

Analysis of spatial structure of electrons in the Jupiter's radiation belts using GMRT : Coordinated observations with Juno

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Jupiter's synchrotron radiation (JSR) is emitted from the relativistic electrons trapped in the Jupiter's radiation belts. Its intensity and frequency depend on electron energy, electron number density, and magnetic field strength. Therefore, radio observations of JSR are the most effective probes for studying the spatial structure and dynamics of radiation belts. One of the dominant physical processes in the Jovian magnetosphere is electron loss caused by the sweeping effect of the Jovian moons (Amalthea and Thebe) orbiting inside the radiation belts. As electrons diffuse inward, substantial populations of electrons are lost owing to collisions with the moons. The electron loss due to the sweeping effect strongly depends on the electron energy and pitch angle (angle of the electron velocity vector with respect to the local magnetic field). As a result, a difference in the electron energy is expected between lower pitch angle electrons, which contribute to the radiation at high-latitude and higher pitch angle electrons near the equator. However, this energy dependence has not yet been demonstrated by observation.

We conducted simultaneous cooperative observations with radio interferometers, including Giant Metre Wave Radio Telescope (GMRT) in India, and single telescopes in Japan (Iitate and Usuda) at the time of Juno's perijove (PJ66) on 23 October 2024. Juno is currently on a trajectory that passes through the radiation belts, providing a valuable opportunity to obtain information on the electron distribution based on the in-situ measurement. On the other hand, ground-based radio observations play an important complementary role to Juno. While Juno's in-situ observations are not able to provide a complete spatial distribution of the radiation belts, two-dimensional radio maps of JSR can provide a complete picture of the spatial distribution. In addition, multi-frequency observations can estimate the energy spectrum of the electrons, which is expected to improve a physical model of the radiation belts.

We observed JSR by GMRT in two frequency bandwidths, Band 2 (125-150 MHz) on 21-22 October 2024 and Band 4 (550-900 MHz) on 22-23 October 2024. As part of the multi-frequency observation campaign, we analyzed the GMRT Band 4 data using an analysis method called Source Peeling and Atmospheric Modeling (SPAM), which calibrates propagation delays caused by the terrestrial ionosphere. As a result, we succeeded in producing high-resolution radio images that spatially separate high-latitude and equatorial radiation.

In this paper, we present the results of the radiation belts images from GMRT observations and discuss the spatial structure of electrons in the radiation belts.

Keywords: Jupiter, Synchrotron radiation, GMRT, Radio telescope, Radiation belt, Juno