URSI-RCRS 2024, ARIES/GEHU, Bhimtal, India, 22 - 25 October, 2024

Looking for tiny-time-ticks from neutron stars using the GMRT high resolution southern sky survey for pulsars and transients

B. Bhattacharyya[(1)], and GHRSS team members
(1) National Center for Radio Astrophysics, e-mail: bhaswati@ncra.tifr.res.in.com

Neutron stars, observed as pulsars, offer a unique window into understanding the fundamental behaviors of matter, energy, space, and time under extreme conditions. Time-ticks from the pulsars are observable with rotation of the neutron stars. Despite significant advancements in survey technologies over the past decade, the current catalog of approximately 3000 known pulsars represents less than 5% of the anticipated number of detectable radio pulsars. To address this challenge, we are conducting the GHRSS survey dedicated to pulsars and transients using the GMRT. This survey operates at higher sensitivities compared to any other existing or ongoing low frequency surveys in the southern hemisphere (i.e., within −20 deg<DEC<−54 deg and |b|>3 deg). The calculated theoretical sensitivity for a 10-minute pointing duration in GHRSS at 400 MHz, considering a 200 MHz bandwidth, is 0.25 mJy (~0.32 mJy for 120 MHz usable bandwidth). We conduct the fast Fourier transform (FFT, Staelin, 1969a) based periodicity search to detect the short-period pulsars. In total we have 31 discoveries from the GHRSS survey. Out of these we have discovered 22 pulsars including three MSPs and two mildly recycled pulsars using fast Fourier transform (FFT) based periodicity search to detect the short-period pulsars. An alternative to FFT-based search methods called the FFA search, provides superior sensitivity to search for signals with long periods and short duty cycles. In the GHRSS survey, we are using an FFA-based pipeline to search for isolated pulsars in a period range of 100 ms to 100 s. Six pulsars were discovered in the FFA-based searches. Our analysis has detected single pulses from numerous in-beam pulsars, as well as known repeating fast radio bursts. Three Rotating Radio Transients (RRATs) were discovered through this method. Discovery is only the half of the job, next comes regular followup observations of the objects discovered by the GHRSS survey. The GHRSS discoveries including three millisecond pulsars(MSPs) in binary systems, two mildly recycled pulsars, six long period pulsars, two nulling pulsars, one pulsar with a γ-ray counterpart and three rotating radio transients (RRATs). One of the MSPs discovered by the GHRSS survey, J2144−5237, is in a binary system with an orbital period of 10 hours. Another MSP J1242−4712 is a spider MSP that is bridging the gap between the Redback and Black Widow spider pulsars binary and isolated MSPs. The third MSP discovered by the GMRT, is a rather unusual MSP in ~24 hrs orbit, with an indication that this MSP could be part of a triple pulsar system. Thus the discoveries from the GHRSS survey is pushing the parameter space of the known pulsars and possibly probing pulsars with a luminosity distribution that will be targeted by the next generation sensitive telescopes like the square kilometer array (SKA).