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Novel techniques enable GMRT to discover new pulsars for probing Gravitational Waves.

Using a novel technique of "gated imaging", a team of scientists led by a PhD student Mr Shyam Sunder working under Dr Jayanta Roy at NCRA-TIFR have identified precise locations of two new Millisecond Pulsars (MSPs). The novel "gating imaging" technique significantly accelerates the process of measuring pulsar parameters with higher precision compared to the standard analysis technique. The new MSPs discovered and precisely localized using GMRT will add to the international programs in their search for the imprint of the Gravitational Wave background.

Millisecond pulsars (MSPs) are nature's greatest clocks and one of astronomy's most fascinating phenomena. They are incredibly tiny, dense neutron stars that spin hundreds of times per second. Despite having comparable mass as our Sun, they are compressed into a radius of 10-20 km. Pulsar radiation becomes visible only when the emission beam is directed towards Earth, similar to how a lighthouse can only be seen when its light points in the observer's direction, creating a pulsed appearance. The faint nature of MSPs makes locating and identifying them accurately challenging. This leads to significant delays and necessitates additional telescope time between MSP detection and subsequent identification for follow-up studies. To compound the problem, pulse dispersion during transmission through the ionized medium can disrupt the pulsed characteristic, especially for these rapidly rotating objects.

Ongoing sensitive surveys conducted with the Giant Metrewave Radio Telescope (GMRT) in Pune have revealed many intriguing fainter millisecond pulsars. Specifically, the GMRT High-Resolution Southern Sky (GHRSS) survey, led by Dr. Bhaswati Bhattacharyya and a team of scientists from NCRA-TIFR, University of Manchester (UK), West Virginia University (USA), the National Radio Astronomy Observatory (USA), and the Naval Research Laboratory (USA), has discovered 30 new pulsars, including 3 MSPs.

In follow-up studies of two of these MSPs, led by NCRA-TIFR PhD student Mr. Shyam Sunder working under Dr. Jayanta Roy, the GHRSS team promptly localized the objects using a novel technique called "gated imaging." This resulted in over a 3000-fold improvement in positional uncertainty. The application of this technique significantly reduces the time required for conventional imaging, thereby accelerating the follow-up studies of MSPs. The recent upgrades in the operating bandwidth of the GHRSS have enhanced its capability to detect even fainter MSPs.

The two newly discovered MSPs localized using the upgraded "gated imaging" technique by GHRSS provide significantly higher precision in measuring pulse arrival time and pulse dispersion. Both of these parameters are indicators for assessing their candidacy for inclusion in the International Pulsar Timing Array, designed to detect the background of Gravitational Waves. The precision achieved by the GMRT MSPs is comparable to that of some of the most suitable pulsars included in the global effort to detect Gravitational Waves.

The detection of Gravitational Waves is highly sensitive to the number of MSPs involved in the experiment. A higher number of MSPs leads to faster detection of Gravitational Waves. Therefore, the recent localization of two MSPs using GMRT is aiding international programs in their search for the imprint of the Gravitational Wave background. This finding demonstrates the effectiveness of GMRT, aided by novel techniques, in contributing sensitive probes to worldwide efforts in detecting Gravitational Waves.

This article is based on the Published work “The GMRT High Resolution Southern Sky Survey for Pulsars and Transients. V. Localization of Two Millisecond Pulsars' ' which was recently published in the Astrophysical Journal (link of article: https://iopscience.iop.org/article/10.3847/1538-4357/acc10f).

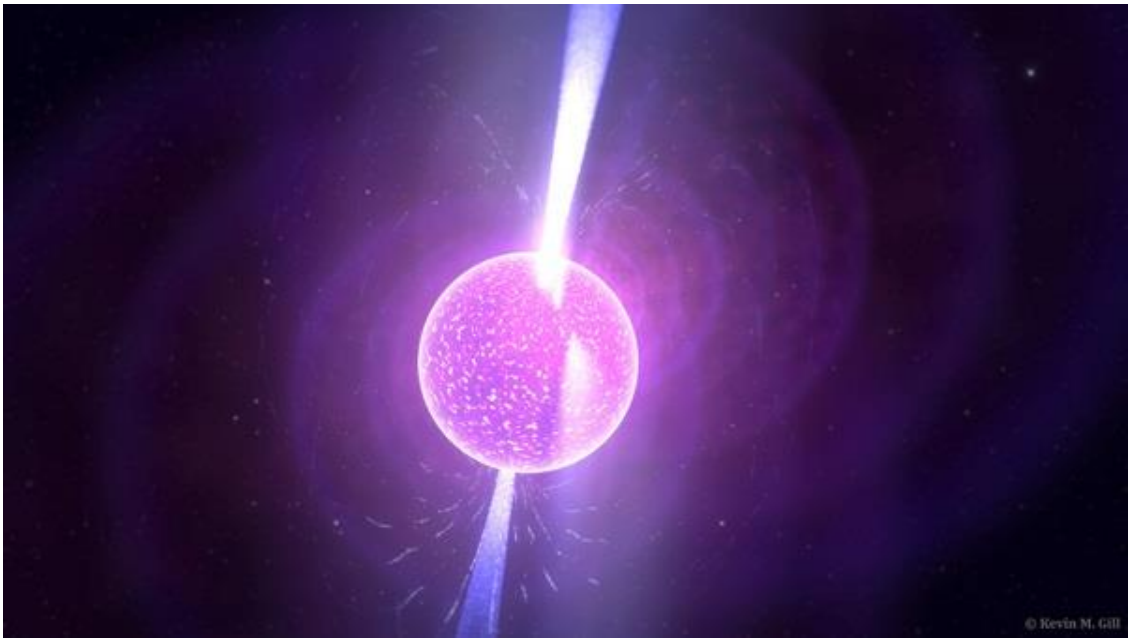
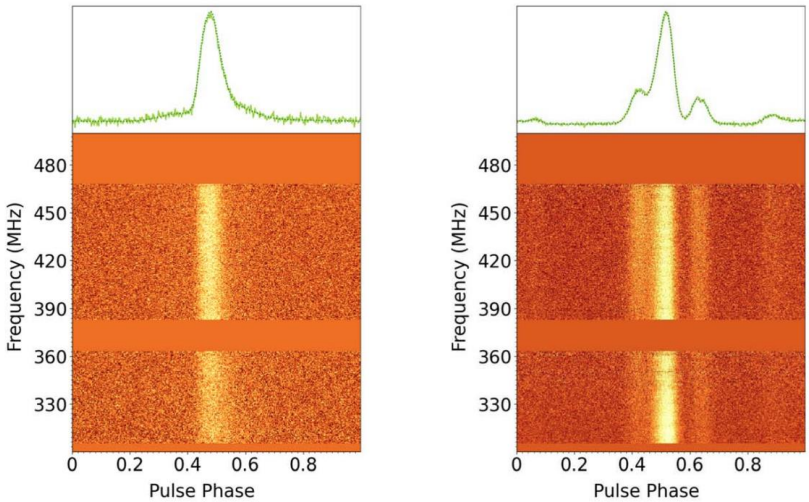


Figure1: Image illustrating a neutron star with Pulsed emission. Image credit: By Alison Klesman.
Link of image: https://astronomy.com/news/2018/09/pulsar-with-ir-emission



(a) J1242−4712, Band-3 (b) J2101−4802, Band-3

Figure 2. Two new pulsars discovered with the Giant Metrewave Radio Telescope showing the imprints of pulsed emission. The image is from a published work upon which this article is based. Image Credit: Sunder, Roy and Bhattacharya, Link: https://doi.org/10.3847/1538-4357/acc10f

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