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Detecting the Undetected: Unlocking Pulsar Low Frequencies Discoveries with the GHRSS survey using GMRT.

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Pulsars are highly magnetized (10^8 to 10^{13} Gauss [1]), fast-rotating neutron stars emitting electromagnetic beams, mainly in radio, X-ray, and gamma-ray bands. Due to their high periodic stability (10^{-15} to 10^{-21} s/s [1]), millisecond pulsars (MSPs, P $\leq$ 30 ms [1], 17% of total pulsar population) are key to Pulsar Timing Arrays for gravitational wave detection. According to estimates of the Galactic population, numerous MSPs are still unknown, ranging from 40,000 to 90,000 [1]. Due to their weak signals, steep Spectral index (-1.7) [1], and binary motion smearing (for binary pulsars), many MSPs remain undetected due to limitations in sensitivity, survey coverage, and observational cadence. To address these challenges and enhance the discovery of new pulsars, large-scale, high-sensitivity surveys are crucial. The Giant Metrewave Radio Telescope (GMRT) High-Resolution Southern Sky (GHRSS) survey [2] is one such initiative, uniquely designed to detect pulsars and transients in the southern sky by utilizing the GMRT's advanced low-frequency capabilities.

GHRSS survey is an off-galactic plane survey for the pulsars and transients in the southern sky (−20 deg < DEC < −54 deg) with |b| > 3 deg [2]. The survey operates at band-3 (300 - 500 MHz), having a sampling time of 81.92 μs. The calculated theoretical 10σ sensitivity for a 10-minute pointing duration in the GHRSS at 400 MHz, considering a 200 MHz bandwidth, is 0.25 mJy [2]. The survey aims to match or exceed the sensitivity of the GBNCC survey but in a complementary sky region. We have included the Gaussian Hellinger Very Fast Decision Tree (GHVFDT) machine learning classifier to enhance the effectiveness of pulsar identification by efficiently distinguishing real pulsar signals from RFI and noise.

To date, the GHRSS survey has yielded 31 discoveries (as illustrated in figure-1), including 25 normal pulsars, 3 MSPs, and 3 Rotating Radio Transients (RRATs) [2], detected using a combination of advanced search techniques: Fast Fourier Transform (FFT) based periodicity searches for short-period pulsars, Fast Folding Algorithm (FFA) searches for detecting long-period pulsars with low duty cycles, and GPU-accelerated single pulse searches for identifying Rotating Radio Transients (RRATs) and Fast Radio Bursts (FRBs). The increased sensitivity of upgraded GMRT (uGMRT), combined with advanced RFI mitigation and machine learning techniques, has resulted in new pulsar detections, including MSPs. Currently, I'm looking for pulsars and setting up new observations. I have re-detected 16 pulsar-like candidates from the GHRSS archival data, awaiting confirmation. This extended abstract presents our latest findings and discusses the prospects of the GHRSS survey.

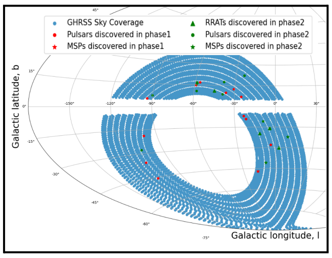

Figure 1. GHRSS sky coverage and the discoveries.

1. D. R. Lorimer and M. Kramer, *Handbook of Pulsar Astronomy*. 2004. [Online]. Available: https://assets.cambridge.org/97805218/28239/copyright/9780521828239_copyright.pdf

2. B. Bhattacharyya *et al.*, "The GMRT High-resolution Southern Sky Survey for Pulsars and Transients. II. New Discoveries, Timing, and Polarization Properties," *The Astrophysical Journal*, vol. 881, no. 1, p. 59, Aug. 2019, doi: 10.3847/1538-4357/ab2bf3.