Astronomers detect traveling Ionospheric disturbances using the GMRT.

The ionosphere is a part of the upper atmosphere of the Earth, lying between 80 and 600 km. It gets its name from the fact that the solar extreme ultraviolet and X-rays ionise the atoms and molecules present at these heights leading to a layer which has ions and electrons. Though it sits far above the clouds, it plays a surprisingly important role in our daily lives. The electrons and ions in this layer leave their mark on the radio waves passing through this layer, including GPS signals. When disturbances occur in this region, known as traveling ionospheric disturbances, they can lead to disruptions in radio communications and GPS accuracy, impacting our ability to communicate and navigate effectively. This disturbance in radio waves can also distort the celestial signals gathered by the Giant Metrewave Radio Telescope (GMRT). By studying these phenomena, scientists gain insights into how to better manage and mitigate their effects on our communication and navigation systems and also develop insights about correction the distortions they impose on the GMRT data.

For the first time, researchers from the Indian Institute of Technology, Indore, used the Giant Metrewave Radio Telescope (GMRT) to detect and characterize Traveling Ionospheric Disturbances (TIDs). The detection of these ionospheric disturbances has been made possible thanks to the GMRT's exceptional sensitivity. Sarvesh Mangla, who has recently completed his PhD from IIT Indore, and his mentor Prof. Abhirup Datta from the Department of Astronomy, Astrophysics, and Space Engineering (DAASE), IIT Indore have successfully detected multiple medium-scale TIDs (with a range of 100 to 300 km) and small-scale TIDs (approximately 10 km) at both the observing frequencies of 235 MHz and 610 MHz. The results of their study also unveiled unexpected changes in the ionosphere during the sunrise hours, along with the observation of significant ionospheric disturbances and smaller-scale structures moving in the same direction. The characteristics of these disturbances are comparable to previous GPS studies conducted at similar geophysical latitudes worldwide.

The Giant Metrewave Radio Telescope (GMRT) is a powerful instrument capable of exploring many mysteries of the universe, encompassing pulsars, galaxies, and the early universe. In addition to its celestial pursuits, it can also serve as a valuable asset in examining the intricacies of Earth's ionosphere. Its findings can improve our knowledge and models of the ionosphere, leading to better technologies and more accurate measurements for navigation and communication. Unlike Global Navigation Satellite System (GNSS) measurements, the radio telescopes are not traditional probes for ionospheric studies; however, the GMRT, located in the low-latitude region, has proven to be very effective in detecting various ionospheric phenomena. Using the GMRT, the authors have demonstrated the capability to achieve precise measurements of ionospheric variations with higher sensitivity compared to GPS and radar instruments.

Prof. Yashwant Gupta, Centre Director, NCRA said “This work shows the new capability of GMRT, bridging the gap between astronomy and earth sciences, by offering a unique perspective on the behavior of the Earth's ionosphere, while also offering the promise of improving the quality of the radio images made by the GMRT. This kind of results is something we had all along believed to be possible with the GMRT, and I very pleased this team led by colleagues from IIT Indore has clearly demonstrated this, thereby opening a new window of research with the GMRT.”

The GMRT's capabilities include measuring the electron density (TEC: a measure of the number of free electrons in a column of the ionosphere) with remarkable accuracy, offering valuable insights into the ionosphere's behavior. Employing models and techniques, the authors have successfully detected medium-scale traveling ionospheric disturbances and smaller waves with wavelengths as small as 10 km simultaneously. MSTIDs candidates with periods between 10 and 30 minutes, or longer, and estimated speeds between 50 and 150 m/s were identified, similar to nighttime MSTIDs in the Northern Hemisphere. Additionally, their research has uncovered intriguing phenomena: unexpected variations in the ionosphere during sunrise and the observation of equatorial spread F disturbances and smaller structures moving coherently.

In summary, Sarvesh Mangla and team demonstrated as how the GMRT significantly advances our understanding of the ionosphere. Its heightened sensitivity and capabilities allow for more precise measurements and comprehensive investigations of ionospheric fluctuations, ultimately leading to improved technologies and enhanced accuracy in fields like radar and satellite imaging. Sarvesh Mangla has recently joined the National Centre for Radio Astrophysics and plans to continue this line of research.

The GMRT is an array of thirty 45-meter antennas spread over a 25 km area in Khodad village, Narayangaon, India. It was built and is operated by the National Centre for Radio Astrophysics of the Tata Institute of Fundamental Research, India, under the Department of Atomic Energy.

This article is based on the Published work “Spectral Analysis of Ionospheric Density Variations Measured With the Large Radio Telescope in the Low-Latitude Region” which was recently published in the prominent international journal Geophysical Research Letters. (link of article: https://doi.org/10.1029/2023GL103305)

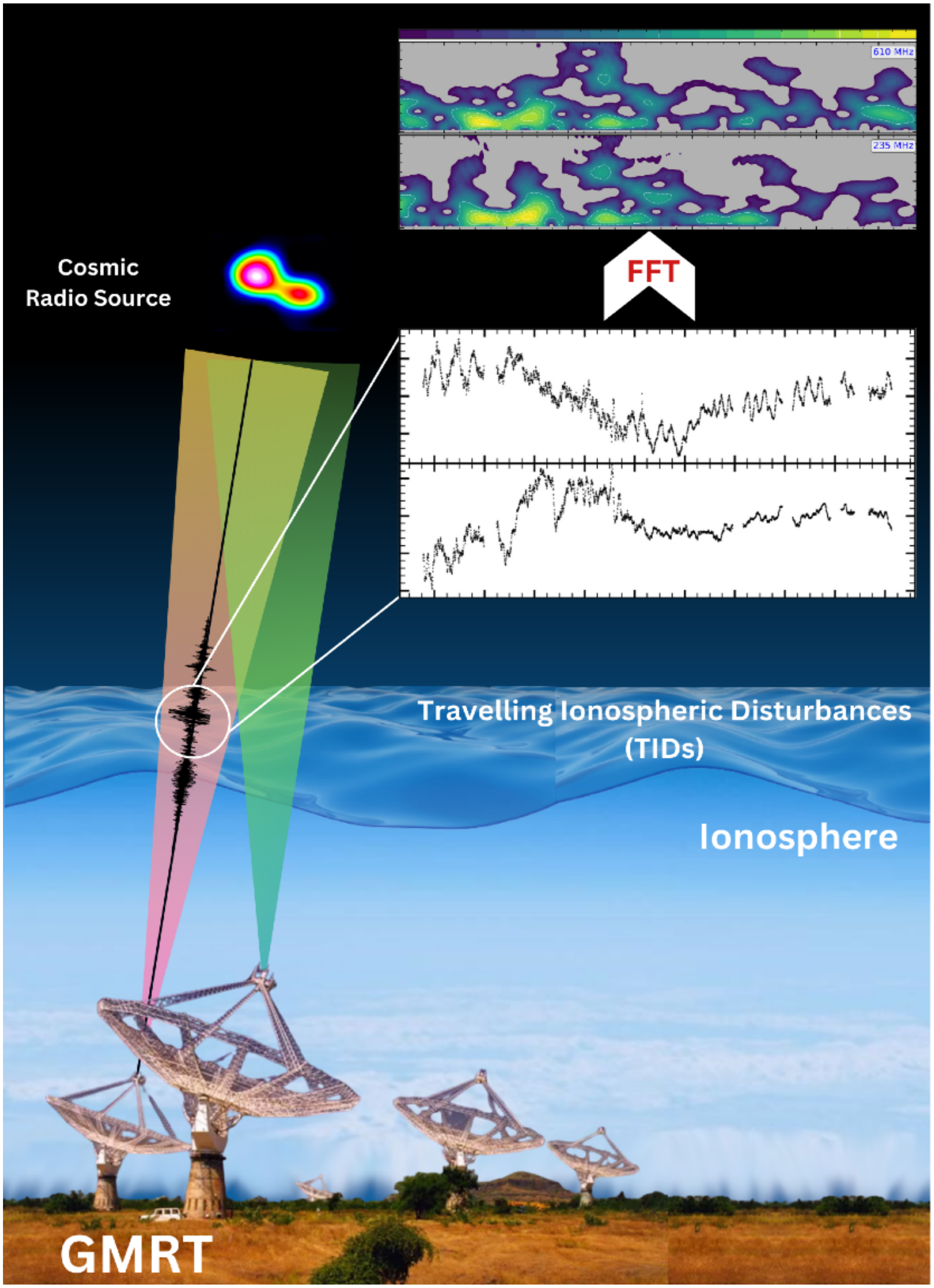

Figure 1: Illustration showing how ionosphere disturbs the distant signal receiving from radio sources and how GMRT detects these signals and better transform them into detecting ionosphere disturbances.

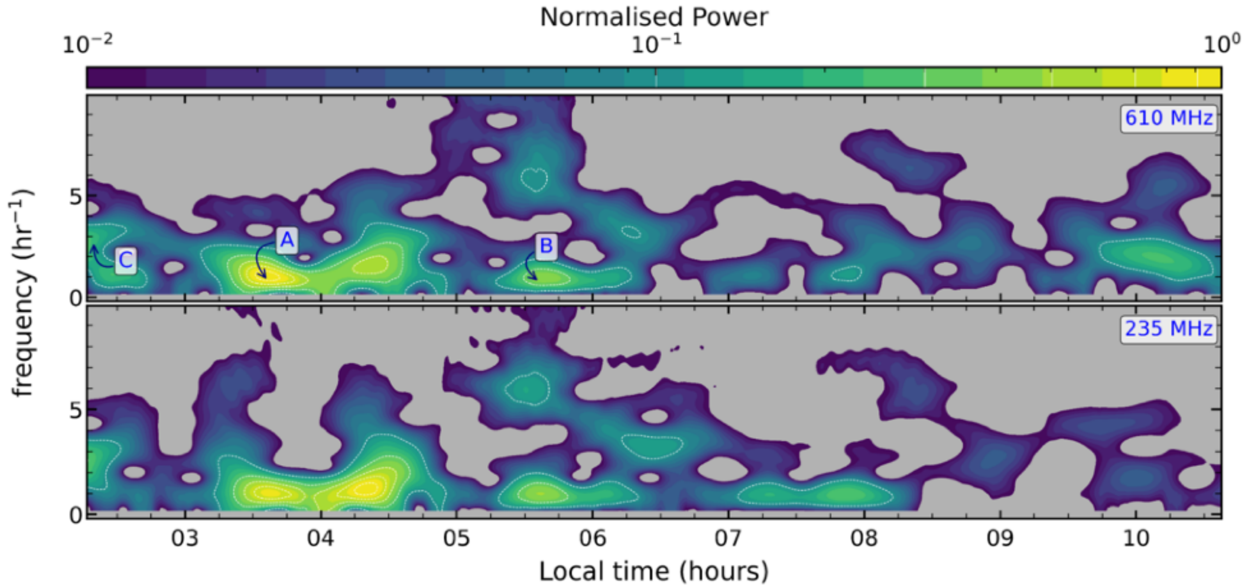

Figure 2: The normalized power as a function of temporal frequency (y-axis) and local time (x-axis). Similar structures are present in both bands, also, smaller structures are more visible in the 235 MHz band compared to the 610 MHz band.

Contacts:

Sarvesh Mangla (mangla.sarvesh@gmail.com); Phone: +91-9899943438
Abhirup Datta (abhirup.datta@iiti.ac.in); Phone: +91-731-660-3545
Yashwant Gupta, NCRA-TIFR, Pune (ygupta@ncra.tifr.res.in) Phone: 020-25719242
Nissim Kanekar (nkanekar@ncra.tifr.res.in) ; Phone: 020-25719248
CH. Ishwara-Chandra (ishwar@ncra.tifr.res.in); Mobile: 9403136630
Divya Oberoi (div@ncra.tifr.res.in); Mobile: 09404059818
Anil Raut: (anil@gmrt.ncra.tifr.res.in); Mobile: 8605525945
J. K. Solanki (solanki@ncra.tifr.res.in); Mobile: 9890447888