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Investigation of the solar UV/EUV related changes in the Jovian radiation belt and thermosphere

H. Kita (1), H. Misawa (1), A. Bhardwaj (2), F. Tsuchiya (1), C. Tao (3), T. Sakanoi (1, 6), Y. Miyoshi (4), Y. Kasaba (5) and A. Morioka (1)

(1) Planetary Plasma and Atmospheric Research Center, Tohoku University, Sendai, Japan (kita@pparc.gp.tohoku.ac.jp), (2) SPL, Vikram Sarabhai Space Centre, Trivandrum, India, (3) Laboratoire de Physique des Plasmas, Ecole Polytechnique, Saint-Maur-des-Fosses, France, (4) Solar-Terrestrial Environment Laboratory, Nagoya University, Nagoya, Japan, (5) Planetary Atmosphere Physics lab., Tohoku University, Sendai, Japan. (6) Visiting Astronomer at the Infrared Telescope Facility, which is operated by the University of Hawaii under Cooperative Agreement no. NNX-08AE38A with the National Aeronautics and Space Administration, Science Mission Directorate, Planetary Astronomy Program

Abstract

In order to investigate atmospheric heating effect by the solar UV/EUV on the Jovian Radiation Belt, we made coordinated observations using a radio interferometer and an infrared telescope. The total flux density of Jovian Synchrotron Radiation (JSR) increased from 6th Nov to 13th Nov in 2011 by about 5%, corresponding to the solar UV/EUV variations. The infrared H_3^+ emission also increased from 7th Nov. to 12th Nov. by 20-30%. These support a theoretical expectation that solar UV/EUV heating for the Jovian thermosphere drives neutral wind perturbations, then the induced dynamo electric field increases the total radio flux density. On the other hand, radio images showed that the equatorial emission peak moved outward by about 0.2 Jovian radii. These observation results showed that the variation of JSR at this time was caused by not global but non-uniform enhancement of radial diffusion.

1. Introduction

Jovian Synchrotron Radiation (JSR) is emitted from relativistic electrons in the Jovian radiation belt, and it is the most effective probe for the dynamics of the Jovian radiation belt. It is theoretically expected that the solar UV/EUV heating for the Jovian thermosphere drives neutral wind perturbations, then the induced dynamo electric field increases radial diffusion [1]. The solar UV/EUV heating is also expected to change the brightness distribution of JSR; i.e. the global enhancement of radial diffusion causes inward shift of equatorial emission peak position. Previous studies confirm that the total flux density of JSR varied corresponding to the solar UV/EUV variations [2], [3], though it is not known whether the temperature of the Jovian thermosphere actually varied during this event. The purpose of this study is to confirm whether sufficient solar UV/EUV heating occurs on the Jovian thermosphere and it actually causes the variations of the total flux density and brightness distribution. We made coordinated observations of a radio interferometer, the Giant Metrewave Radio Telescope (GMRT), and an infrared telescope, the NASA Infra-Red Telescope Facility (IRTF). From the radio interferometer observations, we measured the total flux density and brightness distribution of JSR. From the infrared spectroscopic observations, we estimated the temperature variations of the Jovian upper atmosphere from H_3^+ emission [4].

2. Observations

The GMRT observations were made from 6th Nov. to 17th Nov. in 2011 at the frequencies of 235 and 610MHz. The IRTF observations were made from 7th Nov. to 12th Nov. We used high spectral resolution spectrometer, CSHELL [5], and observed H_3^+ Q(1,0-) 3.953 microns emission. Slit position was located along the sub-solar point and dusk side limb direction.

3. Results

During the period, solar UV/EUV flux variations expected on Jupiter increased monotonically. The GMRT 610 MHz observation shows that the total flux density increased from 6th Nov. to 13th Nov. by about 5%, corresponding to the solar UV/EUV variations (Figure 1). The IRTF observation shows that equatorial H_3^+ emission also increased from 7th Nov. to 12th Nov. by 20-30%, that is, temperature at the equatorial region was expected to increase (Figure 2). On the other hand, radio images showed that the equatorial emission peak position moved outward by about 0.2 Jovian radii.

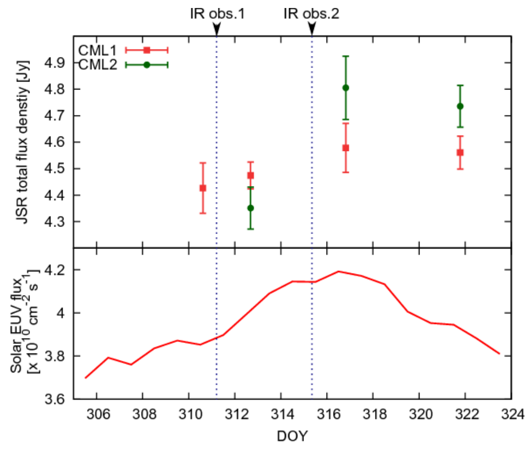

Figure 1: Top: Variations of total flux density of JSR obtained from the GMRT observation in 2011. Observing frequency is 610 MHz, and the total flux densities at the longitudes of 270-300 and 300-330 degrees were observed (CML1, CML2). Bottom: Solar EUV flux observed by the SOHO satellite.

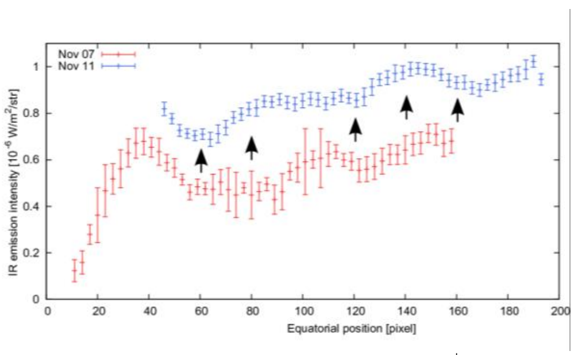

Figure 2: Radial distribution of Jovian H_3^+ emission at the equator observed by the IRTF-CSHELL. Slit was located along the sub-solar point (right hand side, around 140-160 pixel) to the dusk side limb (left hand side, around 20-40 pixel) direction. The data is running-averaged by 20 pixels.

4. Discussions and Conclusions

These observation results could be explained by not global but radially localized enhancement of inward diffusion. It is expected from a numerical simulation study of the Jovian upper atmosphere (after [6]) that temperature variations induced by the solar UV/EUV enhancement propagate from the auroral latitude to lower latitude region. These temperature variations cause enhancement of radial diffusion at the outer region which shift the equatorial peak position outward. Hence, we propose a scenario that radial diffusion increased not globally but locally at the outer region of more than L=2 during this period. The further confirmation of the solar UV/EUV heating effect on the Jovian radiation belt is deferred to future studies in ground-based observations; detailed mapping of H_3^+ emission and daily base observation are necessary to confirm that the temperature variations actually propagate from the auroral latitude to lower latitude region. In addition to these, direct temperature measurement using intensity ratio of H_3^+ emission line is needed for more reliable results.

Acknowledgements

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References

[1] Brice, N. M., and McDonough, T. R., Icarus, 18, 206, 1973.

[2] Miyoshi, Y., Misawa, H., Morioka, A., Kondo, T., Koyama, Y., and Nakajima, J., Geophys. Res. Lett., 26, 9, 1999.

[3] Tsuchiya, F., Misawa H., Imai K., and Morioka A., Journal of Geophysical Research (Space Physics), 116, A09202, 2011.

[4] Miller, S., Achilleos, N., Ballester, G. E., Lam, H. A., Tennyson, J., Geballe, T. R., and Trafton, L. M., Icarus, 130, 57-67, 1997.

[5] Greene, T. P., Tokunaga, A. T., Toomey, D. W., and Carr, J. S., Proc. SPIE, 1946, 313-324, Infrared Detectors and Instrumentation, Albert M. Fowler; Ed., 1993.

[6] Tao, C., Fujiwara, H., and Kasaba, Y., Journal of Geophysical Research (Space Physics), 114, A08307, 2009.