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Astronomy with the Giant Metrewave Radio Telescope (GMRT)

V.K. Kapahi and S. Ananthakrishnan

National Centre for Radio Astrophysics, TIFR, Poona University Campus, Poona 411 007, India

The Giant Metrewave Radio Telescope (GMRT) being built by NCRA-TIFR at a site about 80 km north of Pune is now in an advanced stage of completion. It is a modern aperture synthesis instrument consisting of thirty fully-steerable parabolic dishes of 45 m diameter each. While twelve of the dishes are located more or less in a random pattern within a central region of about 1 km x 1 km in size, the remaining dishes are spread out along the three arms of an approximate 'Y'-shaped configuration, providing a maximum baseline of about 25 km (Figure 1). The array would be capable of operating in any of the six different frequency bands centered around 50, 151, 232, 327, 610 and 1420 MHz. Technical details about the design of the antennas and the receiver system are given in Swarup *et al.* (1991). Some salient features of the system are summarized in the Table below.

GMRT System parameters

Frequency (MHz)	Primary (deg)	Synthesised Beam (arcsec)	T_{sys} Beam (°K)	S_{min}* (mJy)
50	9.0	60	8170	4300
150	3.0	20	578	300
233	2.0	13	234	120
327	1.4	9	108	56
611	0.7	5	102	53
1420	0.3	2	98	67

* S_{min} is the theoretical value of the minimum detectable flux density which is 5 times the rms noise for natural weighting, a bandwidth of 16 MHz and a time constant of 10 hours.

Although GMRT has been designed to be a very versatile instrument capable of investigating a variety of radio sources and phenomena ranging from within our Solar System to the most distant galaxies known in the universe, one of the major scientific objectives that has been kept in mind in deciding the antenna configuration is the possibility of detecting

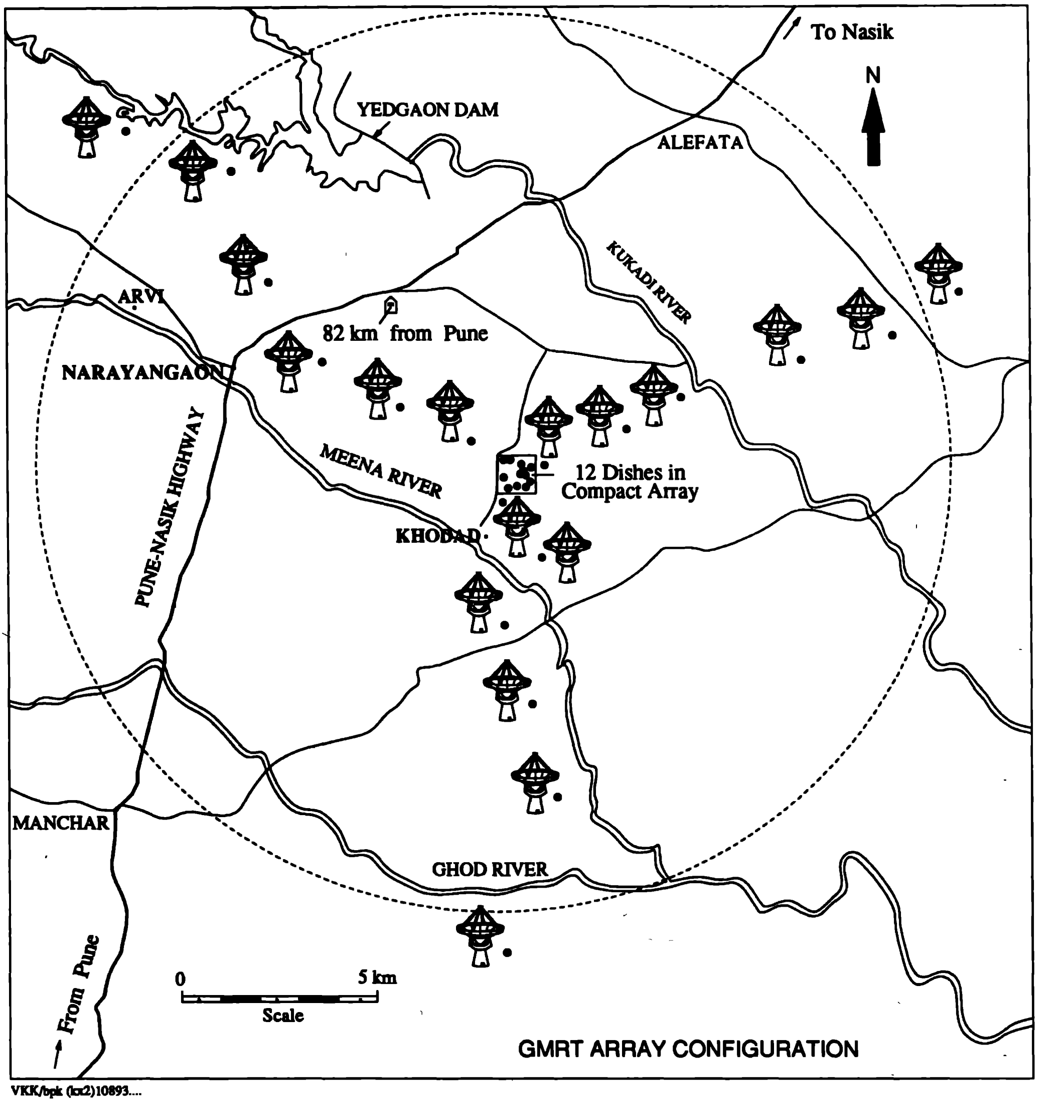

Figure 1. Antenna configuration of the Giant Metrewave Radio Telescope. The dotted circle indicates the approximate size of the synthesized aperture.

clouds of neutral Hydrogen (HI) from protoclusters at epochs corresponding to redshifts between about 3 and 8 when the 21 cm line from HI is expected to be redshifted to the metrewave band of the radio spectrum. The original expectation when GMRT was first proposed was that the giant HI clouds in the pancake models should be readily detectable with the sensitivity of GMRT. Even in the cold dark matter scenarios of the post COBE era it has been estimated (Subramanian & Padmanabhan 1993) that HI emission from protoclusters might be just detectable with GMRT. Irrespective of the theoretical scenarios and the actual detection of the HI line from high redshifts, sensitive observations with GMRT would be important for placing stronger constraints to models of galaxy and structure formation in the Universe.

The special features or strengths of the GMRT design may be summarized as follows

* Coverage of a large part of the sky, $\delta > -57°$
* Spectral line capability over a bandwidth of 16 MHz
* Operation at decimeter and metre wavelengths with relatively low levels of RFI
* Reasonably good u-v coverage, providing both short and long baselines
* Complete polarization measurement capability
* High detection sensitivity and speed of operation

These features will make GMRT particularly suitable for many types of astrophysical studies, only a few of which are briefly mentioned below.

In addition to the ability to detect the HI line at high redshifts corresponding to the different frequency bands, the availability of a wide band feed at 1.4 GHz (covering the range between about 1 and 1.4 GHz) on the GMRT dishes will allow HI studies of external galaxies to be extended to cosmologically significant distances. Such studies inlcude velocity fields, rotation curves and the application of the Tully-Fisher relation (between HI velocity width and galaxy luminosity) to the investigation of deviations from the Hubble flow.

The metrewavelength capability of GMRT should be particularly important for continuum imaging of extended sources with steep low frequency spectra. Such components are generally associated with the oldest population of relativistic electrons and multifrequency imaging can provide important information on spectral distributions and ageing effects in radio galaxies and quasars. Extended emission with very steep spectral index can also be indicative of relic radio emission in which the nuclear engine is no longer active and the radio emission arises from the leftover electrons from an active phase in the past. Only a few such relic sources associated with radio galaxies (*eg.* Roettiger *et al.* 1994) or with clusters of galaxies (*eg.* Joshi *et al.* 1986) are presently known. Another class of poorly understood sources with very steep spectra in this category could be the large radio halos found in a few clusters of galaxies (*eg.* Hanisch 1982). Steep spectral indices can also be very profitably used to find radio galaxies at high redshifts. The most distant galaxies currently known have in fact mostly been found by concentrating on the steep spectral index population in radio source samples (*eg.* Kapahi 1992; McCarthy 1993).

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Non-thermal halos around spiral galaxies that have been detected in a few edge-on galaxies and are also know to show considerable polarization (Sukumar & Allen 1991) could form another good subject of study using GMRT, leading to a better understanding of the formation and evolution of magnetic fields in spiral galaxies.

The depolarization asymmetry seen in the lobes of many radio quasars (Garrington *et al.* 1991) is believed to arise in the magnetoionic medium or halos surrounding elliptical galaxies. In the case of many radio galaxies the depolarization asymmetry is expected to become significant only at metre wavelengths. GMRT could thus become an important tool in the study of such galactic halos.

The high sensitivity and speed of GMRT are very well suited to making large scale surveys of the sky which are of immense significance to cosmological studies and for understanding the properties and evolution of different populations of radio sources. Most of the existing or proposed deep surveys are being done at frequencies $\gtrsim$ 1.4 GHz. It is estimated that only about 3 months of GMRT time would be required to make an all sky survey complete to about 1 mJy at 327 MHz, containing several million radio sources.

Most of the topics highlighted above are in the field of extragalactic astronomy and cosmology. There are a large number of problems in Solar System astronomy and Galactic astronomy as well in which GMRT would be able to make outstanding contributions. Pulsars are perhaps one of the most important of these. Because of its large collecting area and sky coverage as well as the polarization capability, GMRT should become one of the most important instruments for studying pulsars. It would be particularly valuable to carry out sensitive searches for a large number of rapidly rotating millisecond pulsars. Only a handful of the several hundred known pulsars belong to this category (Taylor *et al.* 1993). Special backends are being built by the Raman Research Institute and NCRA for search as well as study of individual pulsars with high time resolution. While searches over large parts of the sky would be carried out using the GMRT dishes in an incoherent mode, detailed studies of known pulsars, including accurate timing measurements would be undertaken with the dishes connected as a phased array.

References

Garrington S.T., Conway R.G., Leahy J.P., 1991, MNRAS, 250, 171.

Hanisch R.J., 1982, A&A 116, 137.

Joshi M.N., Kapahi V.K., Bagchi J. 1986, in Radio Continuum Process in Clusters of Galaxies, eds C.P.O'Dea & J.M. Uson, NRAO, Greenbank, p. 73.

Kapahi V.K., 1992, BASI, 20, 49.

McCarthy P.J., 1993, ARA&A, 31, 639.

Roettiger K., Burns J.O., Clarke D.A., Wayne A.C., 1994, ApJ, 421, L23.

Subramanian K., Padmanabhan T., 1993, MNRAS, 265, 101.

Sukumar S., Allen R.J., 1991, ApJ, 382, 100.

Swarup G., Ananthakrishnan S., Kapahi V.K., Rao A.P., Subrahmanya C.R. , Kulkarni V.K., 1991 Current Science, 60, 95.

Taylor J.H., Manchestor R.N., Lyne A.G., 1993, ApJS, 88, 529.