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Pulsar Research with the GMRT : A Status Report

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Abstract. The Giant Metrewave Radio Telescope (GMRT) coming up near Pune, India will be one of the important instruments for pulsar research work at metre wavelengths. Here we describe the capabilities of the GMRT for pulsar work and give the current status of the telescope in this context. Results from recent test observations are also summarised.

1. Introduction

The Giant Metrewave Radio Telescope (GMRT) which is nearing completion at Khodad near Pune in India, is going to be a major facility for research in radio astronomy (Swarup et al. 1997). The GMRT consists of 30 antennas, each of 45 metre diameter, spread out over a radius of 15 km. Fourteen of these dishes are concentrated in a central square of 1 km x 1 km, while the rest are distributed along three arms of a roughly Y shaped array. The GMRT is designed to operate in six frequency bands : 50 MHz, 150 MHz, 235 MHz, 325 MHz, 610 MHz and 1000 - 1450 MHz. Of these, all bands except the 50 MHz are now operational. A maximum bandwidth of 32 MHz is available at any of these bands.

The GMRT has two main modes of operation : (i) aperture synthesis mode for mapping radio sources and (ii) array mode for study of compact objects such as pulsars. To meet these requirements, two main digital back-ends are connected to the telescope : (i) a correlator and (ii) a pulsar receiver.

2. The GMRT as a pulsar instrument

In the array mode, the GMRT can be used for pulsar studies in two ways : (i) The Incoherent Array (IA) mode and (ii) The Coherent Array or Phased Array (PA) mode. In the former, the power signals from different antennas are combined to give the final signal for pulsar studies whereas in the latter, the voltage signals are added to get the final signal for two orthogonal polarisations. The PA mode will give a $\sqrt{N}$ better signal to noise ratio than the IA mode for pulsar observations using N dishes, but the beamwidth will be much narrower than the single antenna beamwidth of the IA mode. Thus the IA mode will be most useful for large scale pulsar search observations, while the PA mode is ideally suited for studies of individual pulsars with full polarimetry.

Besides prodiving a large effective collecting area ($\approx$ 30,000 sq.m.) for metre-wavelength observations of pulsars, one of the special capabilities of the pulsar mode of the GMRT is the ability to observe *simultaneously* at two (or more) different wave-bands. This is achieved by grouping the antennas into sub-arrays, each operating at a different frequency, and suitably processing the signals from these.

A special purpose, fully digital pulsar receiver has been designed for the GMRT to achieve the above goals. The first block of this is the GMRT Array Combiner (GAC), built by the Raman Research Institute, Bangalore. It combines the signals from a maximum of 30 antennas for both incoherent and coherent array operations. In both cases, the signals have 256 spectral channels, and the sampling rate at the output of the GAC is 16 microseconds. Currently, two pulsar back-ends are attached to the IA array output of the GAC : (i) the search processor which preintegrates the data to a desired sampling rate, subtracts long term running mean for each frequency channel and provides 1-bit samples to the data acquisition computer (ii) the IA DSP processor which provides multi-bit data at fast sampling rates. For the PA output of the GAC, the back-ends are (i) the PA DSP processor which will be used for coherent dedispersion and providing an output for VLBI recording and (ii) a polarimeter (being built by the Raman Research Institute, Bangalore). All sections of the pulsar receiver are controlled by a pulsar master console program with a friendly graphical user interface, that runs on a UNIX workstation. The data are acquired on Pentium computers using high speed PCI data acquisition cards, and are transferred to the UNIX workstation for offline analysis and storage.

3. Current Status and Some Recent Observations

Most aspects of the hardware and software for incoherent array mode have been tested and this mode is in regular use. Test observations of well known pulsars have been carried out using this mode with satisfactory results. The phased array mode is currently being debugged. The procedure for phasing the array has been worked out and tested successfully. Test observations with calibration sources and pulsars are in progress. Hardware for polarimetry and coherent dedispersion is being debugged and these are expected to be available in the near future.

Several pulsars have been observed recently at different frequency bands to obtain their integrated pulse profiles. Selected pulsars have been observed to study their drifting and nulling behaviour. Simultaneous dual frequency observations of a few pulsars have recently been carried out with the following goals : (i) comparison of radio emission properties at different frequencies (ii) accurate estimation of dipsersion measures and their temporal variations (iii) dynamic spectra studies to probe interstellar scintillation effects. Some interesting results are expected to emerge from these first observations.

References

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