National Centre for Radio Astrophysics(NCRA)-TIFR, Pune
Press Note English-19th Nov 2021

GMRT discovers several rare class of radio stars

A group of astronomers led by astronomers at NCRA, Pune, has discovered eight stars belonging to a rare class of stars called 'MRPs', or, Main-sequence Radio Pulse emitters, using the Giant Metrewave Radio Telescope (GMRT), located near Pune. In addition, the team has discovered three more such stars in the past using the GMRT. Thus, of the total 15 MRPs known so far, 11 were discovered with the GMRT, of which 8 are discovered in 2021 alone, thanks to the wide bandwidth and high sensitivity of the upgraded GMRT. These discoveries are the fruits of an ongoing survey with the GMRT, which was launched specifically for the purpose of solving the mystery of MRPs. The success of the GMRT programme has revolutionized the notion about this class of stars, and has opened up a new window to study their exotic magnetospheres.

The MRPs are stars hotter than Sun with unusually strong magnetic fields, and much stronger stellar wind. Due to this, they emit bright radio pulses like a lighthouse. Though the first MRP was discovered in 2000, it was only due to the high sensitivity of the upgraded GMRT (uGMRT) that the number of such stars known have increased many fold in recent years, with 11 of the 15 discovered using the GMRT. The success of the survey with the uGMRT suggest that the current notion that MRPs are rare objects may not be correct. Rather, they are probably more common, but are difficult to detect. This is due to the fact that the radio pulses are visible only at certain times, and the phenomenon is mostly observable at low radio frequencies. This is the frequency range where the uGMRT stands out as the most sensitive telescope in the world. The high sensitivity of the uGMRT and its ability to make high resolution images were instrumental in enabling the recovery of the pulsed signal from the different types of radiation coming from the sky. This, combined with a strategic observation campaign allowed the astronomers to overcome the difficulties, and reveal the true nature of these objects. The study with the uGMRT allowed them to find that the magnetic field and temperature are two quantities that appear to play the major role in deciding how intense the radio pulse will be. These findings will be crucial in understanding what switches off the production of radio pulses in a hot magnetic star.

A research paper describing these new results has been recently accepted for publication in The Astrophysical Journal. The lead author Barnali Das recently completed Ph D thesis, working under the supervision of Prof. Poonam Chandra, at the National Centre for Radio Astrophysics, Tata Institute of Fundamental Research, Pune. Barnali Das and Prof. Chandra have been actively involved in various projects aiming at the characterization of this little known class of objects MRPs. In fact, the name MRP was introduced by them in the year 2020. In an effort to understand their properties, they have performed the most extensive study of MRPs over an ultra-wide frequency range, using two of the world's leading radio telescopes: the GMRT and the U.S. based Karl G. Jansky Very Large Array (VLA). Their work, for the first time, showed that the radio pulses emitted by MRPs contain a vast amount of information regarding the stellar magnetosphere. The pulsed radio emission from MRPs are the only visible signatures of the theoretical models which predicts tiny explosions in magnetic massive stars which occur at

specific locations in the magnetosphere of the star. These explosions have been predicted to play an important role in regulating the transport of wind materials surrounding the star, and are likely to affect the stellar evolution as well. The radio pulses produced by MRPs are the only probes that are sensitive enough to reflect the changes incurred by these relatively weak events. Further experiments are underway to characterize these changes in pulse-behavior so as to be able to use the radio pulses to study the dynamic stellar magnetospheres.

The GMRT is a radio telescope located at Khodad, 80 km away from Pune, operating over 150-1420 MHz. It consists of 30 antennas, each of 45m diametre, and is operated by the NCRA-TIFR. The VLA is a radio telescope located at Socorro, New Mexico in the USA, cosisting of 30 antennas, each of 25m. It is operated by the National Radio Astronomy Observatory, USA.

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