The dynamics of Jovian inner magnetospheric plasma based on a radial diffusion model and the HISAKI observation

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We developed a time-dependent radial diffusion model to evaluate chemical reactions and radial transport of ions and electron in the Jovian inner magnetosphere. We compared equilibrium plasma distribution with the HISAKI observation to validate the model, then investigated mass and energy flows in the magnetosphere when plasma source from Io temporally changed. The radial distribution of the plasma has been examined based on steady state models and observations of Voyager 1, 2 and Cassini spacecraft. However, the time dependent model and comparison of the model with continuous observations have not been reported yet. The purpose of this study is to develop a model that has a capability to track the time variation of the radial distribution and compare it with HISAKI observation.

In the model, we track mass and energy balances of major heavy ions of Io origin (O^+-O^{3+} and S^+-S^{4+}). The equation system is based on the mass and energy transport model [*Delamere et al., 2005*]. Nearby the Io's orbit, 5.8 R_J from Jupiter, plasma parameters (density and temperature of ions and thermal electrons) are calculated by the physical chemistry model [*Delamere and Bagenal 2003*] and are used as the inner boundary condition for our model. At the outer boundary (about 30 R_J), the plasma parameters are fixed with extrapolated values of HISAKI observation. We considered several chemical interactions: electron impact ionization, electron recombination, charge exchange, Coulomb interaction and radiation through electron collision excitation based on the previous study. The initial values of temperature and density of ions and thermal electrons were given from the HISAKI observations in November 2013 when Io's volcanic activity was quiet. Since the plasma diffusion due to the interchange instability depends on the radial distribution of plasma, we adopted the diffusion coefficient D_{LL} based on *Siscoe and Summers* [1981]. In order to verify the validity of the model, the steady state temperature and density of ions and electrons in the region of 6-10 R_J were compared with the HISAKI observation and we got the parameters that best matched with the observation. The ion temperature had wide range of 100-370 eV, and electron temperature was 5-9 eV, which was consistent with HISAKI observation. Under the condition when Io's volcanic activity was quiet, we obtained five parameters at L=6: the hot electron fraction f_{he} is 0.2 (%), the hot electron temperature is 60 (eV), the neutral source rate S_n is 6.5×10^{-4} (/cc/s), p and k_Ω which determined the radial diffusion coefficient are estimated to be 2.0 and 8.0×10^{-16}, respectively. For these parameters, we also explored the sensitivity to the radial distribution. Comparison of the timescales for each chemical reaction and the diffusion at steady state suggested that O^+ and S^{2+} were the most dominant ions in IPT under these conditions. As for the time variations of the IPT, we compared the results of our model with the HISAKI observation during the IPT emission enhancement in 2015. In this event, we assumed the injection of neutrals started on the day of year (DOY) 10 in 2015. The observed time variations of IPT is reproduced by introducing both increase of neutral source rate S_n and variation of the hot electron density. We traced the mass and energy flow among the neutrals, ions, and electrons. For the mass flow, neutralization by charge exchange and recombination was the most dominant loss process. As for the energy flow, the 70 % of source process was provided from thermal electron heating by hot

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electrons, and 80% of loss process was the UV radiation. These balances were similar to those reported by the previous study. While the diffusion coefficient D_{LL} was consistent with previous studies, the coefficient k_{Ω} was over 100 times larger than the theoretical value. It implies that the formulation of diffusion coefficient based on interchange instability by *Siscoe and Summers* [1981] would be updated.

Keywords: Jupiter, Io, Hisaki satellite

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