Development of a radial diffusion model of Jovian inner magnetospheric plasma aimed at comparison with HISAKI satellite observation

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We focus on the development of a diffusion model that estimates interaction and radial transport of various ions and electron in Jovian inner magnetosphere to understand the balance of mass and energy of plasmas and their temporal changes. We also verify the model results with the data obtained by the extreme ultraviolet spectroscope satellite HISAKI.
Jovian first satellite Io has active volcanoes and releases the plasma of the volcanic gas origin to the inner magnetosphere. The plasma is distributed in donut shape along the revolution orbit of Io by co-rotating with Jupiter, and it is called Io plasma torus. 90% of the total mass of Jovian magnetosphere plasma is supplied from Io, and it is transported on the time scale of several tens of days in the radial direction while obtaining energy from the angular momentum of Jovian rotation. Revealing the mass and energy balance of plasma in Jovian inner magnetosphere is an important to understand the macroscopic physical phenomena of the magnetosphere.
The radial distribution model of steady state Jovian magnetospheric plasma was developed based on observation results of Voyager 1, Voyager 2, Cassini spacecrafts. However, there is no report on a model that explains time variation of radial distribution of ions and electrons.

In this study, we are developing a model with the Fokker-Planck equation that can track mass and energy balance of major heavy ions of Io origin (O^+,O^{2+},S^+,S^{2+},S^{3+}) and time evolution of radial transport. We modified the steady state model foe mass and energy transport in Jovian magnetosphere by Delamere *et al*. (2005) to estimate time variations by the Forward Time Central Space (FTCS) method. From Delamere & Bagenal (2003), considering the chemical interaction between ions and electrons by charge exchange, we cited coefficients of electron impact ionization, electron recombination, Coulomb interaction, and radiation due to electron collision excitation. Radiative rate is calculated from the CHIANTI database.The initial temperature and density values of each ion and thermal electron were adopted from HISAKI’s observation data in November 2013 when the volcano activity was quiet [Yoshioka *et al*., 2018]. We assumed that the distribution of neutral atoms (O, S) depends only on the radial direction. For inner boundary conditions, the spatial differentiation of the density was 0 and the ion temperature was 60 eV at 6 R_J. For outer boundary conditions, at 30 R_J, both density and temperature match with values calculated by the function obtained from HISAKI’s observation. We compared the model results with the HISAKI’s observation data in the region of 6-9 R_J under the steady state conditions. We obtained that the number density of ions with higher valence number tend to be greater than that of observation result. For example, the number density of O^{2+} was 1.2 to 2.0 times greater than observed value. The model estimated the electron temperature to be 6 to 8 eV that was several eV higher than observation value. We considered that the increase in number density of high valence number ions may be due to overestimation of electron impact ionization. We also estimated higher electron temperature than observed value. In addition, we obtained that the temperature with low valence ions was higher than observation value, for example, O^+ temperature was higher than 280 eV at 12 R_J. This discrepancy may be

caused by the heating of pick-up ion gained by high electron temperature. In this presentation, we give detailed comparison between model and observation and quantitative verification.

Keywords: Jupiter, HISAKI