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GIANT METREWAVE RADIO TELESCOPE (GMRT)

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ABSTRACT The Giant Metrewave Radio Telescope (GMRT) is being set up near Pune in India consisting of 30 numbers of 45-m diameter parabolic dishes. Twelve of these are being placed in a central array, about 1 x 1 km^2 in size, and the remaining eighteen along three 14-km long arms forming a Y-shaped array. GMRT will operate at six frequency bands near 38, 153, 233, 327, 611 and 1420 MHz. It is expected to be completed progressively by 1993, and will be the world's largest radio telescope operating at metre and decimetre wavelengths.

INTRODUCTION AND SCIENTIFIC OBJECTIVES

There exists an outstanding need for a large radio telescope providing sufficiently high sensitivity and resolution in the frequency range from about 30 to 1700 MHz for studying several important astrophysical problems. The relatively low level of radio frequency interference in India in the above frequency range is also advantageous for the Giant Metrewave Radio Telescope, which is under construction at Khodad (latitude 19^{o} 05' 25" N; longitude 74^{o} 02' 58" E), near Pune (Swarup 1984, 1990). An important scientific goal will be to search for the highly redshifted 21-cm line radiation from primordial clouds of neutral hydrogen, expected to arrive somewhere within the frequency range from about 130 to 350 MHz, corresponding to redshifts, $z \simeq 3 - 10$. GMRT is likely to triple or quadruple the known number of pulsars, particularly the milli-second and binary pulsars which would allow testing the General Theory of Relativity and also may lead to the detection of primordial gravitational radiation. Studies of neutral hydrogen and OH mega-masers in distant galaxies, quasar absorption line systems, transient radio sources, radio recombination lines, deuterium line radiation at 327 MHz, steep spectrum radio sources, metre wavelength variables, radio source surveys and fine structure in a variety of galactic and extragalactic radio sources, including our solar system, are likely to give us many

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new results and possible breakthroughs, in view of the high sensitivity of GMRT.

ARRAY CONFIGURATION AND THE 'SMART' ANTENNA DESIGN

GMRT will consist of 30 numbers of 45-m dia dishes. In order to obtain adequate sensitivity for diffuse features in galactic and extragalactic sources, and for searching for proto-clusters, whose size is estimated to be around 5-10 arcmin, twelve antennas of GMRT are being placed in a random array of about 1 x 1 km^2 in size. The other eighteen antennas are to be placed along three 14 km-long arms which together form a Y-shaped array (Fig. 1). GMRT will operate as an 'Earth-Rotation Synthesis Radio Telescope' giving a resolution of about 2 arcsec at 1420 MHz (Table 1).

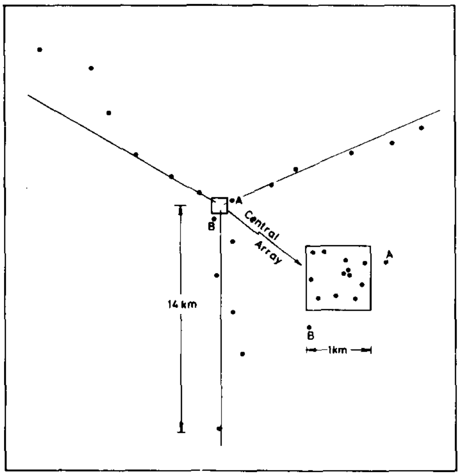

Fig. 1. Array Configuration of GMRT consisting of thirty 45-m dia steerable dishes

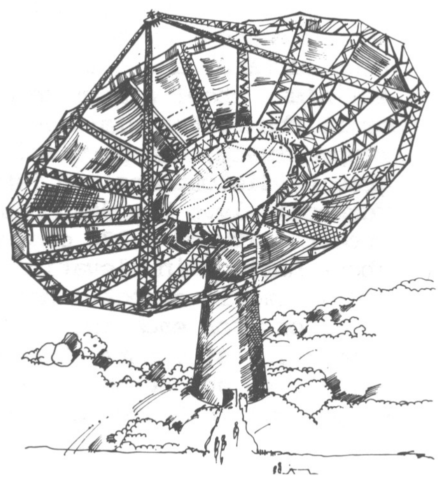

Fig. 2. An Artist's sketch of 45-m dia SMART dishes

A diameter of 45-m was chosen for GMRT dishes in order to minimise the effect of non-isoplanacity of the ionosphere at metre wavelengths (Subrahmanya, 1991). Since the highest operating frequency of GMRT is less than 1700 MHz, wire mesh is used for the reflecting surface, so as to minimize the wind loading. A mesh of relatively thin wire is chosen since it does not snow at the antenna location. Also a novel design concept called SMART (Stretched Mesh Attached to Rope Trusses) has been developed for the GMRT dishes (Fig. 2). Circumferential rope trusses made of 4.0 and 2.5 mm diameter stainless steel wire ropes are stretched under tension (~ 250 kg for 4 mm rope) between 16 adjacent parabolic frames to provide support

Table 1 : GMRT system parameters

Freq. (MHz)	Primary Beam (deg.)	Synthesized Beam (arcsec)	T sys (K)	S (5σ) (μJy)	Efficiency	A_{eff} m^2
1420	0.3	2	85	40	0.5	24000
611	0.7	5	82	40	0.65	31000
327	1.4	9	104	40	0.65	31000
233	2.0	13	169	90	0.65	31000
150	3.0	20	477	240	0.65	31000
38	12.1	80	13930	7000	0.5	24000

for the curved reflecting surface of the parabolic dishes. The surface consists of nearly 960 plane facets; more elaborate rope truss structure could have been adopted in case a better approximation to the curved surface was required. The reflecting surface, attached to rope trusses, is made of 0.55 mm dia stainless steel wire mesh of size 10 x 10, 15 x 15 and 20 x 20 mm in the central, middle and outer one thirds of the dish respectively; the permissible rms surface errors (including gravity distortions and fabrication errors) are 8, 12 and 20 mm respectively. The dish has an altazimuth mounting, with steerability of ± 270 degrees in azimuth and 15 to 120 degrees above horizon in elevation. A tracking accuracy of about 1 arcmin rms is expected using a counter-torque system of two 6 HP motors for each axis. The total tonnage of the dish, its supporting structure, the counterweight and the yoke are about 36, 12, 40 and 36 tonnes respectively. The torques are comparable to those for a conventional 22-m dish.

ANTENNA FEEDS AND RECEIVER SYSTEM

The feeds and receiver system are being designed to allow observations at 38, 153, 233, 327, 610 and 1420 MHz with a bandwidth selectable in six steps from 0.25 to 32 MHz. The expected system parameters are given in Table 1. All the feeds are mounted on a rotatable turret and provide dual circularly polarized outputs connected to low noise amplifiers. A local oscillator synthesizer system is used to give two 32 MHz wide IF outputs centred at 130 and 170 MHz. The LO reference, IF and telemetry signals will be sent on single-mode optical fibre links using an amplitude modulated analog transmission.
An FX type correlator system is being built using about 2000 VLBA chips. The outputs of each antenna corresponding to two 16 MHz wide signals for each of the two polarizations are connected to four 256 channel FFT machines whose outputs are

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connected to a cross-multiplier and a long-term integrator system, giving about 240,000 outputs. Integration time would be variable from 0.1 to 30 s. The mapping strategies are described by Rao (1991) and a parallel processing computer being developed for GMRT by Kulkarni (1991). The outputs of the FFT machines will be digitally added for providing a phased-array output for VLBI and pulsar observations. A pulsar timing and search machine is also planned.

CONCLUSION

GMRT will have a collecting area comparable to that of the Arecibo Telescope (Gordon & Lalonde, 1961) but much higher resolution. Its area will be 3.6 times that of the VLA (Napier et al. 1983), with a much broader usable receiver bandwidth at metre-wavelengths due to lower Radio frequency interference (RFI) prevailing in India. Its successful low cost design opens up the prospects of a much more sensitive telescope as an international effort, say an array of 100 antennas of 100 m diameter with a low system temperature and placed upto 200 km apart, with the majority within a few km. The site should have low RFI, low winds and free from snow. There are several optimisation possibilities of the GMRT design and it is hoped to initiate preliminary studies for the purpose over the next year or two.

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P. Hall: Is there provision made for future cooled receivers?
G. Swarup: Yes, we would be able to install cooled receivers at a future date in the 600-1700 MHz frequency range.