The radial plasma transports in Jupiter's inner magnetosphere seen by spectroscopic observation.

Kazuo Yoshioka[1], and Hisaki Science team
[1] Graduate School of Frontier Sciences, The University of Tokyo
e-mail (speaker): kazuo.yoshioka@edu.k.u-tokyo.ac.jp

The Io plasma torus (IPT), located in the Jovian inner magnetosphere (6-8 Jovian radii (R_J) from the planet), is filled with electrons and heavy ions such as sulfur and oxygen, a significant portion of which originates from the volcanoes on Io. The IPT serves as a crucial region connecting the primary plasma source (Io) with the middle and outer magnetosphere, where highly dynamic phenomena occur. Understanding the behavior of plasma in the IPT is essential for discussing the plasma dynamics in the whole Jovian magnetosphere (Fig. 1).

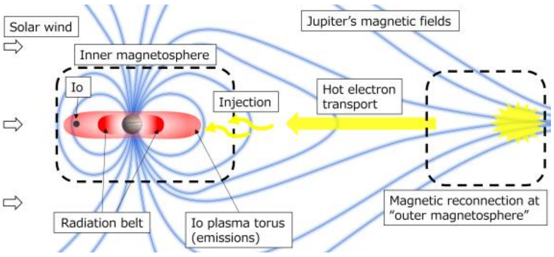

***Fig. 1** Schematics of Jovian magnetosphere*

A comprehensive understanding of the IPT can be achieved through spectral analysis of ion emissions, which are generated by electron impact excitation. This method is called as "Plasma diagnosis". The emission lines from ions in the IPT is mainly in the extreme ultraviolet (EUV) region. Therefore, EUV spectroscopic data are important for the study of Jupiter's inner magnetosphere.

Hisaki, an Earth-orbiting spacecraft equipped with the extreme ultraviolet spectroscope EXCEED, have been providing high-resolution spectra of IPT (Fig.2). Hisaki has been launched in 2013 and still working in 2023[1].

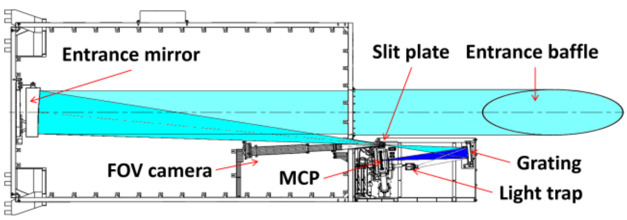

***Fig.2** Optical schematics of EXCEED on Hisaki*

It sub-continuously observe the IPT and take spectral images every 1 minute during almost half of its orbital period of ~100 minutes. The spectral range of EXCEED is from 52 to 148 nm and its spatial and spectral resolutions are around 0.5 R_J and 0.3-1.0nm FWHM, respectively. By using those data and plasma diagnosis method, we can deduce the plasma parameters such as electron density and temperature, and ion densities [2-4].

The data also has undergone physical chemistry modeling, assuming axial symmetry. The investigation has yielded radial profiles of various parameters, including electron density, temperature, and ion abundances. Moreover, the transport timescale for inward-moving mid-magnetospheric plasma has been determined to be 2-40 hours, based on the profile of supra-thermal electrons. The physical chemistry modeling indicates an outward transport timescale of approximately 30 days for Io-derived plasma. The ratio between inward and outward plasma speeds (~ 1%) is consistent with the occurrence rate of depleted flux tubes observed through in-situ measurements by instruments on the Galileo spacecraft [5].

In addition, Hisaki observations also revealed that the dynamics of the Jovian magnetosphere are greatly influenced in response to the Io's volcanic activity. In early 2015, when various observations indicated an upsurge in volcanic activity, Hisaki embarked on continuous observations of the Jovian magnetosphere, focusing on the aurora emissions and the emission emanating from the IPT (Fig.3). By employing plasma diagnosis to analyze the intensified spectrum, in conjunction with a physical chemistry model used to deduce plasma parameters, the study revealed a significant increase in plasma density and a radial flow rate approximately 2-4 times faster than during a period of volcanic quiescence. Subsequently, about a month later, the aurora emissions, indicative of middle magnetospheric activities, exhibited multiple peaks of heightened brightness.

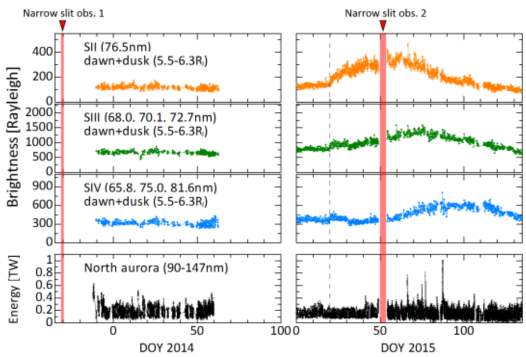

***Fig.3** Temporal variation of Io plasma torus brightness during volcanically quiet and active periods [6]*

In this presentation, the Hisaki mission, its data analysis, and the new knowledge about Jupiter's magnetosphere provided by the Hisaki data will be introduced.

References
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[4] Yamazaki et al. 2014, *SSR* 184, 259
[5] Yoshioka et al. 2017, *JGR* 122, 2,999
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