URSI - RCRS 2022, IIT (Indore), India, 1 - 4 December, 2022

Enabling VLBI for the upgraded GMRT

Visweshwar Ram Marthi*[(1)], Preeti Kharb[(1)], S. Harshavardhan Reddy[(2)], Sanjay Kudale[(2)], Bhal Chandra Joshi[(1)], Prakash Hande[(2)], Sandeep Choudhari[(2)], B. Ajith Kumar[(2)] and Yashwant Gupta[(1)]
(1) NCRA-TIFR, Post Bag 3, Ganeshkhind, Pune - 411 007, India, e-mail: vrmarthi@ncra.tifr.res.in;
(2) Giant Metrewave Radio Telescope Observatory, Khodad, India.

The GMRT, despite being one of the most sensitive low-frequency imaging instruments, had not been able to fully realize its potential for Very Long Baseline Interferometry (VLBI). This was partly because of engineering challenges in the pre-upgrade avatar including clock stability, frequency coverage and analog and digital receiver electronics. The upgraded GMRT has addressed many of these constraints and has unlocked the potential for global VLBI at low radio frequencies. Specifically, the adoption of the most up-to-date time-frequency standards, a modern, highly flexible digital receiver design and software-enabled signal processing instrumentation allows for harnessing the full VLBI potential of GMRT.

VLBI requires bandwidths of 2^n MHz which standard VLBI facilities have built into their ground-up engineering design. The GMRT, being a standalone interferometric facility, has to explicitly work around the limitations imposed by the 100/200/400 MHz bandwidths enabled by the upgrade. This is implemented in software by a combination of digital downconversion and bandpass filtering, followed by a sample rate conversion to match the Nyquist rate for the target bandwidths. Finally, the Nyquist sampled byte stream is translated to a dual-thread, 2-bit VDIF timestream for correlations with other telescopes. Additionally, the beamformer of the GMRT Wideband Backend (GWB) correlator beamformer gives a phased-array spectral voltage (PASV) baseband beam that provides the flexibility to add the signal from any number of antennas in phase through an adding box. Because of its inherently high sensitivity in the phased-array mode, the GMRT is uniquely positioned to provide a number of intermediate baselines, bridging a gap between the European and East Asian VLBI facilities. The flexibility of the GMRT wideband backend also means that it is suitable both for simultaneous wideband imaging (using a single GMRT dish) as well as high-sensitivity observations of pulsars, fast radio bursts and their host galaxies (using the phased-array mode).

Earlier this year, the GMRT participated separately in successful VLBI fringe test experiments with a subset of telescopes of the European VLBI Network (EVN) and the Australian Long Baseline Array (LBA). These repeatable 1450-MHz fringe detections have firmly established the ability of the GMRT to participate in future VLBI science observations and the number of niche advantages it provides. In the immediate term, several pilot experiments are being proposed to study the suitability of the GMRT for specific scientific investigations such as small-scale neutral Hydrogen in the Milky Way and VLBI Scintillometry of interesting pulsars.

The GMRT has an indispensable role to play in the future of VLBI, particularly in the SKA era, being favourably located with respect to both SKA-Low (in Australia) and SKA-Mid (in South Africa) and having good frequency overlap with both these facilities. As the GMRT gears up its offline and real-time VLBI signal processing capabilities, we are exploring pathways to engage more meaningfully with other VLBI partners. In the near future, VLBI will be a regular observing mode offered by the GMRT.