Variations of System IV period of the sulfur ions in the Io torus for the volcanic event in 2015

*Arakawa Ryo[1], Hiroaki Misawa[1], Fuminori Tsuchiya[1], Masato Kagitani[1], Ichiro Yoshikawa[2], Kazuo Yoshioka[2], Fumiharu Suzuki[2], Tomoki Kimura[3], Go Murakami[4], Atsushi Yamazaki[4]

1. Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2. Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 3. Nishina-Center for Accelerator Based Science, RIKEN, 4. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

Previous ground-based and probe observations of Io plasma torus (IPT) in visible, near-infrared and extreme ultraviolet (EUV) wavelengths have detected a periodic time variation whose period is longer than System III Jupiter’s rotation period (9.925 h). It has been called System IV period (~10.21 h). The “dual hot electron model” in which hot electron populations has two azimuthal variations corotating at System III period and sub-corotating at System IV period is proposed to account for the System IV period measured by the Cassini UVIS observation (Steffl et al., 2008). However, little progress has been made in explaining an origin of the System IV period.
The Cassini UVIS observation of IPT was made just after Io’s volcanic eruption in 2000. It is reported that the System IV period derived from the Cassini observation was 10.07 h, which was shorter than the typical System IV period of 10.21h (Steffl et al., 2006). The causal relationship between plasma source enhancement due to the volcanic event and change in the System IV period is not clear from the Cassini observation. Here, we analyzed time variations in EUV emissions from IPT obtained by the HISAKI satellite to understand the mechanism responsible for the System IV period and the influence of Io volcanic activity on IPT.
The observation period used in this study is from December 2014 to the middle of May 2015. During this period, enhancement of Io volcanic activity from January to March 2015 was reported from the observation of Iogenic sodium emission (Yoneda et al., 2015). To find variations of the System IV period in the EUV brightness, the System III longitude at peak EUV intensity was derived by the following procedure: (1)Extracting the time variations of sulfur ion emission intensity at S II 76.5 nm + 126 nm , S III 68 nm, and S IV 65.7 nm + 140.5 nm every 10 days (data window) from the HISAKI Level-2 data. (2) Selecting the data of Io phase angle range from 0-45 degrees (180-225 degrees) in dawn (dusk) side, which corresponds to the downstream region of Io, to remove the dependence of EUV brightness on Io’s position. (3) Plot the data as a function of the System III longitude. (4) Fitting a second order sinusoidal curve to the data, where the first and second order terms correspond to the System III period and the half of System III period, respectively. The half of the System III period is produced because the rate of electron impact ionization of sulfur ions increases at the intersection of the centrifugal and rotational equator. The time variation in the phase of the component of the first order term indicates the System IV modulation. From the analysis, the System IV periods of SII 68 nm before and after the volcanic event (Dec. 1, 2014 - Jan. 20, 2015 and April. 20 - May 14, 2015, respectively) were roughly 10.10 h and 10.07 h, respectively. During the volcanic event, the System IV period was 9.97 h. This is the first observational evidence which shows that the System IV period has shortened after the enhancement of Io volcanic activity.
Origin of the System IV period has been discussed with sub-corotation of plasma in IPT; since the sub-corotation occurs due to mass loading of newly picked-up ions into IPT, it is expected that the System IV period becomes long during the Io volcanic event. However, the result derived from the HISAKI observation shows the opposite feature and will give important information to constrain the origin of the

System IV period.
We plan to derive the ion composition, electron density, electron temperature, and hot electron fraction in IPT by EUV spectral diagnosis analysis. Comparing the plasma parameters with the change in the System IV period presented here, we try to understand the influence of Io volcanic activity on the Jovian magnetosphere in detail.

Keywords: Io plasma torus, Io volcanic eruption, System IV period

