*5th URSI-RCRS 2022, IIT Indore, India, 1 - 4 December 2022*

# Characterizing Low-Latitude Ionosphere with GMRT

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Radio interferometers are the array of antennas that measures the "spatial coherence function" [1] to observe astronomical sources in the sky. During the low-frequency observation ($\leq$1 GHz), they require a detailed calibration procedure to remove the effects of the ionosphere particularly in the low signal-to-noise ratio (S/N) regime. Thus, the same calibration data can provide insight into the ionosphere. Interferometers like upgraded Giant Meterwave Radio Telescope (uGMRT; [2]), LOwFrequency ARray (LOFAR; [3]), Very Large Array (VLA; [4, 5] ), Murchison Widefield Array (MWA; [6, 7]), and future instruments such as Square Kilometre Array (SKA; [8]) are all affected in the similar way.

Here, our motivation is to study the Equatorial Ionization Anomaly (EIA) region, which has prominent plasma turbulence effect. In this region, which extends up to $\pm 20^\circ$ magnetic latitudes, Earth's ionosphere continues to vary at dawn and has unanticipated changes during night-time [2]. These activities in the EIA region can often lead to disruption in communication and navigation such as global navigation satellite system (GNSS). Various telescopes like VLA ($\sim 34^\circ$ N), MWA ($\sim 26^\circ$ S), LOFAR ($\sim 53^\circ$ N), have also studied the ionosphere. But due to their location constraints, their studies were limited to their local ionospheric region. Pathfinder for SKA, GMRT is one of the largest sensitive radio telescopes operating at low-frequency regimes. The geographical location and configurations (centre square and arms antennas) of the GMRT ($\sim 19^\circ$ N) make this telescope unique to explore the sensitive regions between the northern crest of the EIA and the magnetic equator in different spatial scales.

Our recent analysis has successfully demonstrated that the GMRT can detect irregularities in total electron content (TEC) with amplitudes $\sim 10^{-3}$ TEC Unit (TECU) and can measure TEC gradient with a precision of about $7 \times 10^{-4}\,\mathrm{TECU\,km^{-1}}$ using observation taken at 610 MHz [2]. Continuing with such a study, we introduce a method to do spectral analysis on the measured TEC gradient, which is calculated using the polynomial based method. While this method is insensitive to fine-scale structure, it effectively tracks individual waves associated with medium scales travelling ionospheric disturbances (MSTIDs). Furthermore, speed and direction of individual waves is also estimated with this method.

## References

[1] Cornwell, T. & Fomalont, E. B. 1999, *Synthesis Imaging in Radio Astronomy II*, 180, 187 doi:1999ASPC..180..187C

[2] Mangla, S. & Datta, A. 2022, *MNRAS*, **513**, 964. doi:10.1093/mnras/stac942

[3] Mevius, M., van der Tol, S., Pandey, V. N., et al. 2016, *Radio Science*, 51, 927. doi:10.1002/2016RS006028

[4] Helmboldt, J. F., Lazio, T. J. W., Intema, H. T., et al. 2012, *Radio Science*, 47, RS0L02. doi:10.1029/2011RS004787

[5] Helmboldt, J. F., Lazio, T. J. W., Intema, H. T., et al. 2012, *Radio Science*, 47, RS0K02. doi:10.1029/2011RS004883

[6] Loi, S. T., Trott, C. M., Murphy, T., et al. 2015, *Radio Science*, 50, 574. doi:10.1002/2015RS005711

[7] Jordan, C. H., Murray, S., Trott, C. M., et al. 2017, *MNRAS*, 471, 3974. doi:10.1093/mnras/stx1797

[8] Dewdney, P. E., Hall, P. J., Schilizzi, R. T., et al. 2009, *IEEE Proceedings*, 97, 1482. doi:10.1109/JPROC.2009.2021005