Short-term variability of Jupiter's extended sodium nebula

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Dissertation for partial fulfillment of the Degree of Master of Science
Graduate School of Science, Tohoku University
2007

Abstract

It is well-known that Jupiter is surrounded by the sodium nebula which extends over several hundreds Jovian radii in the Jupiter's equatorial plane. Sodium atoms consisting the nebula have to have large velocities so that they can escape from the strong gravitational field of Jupiter. It is believed nowadays that pick-up of Io's ionospheric ions, such like NaX+, by Jupiter's co-rotating magnetic field, and their subsequent dissociative recombination with an electron in Io plasma torus is a primary source of producing those fast neutral sodium atoms.
More abundant ionospheric ions including NaX+ are expected to exist in Io's dayside hemisphere than in the nightside. When Io's leading hemisphere is illuminated by the sun, it is also expected that more abundant NaX+ ionospheric ions are picked up by Jovian co-rotating magnetic field, and they will produce more abundant fast sodium atoms. This scenario suggests that such diurnal change of the Io's ionosphere will result in the east-west asymmetry of sodium nebula, and such asymmetry will change with respect to Io's orbital motion in the inner region of the nebula.
However, such phenomenon has not been observed clearly in the past. It is because a field of view of instruments used in the past observations was too large, and they could not clearly detect the inner region of the nebula, while the outer nebula is not suitable to detect asymmetry of the sodium nebula with respect to Io's orbital motion.
Ground-based optical observation of D1 and D2 line emissions from Jupiter's sodium nebula was carried out at Mt. Haleakala in Maui, Hawaii by using an imager with a medium FOV, which had been optimized for an observation of the inner sodium nebula. In this observation, we could obtain images of sodium nebula

in a region within 50 RJ (Jovian radii) from Jupiter.

The sodium nebula showed distinct enhancement in the first half of the observation period. The duration time of this enhancement is quite shorter than that observed in the past. In the latter half of the observation period, the sodium nebula was stable. Observational results obtained in this period can be regarded suitable to identify the variation of the sodium nebula with respect to the Io's orbital motion. In the latter half stable period, east-west asymmetry of the nebula with respect to Io's orbital motion was clearly identified. Particularly, brightness amplitude in Jupiter's equatorial plane is greater in the western side of Jupiter than in the eastern side of Jupiter at a distance of 25 RJ and 50 RJ from Jupiter.

These characteristics of the sodium nebula obtained from our observation were successfully reproduced by model simulation which was carried out taking the scenario mentioned above into account.

We conclude that Io's ionosphere is expected to be controlled by the solar radiation like the Earth, and pick-up rate of NaX+ ion from Io's ionosphere varies with respect to solar illumination on the Io's leading hemisphere. As a result, the D1 + D2 brightness of the sodium nebula shows a different brightness amplitude in the eastern side and the western side of Jupiter.