would lead to a better understanding of atmospheric evolution on Mars, and this simulation aims to help measurements by MMX.