Daily variation of Enceladus neutral oxygen torus observerd by Hisaki

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1 Introduction

Water group neutrals in Saturn's inner magnetosphere play the dominant role in loss of energetic electrons and ions because of abundance of the water group neutrals [e.g., *Paranicas et al.,* 2007; *Sittler et al.,* 2008]. Understanding of the temporal and spatial distributions of the neutrals is required to understand the plasma-neutral dynamics in Saturn's inner magnetosphere. Water molecules mainly originating from Enceladus lead to the productions of hydroxyl radicals and oxygen atoms through dissociation reactions. The atomic oxygen in the magnetosphere of Saturn was discovered by UVIS onboard Cassini [*Esposito et al.,* 2005]. *Melin et al.* [2009] reported the spatial distribution and the variation of the total number of oxygen with time scale of several days – several tens of days. The oxygen atom therefore provides a good clue to examine the dynamics of the inner magnetosphere of Saturn through remote observations. To examine the oxygen dynamics in the inner magnetosphere of Saturn, we use the spectrometer EXCEED (Extreme Ultraviolet Spectroscope for Exosphere Dynamics) [*Yoshioka et al.,* 2013; *Yoshikawa et al.,* 2014; *Yamazaki et al.,* 2014] onboard Japanese Earth orbiting satellite "Hisaki". EXCEED detected oxygen brightness at 130.4 nm. In this paper, we report (1) short term (daily) variation, (2) dawn-dusk distribution, and (3) Enceladus phase angle dependence, of the oxygen atom emissions for the first time. The observational period was from May 23th to June 16th in 2014.

2 Observation

Figure 1 shows the imaging spectra observed by Hisaki/EXCEED. The vertical (horizontal) axis is spatial structure (wavelength). The top (bottom) panel contains the spectra originating from geocorona (geocorona + Saturn) emissions. The integration time of top (bottom) panel is 2316 (6843) minutes during the period from May 23th to June 16th in 2014. The slit position is set to cover Enceladus neutral torus as shown in the left panel of Figure 1. It is found that the brightness of oxygen in the top (bottom) panel is detected at 130.4 nm due to the geocorona (geocorona + Saturn neutral torus). The brightness of Enceladus neutral oxygen is obtained by subtracting the spectrum in the top panel from the spectrum in the bottom panel.

The temporal variation of the observed neutral oxygen within ±10 Rs (Rs: radius of Saturn, 60,268 km) is shown in Figure 2. The oxygen intensity per 1 day is obtained by integrating the subtracted data per 1 day within ±10 Rs. The dot line shows the error. It can be seen that the daily variation of oxygen is first detected.

Figure 3 indicates the daily variation of neutral oxygen at the dawn (red) and dusk (blue) sides. It is likely that the intensity at the dusk side could be slightly stronger than that at the dawn side, although the difference of the intensities is not clear. The variation of Enceladus phase-dependent neutral oxygen is also not clear as shown in Figure 4. We divide the Enceladus phase-dependent neutral oxygen into two regions. ON-Enceladus is determined to be located at the side of Enceladus. The independence of local time and phase angle is consistent with previous models [e.g., *Cassidy and Johnson*, 2010; *Tadokoro et al*., 2012] since the lifetime of the oxygen atom is longer than the revolution period (1.37 days) of Enceladus. The solar wind at Saturn estimated by a model [*Tao et al.,* 2005] was quiet during the observation.

3 Summary

We have examined the temporal and spatial variations of neutral oxygen in the inner magnetosphere of Saturn observed by Hisaki/EXCEED. The our main results are as follows:

1). The daily variation was detected during the period from May 23th to June 16th in 2014.

2). The dawn-dusk asymmetry was not clear during the observation.

3). The Enceladus phase angle dependence was not clear during the observation.

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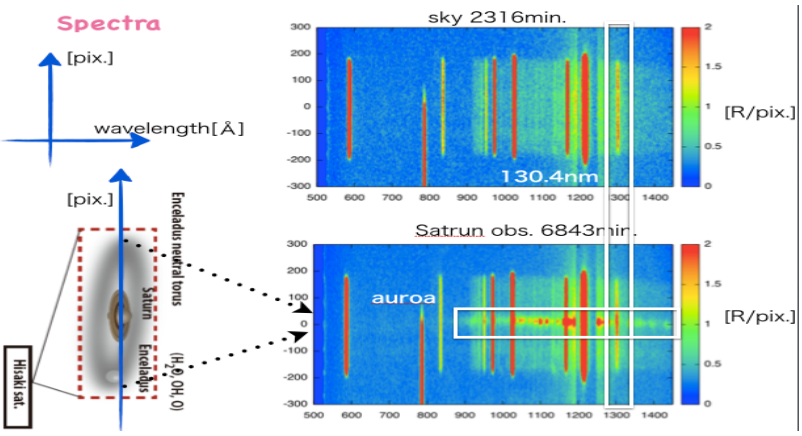

Figure 1. Imaging spectra detected by Hisaki/EXCEED.

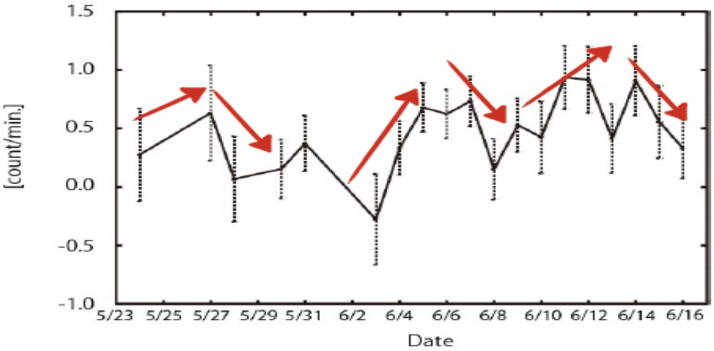

Figure 2. Daily variation of OI 130.4nm emission line intensity during the period from May 23th to June 16th in 2014.

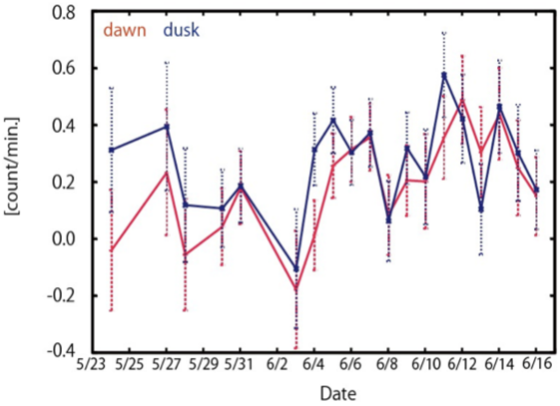

Figure 3. Daily variation of neutral oxygen at the dawn(red) and dusk(blue) sides.

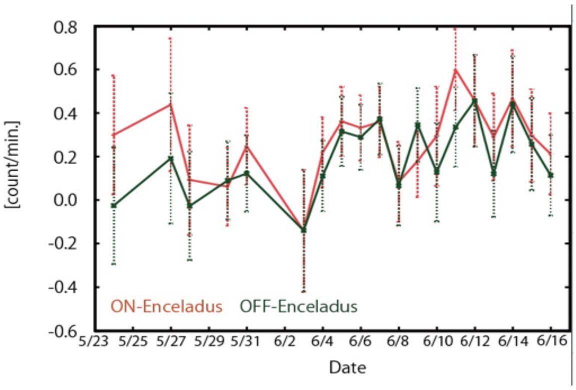

Figure 4. Daily variation of neutral oxygen depending on the phase position of Enceladus; ON-Enceladus (red) and OFF-Enceladus(green).