論 文 内 容 要 旨

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学位論文の題　　名	A study on short-term variations of the Jovian radiation belt using GMRT 大型メートル波帯電波干渉計 GMRT を用いた 木星放射線帯の短期変動の研究		

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＜論文要旨＞

The goal of this study is to investigate physical processes of short term variations of Jupiter's Synchrotron Radiation (JSR) which is important for revealing the origin of relativistic electrons of the Jupiter's Radiation Belt (JRB).

JSR has been frequently observed by some radio interferometers or telescopes in order to understand dynamics and energetics of the relativistic electrons. Recently, Miyoshi et al. (1999) and Bolton et al. (2002) confirmed the existence of "short" term (days to weeks) variations in JSR. The detection of short term variations makes a great impact on the study of JRB because it has been believed for a long time that the strong internal magnetic field and rapidly rotating magnetosphere of Jupiter protect the JRB region from solar wind variations and magnetospheric disturbances as theoretically suggested by de Pater and Goertz (1994).

So far the observations of the JSR short term variations have been made at some frequencies, especially low frequencies of several hundreds MHz, at which the JSR is emitted by low energy particles (F<10MeV). Misawa et al. (2005) and Nomura (2007) suggested that the short term variation is a general feature at low frequencies, and implied that there are some other additional controlling factors. Therefore, it is essential to study its detailed characteristics and the causalities. Theoretically expected physical processes which are responsible for the short term variation are enhanced radial diffusion initiated by solar UV/EUV flux enhancement and scattering of the JRB electrons toward the polar region by whistler-mode wave, although it is still not known whether solar UV flux or whistler-mode wave is a dominant initiator.

In order to investigate physical processes of short term variations, we considered two characteristics in this study. First, we observed JSR using a radio interferometer, the Giant Metrewave Radio Telescope (GMRT), which enables us to identify the variations of the spatial distribution. The previous researches of JSR indicate that short term variations are typical at several hundred MHz, however short term variations of the spatial distribution have not been discussed yet. The GMRT observations were made for JSR at 610 MHz, which is emitted from electrons with approximately 10 MeV. Second, we have made the JSR observations with the clear intension of comprehending the causalities of short-term variations with a time scale of days to weeks. Since the sun rotates at the period of about 26 days, solar activities vary for Jupiter recurrently. They may affect on JSR. However, it is not easy to predict when they would increase and decrease in one solar rotation, and moreover they often show sudden variations. Therefore we observed JSR continuously, totally over two solar rotation periods during the low solar activity period. It is easier to distinguish and evaluate causalities of JSR variations during low solar activity.

In this study, we established the techniques of the spatial distribution measurement for JSR. We selected the observation time only when Jupiter's CML has specific values 100 and 280 degrees, to make effective discussion on physical processes under the limited allocation time. The contamination by the background sources of the JSR has been estimated by the special observations of them, because they significantly affect

the JSR image at low frequency band. Since the normal calibration is not enough to observe JSR, observations of secondary phase calibrator, frequently calibrator observation, and self-calibration were made. Further, multi-facet CLEAN was made so as to remove strong background sources in the outer FOV. Consequently, spatial resolution is less than 1.23 R_J, time resolution is 15 min, and absolute error is normally less than 100 mJy.

We made JSR observations with GMRT at 610 MHz totally 9 times in the period from May to June, 2007 and 13 times in the period from May to June, 2008. The results of the observations are as follows:

- It is confirmed that JSR at 610 Hz usually shows more than 10 percent of total flux variations with the time scale of several day. The time scale does not correspond with transportation of electrons from outside of JRB by the radial diffusion, which takes for more than 100 days.
- There is little correlation between variations of JSR and those of the solar UV/EUV parameters in 2007 and 2008. It indicates that the causality of the JSR enhancement is not temporal enhancement of radial diffusion by solar UV/EUV enhancement, which is a plausible explanation for JSR variations at high frequencies, and implies the possibilities of existence of variations caused by Jupiter itself.
- The characteristics of the spatial variations are obtained. In case of JSR increase, there are two types of variations:
  - enhancement of radial diffusion in the specific radial distance
  - transportation of electrons with the longitude dependence.

  In case of JSR decrease, it is suggested that the following loss processes makes electrons decrease:
  - absorption of electrons by Amalthea
  - synchrotron loss
  - wave-particle interaction
  - other loss processes (e.g., interaction with dust and ring).

As future works, there are two main subjects. First, the spatial variations of JSR are required at multi-frequencies. Especially, the VLA observation at 1.4 GHz is effective. For, it enables us to investigate energy dependent dynamics of the JRB electrons. Second, the elucidation of the hypotheses proposed in this study is required. The continuous spatial observations in all CML are effective. The investigation of particle transportation in specific CML requires the observation in all CML, and that of the precise physical processes during the increase and decrease periods requires the continuous observation. Furthermore, to examine the details of each physical process quantitatively the 3D-model of JRB is required.