The observation of water-group molecule emission in the Enceladus torus with Haleakala T60

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We report the result on the observations of Enceladus torus emissions at the atomic oxygen 630.0nm and the water-vapor ion emission at around 615nm(8-0 band) with Haleakala/T60 and a Vispec(Visible Imager and Spectrograph with Coronagrpahy) during the period from 2015/7/13 to 2015/9/18 (first run) and from 2016/5/17 to 2016/7/23 (second run).

The moon Enceladus, revolves round Saturn at 3.9 Saturn Radii(Rs), emits the plume mainly composed of water vapor from cracks in south polar region called 'Tiger Stripe'. This plume cause the neutral particle rich inner magnetosphere of Saturn and the neutral density is ten times greater than the plasma density. However, its time variation and spatial distribution has been discussed by models and simulation studies, and there is few studies based on observation data. We aim to understand the physical processes in the Saturn's inner magnetosphere by observing the Enceladus torus emissions.

Vispec has two kinds of spectroscopy modes with a high-dispersion echelle gratig(R=76000) and with a single-order grating(R=10000) In the first run, We employed the high-dispersion mode with two kind of slits; one is 60[micro-m] width$*$20[mm] length, or 100[micro-m] width$*$20[mm] length, of which correspond to FOVs of 200"$*$2";,200"$*$3', respectively. In the former slit case the slit was located in the east-west direction of Saturn's equatorial plane (E-W slit), and in the latter slit case the slit was located north-south direction(N-S slit). The detector is covering the wavelength of 629-632[nm] with a wavelength dispersion of $5.98*10^{-3}$[nm/pix] with a 2$*$2 binning mode. Exposure time was 20[min] per 1 frame, and we totally obtained 74 frames (38 frames of E-W data, 36 frames of N-S data). Using the N-S silt data(22 frames, total exposure time is 7.3[hour]), we derived the [OI]630.0[nm] at 3.9Rs in the east side of Saturn to be 0.8+-0.5[R] in 1-sigma suggesting that no significant emission was etected. Considering previous observational result from Kodama et al. 2011 [OI]630.0[nm] brightness is significantly reduced from 4.1+-0.7[R] to 0.8+-0.5[R]. We suggest that the cause of variation might be the difference of observation geometry between 2009 and 2015. Since Saturn's Ring-Opening Angle(ROA) is changing year by year. ROA in 2009 and 2015 were 4.5[deg.](nearly horizontal) and 22.4[deg.], respectively. The column number density of atomic oxygen along the line-of-sight direction is smaller with large ROA, and therefore, the apparent intensity would decrease in the 2015. Assuming the same number density of atomic oxygen observed in 2009, we calculated [OI] 630.0nm brightness of 1.2[R] in the same geometry observed in 2015. In addition to changes of observing geometry, variability of Enceladus plume activity may cause the decrease of torus [OI]630nm emission in 2015.

In the second run,we emoloyed the mid-dispersion spectroscopy mode with the former slit used in the first run. The slit was located in the north-south direction at the Enceladus orbital distance (east and west tangential point). The detector is covering the wavelength of 610-630[nm] with a wavelength dispersion of $4.06*^{-2}$[nm/pix] with a 2$*$2 binning mode. Exposure time was same as the first run making 391 frames in total. Based on the simple estimation, an exposure time of 125[min] is required to obtain the emission of water vapor ion(H_2O^+) with S/N=1. We will analyze these data and will discuss about results on water-vapor ion emission intensity as well as about its variabilities on the Enceladus torus.