Radiative Transport Simulations for 0.4 - 1.9 THz Band Heterodyne Spectroscopy of Martian Atmospheric Trace Gases

*Yuki Hamaguchi[1], Hiroyuki Maezawa[1], Hideo Sagawa[2]

1. Osaka Prefecture University, 2. Kyoto Sangyo University

Radiative transport simulations and line surveys for 0.4 -1.9 THz band heterodyne spectroscopy of the Martian atmospheric trace gases were performed assuming nadir and limb-sounding observations with an orbiter. Heterodyne spectroscopy with frequency high resolution is a useful tool to observe the vertical distributions of the temperature, trace molecules (CO, ^{13}CO, $C^{18}O$, $C^{17}O$, H_2O, HDO, $H_2{}^{18}O$, $H_2{}^{17}O$, ^{18}OCO, H_2O_2, HO_2, O_3, O_2, etc.), and their isotopes from the surface layer of the Martian atmosphere to an altitude of approximately 100 km. In particular, since a background emission source such as the sun is not required, observations can be carried out at any local time such as day/night, morning/evening, etc. In addition, this wavelength range is less affected by dust absorption and scattering so that this tool allows us to observe the lower atmosphere near the surface of Mars even during dust storms. It is also possible to measure the velocity fields of the atmosphere by utilizing the Doppler shift effect. These strengths will provide us the important information for understanding of the atmospheric oxidation processes and photochemical reaction networks in the Martian atmosphere, the three-dimensional information of the material and water circulations driven by seasonal and diurnal changes from the surface layer to the upper layer, the dissipation history of water vapor into space, the resources for terraforming and future manned Mars missions, and so on.

At present, a working group on the Mars Aqueous Environment and Space Climate Orbiter (MACO) project, with an eye to a future small or medium size Mars orbiter satellite, has been formed in Japan. In this study, we also investigated the optimum frequency bands for the THz-band heterodyne spectrometer, which is an optional instrument in this mission plan. The diameter of the antenna is assumed to be 35 cm. The heterodyne detector and spectrometer are assumed to be a Schottky barrier diode (SBD) mixer operated at room temperature and an autocorrelation type digital spectrometer with a bandwidth of 8 GHz and a resolution of 1 MHz, respectively. The shot noise of the SBD mixer detector was taken into account for the spectrum calculations. For example, in 0.9 THz band the emission lines of ^{13}CO, $C^{18}O$, $C^{17}O$, H_2O, HDO, ^{18}OCO, H_2O_2, HO_2, and O_3 can be observed simultaneously by optimizing the frequency setting in double-sideband mode. An altitudinal resolution of better than 6 km will be achieved. When observing high-rise H_2O up to around 100 km, it is possible to respond by switching to a dedicated frequency. How limb-sounding data is processed and compressed on board and downlinked is an important future issue.

In this conference, we will present the results of these simulations.

Keywords: Mars, Planetary Atmosphere, Heterodyne Spectroscpy, Terahertz Remote Sensing