

Ejection mechanisms of sodium atoms originated from Io inferred from high dispersion spectroscopic observation

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In order to clarify the physical mechanism(s) for producing sodium atoms escaping from Io, following observations of resonantly scattered sodium D line emission were carried out almost simultaneously in 2004. They are; (1) observation with the High Dispersion Echell Spectrograph (HIDES) at Okayama Astrophysical Observatory, (2) wide field spectroscopic observation at Iitate Observatory, and (3) wide field imaging observation at Haleakala, Hawaii. Based on comparison between observational results and model simulation, following conclusions were obtained.

1. As escaping mechanisms of sodium atoms from Io, sputtering on the atmosphere of Io by torus ions and dissociative recombination of sodium bearing molecular ions are thought to be steadily taking place.

2. Charge exchange reactions between thermalized torus ion and the atmosphere of Io gives production rate of 2 orders less than that of dissociative recombination. If ever it does exist, emission intensity of sodium atoms produced by this mechanism would be too weak to detect.

3. Production rate for sputtering is estimated to be $1.6-3.4 \times 10^{26}$ atoms/s, and that for dissociative recombination is $2-38 \times 10^{26}$ atoms/s. Variability of these production rates is thought to be dependent on electron density of plasma torus and solar zenith angle on the leading hemisphere of Io.

4. It is suggested that production rate of sputtering process is strongly dependent on electron density of plasma torus. Production rate on the leading hemisphere of Io is 2-3 times that on the trailing hemisphere, suggesting that pick-up ions are producing sputtering and charge exchange in the atmosphere of Io.

5. Production rate of dissociative recombination strongly depends on whether the leading hemisphere is sun lit or not. It is suggested that higher density of NaX⁺ molecules in the daytime atmosphere of Io gives larger production rate.

6. According to the work by Mendillo et al. (2004), our observations were made in volcanically active period. However, large change of production rate due to volcanic activity was not seen in the observational results.