Observation of the O_2^+ first negative band (1,0) emissions in the Mars ionosphere with a visible spectrograph on Haleakala T60

*Toshihisa Suzuki[1], Masato Kagitani[1], Takeshi Sakanoi[1]

1. PPARC, Graduate School of Science, Tohoku University

We carried out ground-based telescope observations of Martian ionospheric O_2^+ emission to obtain global distribution of Martian O_2^+ ionosphere and its variation for understanding Martian atmospheric escape process. After verifying the analysis method, the result suggests that the O_2^+ first negative bands (1NG) (1, 0) emissions are successfully detected, and calculated O_2^+ emission intensity and column density.
Mars has tenuous atmosphere compared with the Earth. One possible model for Martian tenuous atmosphere is caused by atmospheric escape to space for a long time. In addition, present Mars has only weak crustal magnetic fields for limited area, and therefore, it is likely that solar wind strongly affects Martian atmosphere escape. In recent years, ion composition and densities in the Martian ionosphere are revealed by Mars probes (e.g. Mars Express, MAVEN). In the Martian ionosphere, main ion is O_2^+ [M. Benna et al., 2015]. Moreover O_2^+ recombines with an electron, and as a result of a neutral molecule dissociation, neutral atomic oxygens are generated. Since the neutral atomic oxygen energy is higher than escape velocity of Mars, it can be escaped from Martian gravity. This process is important in Martian atmosphere escape. However, it is difficult to detect atomic oxygen by Mars probe in-situ observation, and escape quantity is indirectly estimated by plasma temperature and density from in-situ observations. On the other hand, remote-sensing of Martian ionosphere is useful to obtain global distribution and its time and spatial variations. It is essential to combine in-situ plasma data with global remote sensing for understanding Martian atmospheric escape, such as solar wind impact and/or crustal magnetic field effect on the escape process.
We carried out Martian ionosphere O_2^+ emission observation using Tohoku University T60 telescope (located at the summit of Mt. Haleakala in Maui) with Vispec (Visual imager and Spectrograph with Coronagraphy) from September 10 to 19, 2018. This is the first attempt to detect Martian O_2^+ emission with a ground-based telescope. We focused O_2^+ 1NG (1, 0) bands emission with a peak wavelength of about 561 nm. Visible Echelle spectrograph Vispec (wavelength resolution was 10,000) covered wavelength range from 550 nm to 570 nm. Vispec slit (width 2” ×length 90”) was located near Martian dayside limb parallel to the Martian rotation axis, and exposure time of one frame was 2 minutes. Total exposure time in observation period was 450 minutes. To refer sunlight spectrum reflecting by Martian surface, we acquired spectrum of disk center by Martian surface. First analysis process (subtraction dark, revision by flat-field, wavelength and space) was conducted on each frame, and each frame was added to gain S/N. Finally, sunlight spectrum was subtracted using disk center to obtain O_2^+ 1NG (1, 0) bands emission spectrum. Next, we compared observed O_2^+ spectrum with O_2^+ 1NG (1, 0) model spectrum given by Henriksen and Veseth [1987]. Focusing on only short period wavelength variations, we performed high-pass filter analysis on the both of observed and model spectrum. After that, we calculated the correlation coefficient between observed spectrum and model spectrum, and found that the coefficient maximum is 0.40 with no wavelength lag between two spectra. Data points, i.e., wavelength range, using correlation coefficient analysis were selected so that model O_2^+ emission is relatively intense and the contamination of solar fraunhofer absorption line is negligible. We estimated O_2^+ 1NG (1, 0) emission intensity with a least-square method to be 691 +/- 171 $\times 10^3$ Rayleighs, and the column density to be 4.4 +/- 1.1 $\times 10^{13}$ /cm^2. The estimated column density was greater than that of simulation. In this presentation, we compare O_2^+ emission observation spectrum with model spectrum, and give the estimation of O_2^+ emission intensity and column density in detail. We also give discussion about the

results.

Keywords: Mars, ionosphere, ground-based telescope

