Variation of ion and electron temperature on Io plasma torus after an outburst measured with Hisaki and ground-based observations

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Volcanic gases (mainly composed of SO_2, SO and S) originated from jovian satellite Io are ionized by interaction with magnetospheric plasma and then form a donut-shaped region called Io plasma torus. Ion pickup is the most significant energy source on the plasma torus thought, additional energy source by hot electron is needed to explain energy balance on the neutral cloud theory (e.g. *Daleamere and Bagenal,* 2003). In fact, in-site measurements by Galileo indicates some injections of energetic particles in the middle magnetosphere. Recent EUV spectroscopy from the space shows fraction of hot electron increases as increase of radial distance in the plasma torus (*Yoshioka et al.,* 2014; *Steffl et al.,* 2004). On this study, we focus on variability of electron temperature derived from EUV diagnostics measured by HISAKI/EXCEED after a volcanic outburst in 2015, as well as ion temperatures parallel and perpendicular to the magnetic field measured from the ground-based spectroscopy.

The ground-based observation of sulfur ion emission, [SII] 671.6nm and 673.1nm from Io plasma torus was made at Haleakala Observatory in Hawaii from November 2014 through May 2015 with the high-dispersion spectrograph (R = 67,000) with an integral field unit (IFU) coupled to a 40-cm Schmidt-Cassegrain telescope. The IFU consist of 96 optical fibers (core/crad/jacket diameter are 50/125/250 micro-meters, respectively). The fibers are arranged in 12 by 8 array at the telescope focus which makes high-resolution spectroscopy over field-of-view of 41"" by 61" with a spatial resolution of 5.1" on the sky. Two-dimensional Doppler measurements enables to derive spatial distribution of [SII] emissions as well as their temperatures parallel and perpendicular to the magnetic field. We also made observation of neutral sodium cloud extending up to several hundred of jovian radii as a proxy of supply of neutral particles from Io (*Yoneda et al.,* 2015).

We also employee EUV spectroscopy of Io plasma torus with EUV space telescope Hisaki EXCEED from December 2014 through May 2015. We have made spectral fitting as the following method. First, we made series of EUV spectra averaged over five days. Next, assuming azimuthal homogeneity of Io plasma torus, Abel inversion is made to reduce line-of-sight integration effect. Then, we made fitting of observed EUV spectra (60 - 140 nm) with CHIANTI model spectra by changing electron density and temperature, mixing ratio of ions (S^{+}, S^{++}, S^{+++}, O^{+} and O^{++}) and fraction of hot electron (Te = 100 eV).

Based on observation of neutral sodium cloud (Yoneda et al., 2015), neutral supply started to increase at around DOY= 10, was at maximum at around DOY = 50, and has backed into the initial levels at around DOY = 120. In contrast, plasma diagnostics indicates that hot electron fraction at 7.0 jovian radii was less than 2 % before DOY = 50, started to increase after DOY = 50, and have reached 8(+/-1) % at DOY = 110. In addition, ion temperatures from ground-based observation started to increase after DOY=50 as similar tread of increase of hot electron fraction. EUV emission from aurora was also activated after DOY = 50 as increase of hot electron fraction on the plasma torus.

We also tried to reproduce the observed variation of electron and ion temperatures and densities using 0-dimensional time evolution model. The model calculates mass and energy balances in the torus under given conditions of neutral supply and transportation timescale as made by *Delamere and Bagenal,* 2003. Though hot electron fraction derived from plasma diagnostics is 5-10 times as much as that from the model, the mode with variable hot electron fraction reproduces the observed variation of ion mixing ratio and plasma temperatures well. The result indicates that the injection of hot electron from the outer magnetosphere (and/or local generation of hot electron) is activated after the outburst.