Newsletter

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The Decametre Wave Radio Observatory at Gauribidanur

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The Raman Research Institute and the Indian Institute of Astrophysics are jointly operating a decametre wave radio observatory at Gauribidanur, Karnataka (longitude 77°26′07″ E and latitude 13°36′12″ N). The various antenna arrays, and the receiving systems are described here and the dimensions of the various arrays are shown in Fig. 1.

The main facility at the Observatory is a 'T' shaped array with a 1.38 km east–west arm and a 0.45 km south arm. The total number of dipoles in these arrays is one thousand and they accept east–west polarization. A full reflecting screen of area 60,000 m^2 is mounted below the dipoles. The entire structure is supported by a grid of 3500 wooden poles of varying lengths and heights up to 10 metres to compensate for the terrain. A photograph of the east–west array is shown in Fig. 2.

Fig. 3 shows a photograph of the south array from the southern end. The dipoles of the array are phased in the field by remotely controlled phase shifters and are combined using a binary branching feeder network. The outputs of the east, west and south arms are carried separately by coaxial cables to the main observatory building. The signals are amplified and the sum of the east and west signals is correlated with that of the south arm. This produces a single beam of 26 arcmin × 40 arcmin at the zenith which is normally used for observations of pulsars, scintillations etc.

Such a single beam instrument uses only a part of the total observing time to observe each beamwidth of the sky and thus reduces the surveying sensitivity. Also in a low frequency telescope, ionospheric effects can cause apparent and time variable shifts in the position of the radio sources. Both these make desirable the observation of a large region of the sky in a short time and single beam telescope cannot meet this requirement. To remove some of these limitations multiple beams are formed using two different techniques. In one of them the response of the telescope is steered rapidly in the N–S direction by a special purpose digital control system which supplies switching voltages to the phase shifters. The time required to change the beam from one position to another is of the order of a few millisec. The number of declinations through which the beam is cycled can be varied from one to sixteen. The other technique measures the complex correlations between the E–W array and each one of the 90 rows of dipoles in the south arm. This is accomplished using 128 channel digital correlation receiver. As is well known each correlation coefficient measures one of the spatial Fourier components of the brightness distribution of the sky. Multiple beams can be formed by Fourier synthesis of the measured correlations. In the present case the number of independent beams is 90 in declination, and a region of the sky $\pm 50°$ of zenith angle can be mapped at any given time. The earth's rotation is used to cover the sky in the E–W direction.

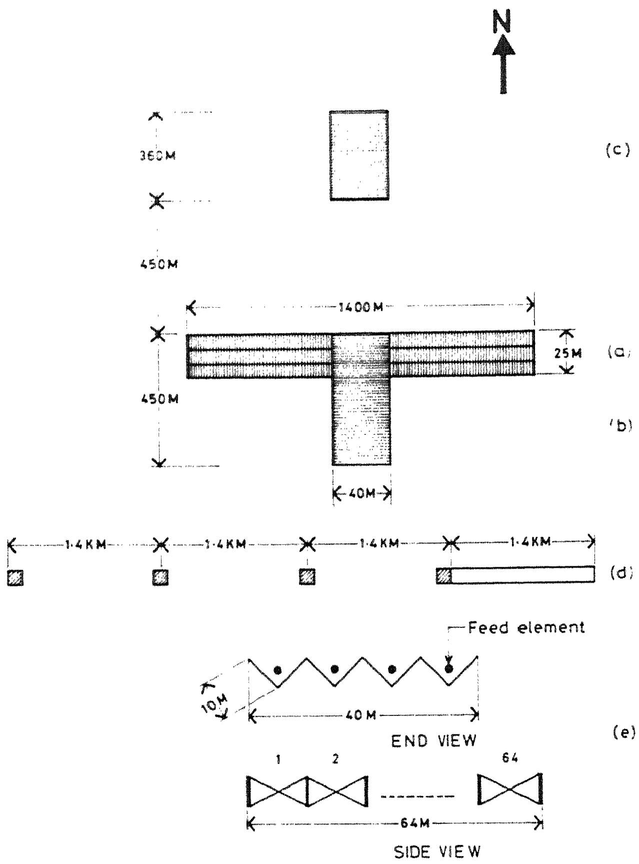

Figure 1. Lay-out and dimensions of various antenna arrays at Gauribidanur. (a) East-West array: 4 rows in N-S direction, 160 dipoles in each row. (b) South array: 90 rows in N-S direction, 4 dipoles in each row. (c) North array: 64 rows in N-S direction, 1 Yagi in each row. (d) Compound Grating Interferometer: E-W array and 4 grating units. Each grating unit consists of 8 Yagis. (e) Broadband array: 64 conical dipoles arranged in a matrix of 4×16 along E-W and N-S directions respectively.

When the E-W array is used in the transit mode a source is present in the beam for approximately two minutes of time. For the detection of pulsars, scintillations and spectral line observations longer observing times are necessary and so a special purpose digital control system was built to track a source by introducing phase shifts across the E-W array. It is thus possible to observe a source for about 40 minutes of time, around meridian transit. Some pulsar profiles observed with this system are shown in Fig. 4. Fig. 5 shows the low frequency recombination lines observed in the direction of Cas A.

The effective area of the telescope is approximately 20,000 square metres at 34.5 MHz. The mean sky brightness at this frequency is about 10,000 K and so the minimum detectable flux density is of the order of 10 Jy (1 Jy$=10^{-26}$ watts^{-2} Hz^{-1}) with an integration time of 24 s and a bandwidth of 400 kHz. The minimum detectable brightness temperature variations are of the order of 1000 K.

The presence of many unresolved sources in the main beam results in a confusion limit of the order of 10 Jy for the 'T' array. It is therefore not possible to decrease the minimum detectable flux limit by increasing the integration time. In order to increase both the resolving power and the sensitivity, an array of 64 yagis have been added to the 'T'. This array is located at a distance of 0.45 km from the centre of the E-W arm of the 'T' as shown in Fig. 1. The beam of this array can be pointed anywhere within $\pm 50°$ of the zenith on the meridian using diode phase shifters and a digital control system. The sum of the outputs of the north and south arrays can be multiplied with the E-W array to produce a beam of 26 arcmin x 20 arcmin at the zenith. A photograph of the north array is shown in Fig. 6.

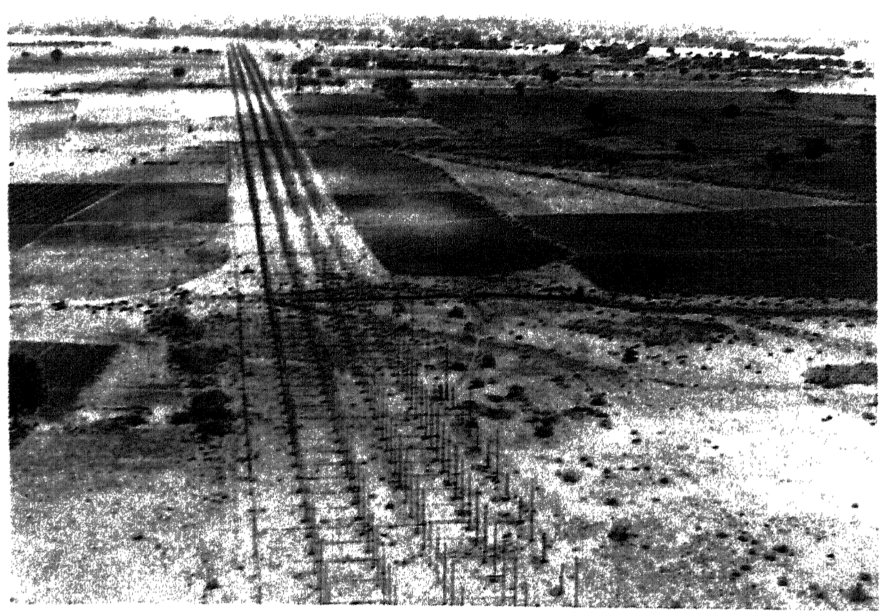

Figure 2. Aeriel view of the East-West array from the eastern end.

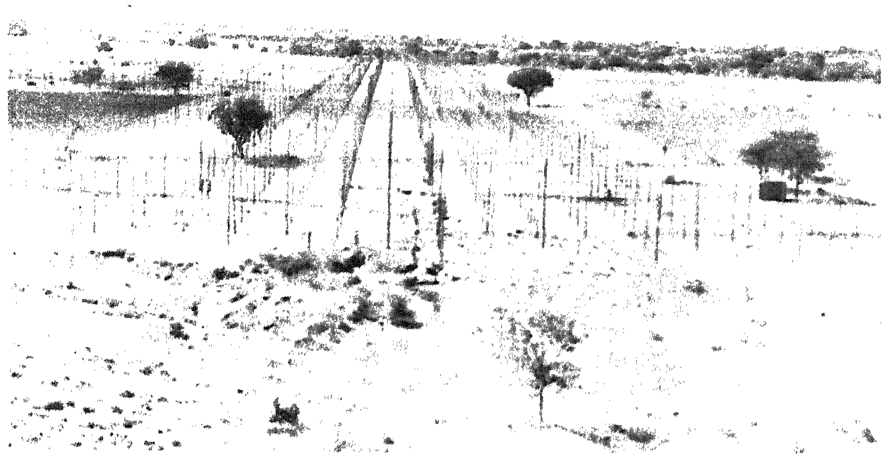

Figure 3. Aeriel view of the South array from the south end.

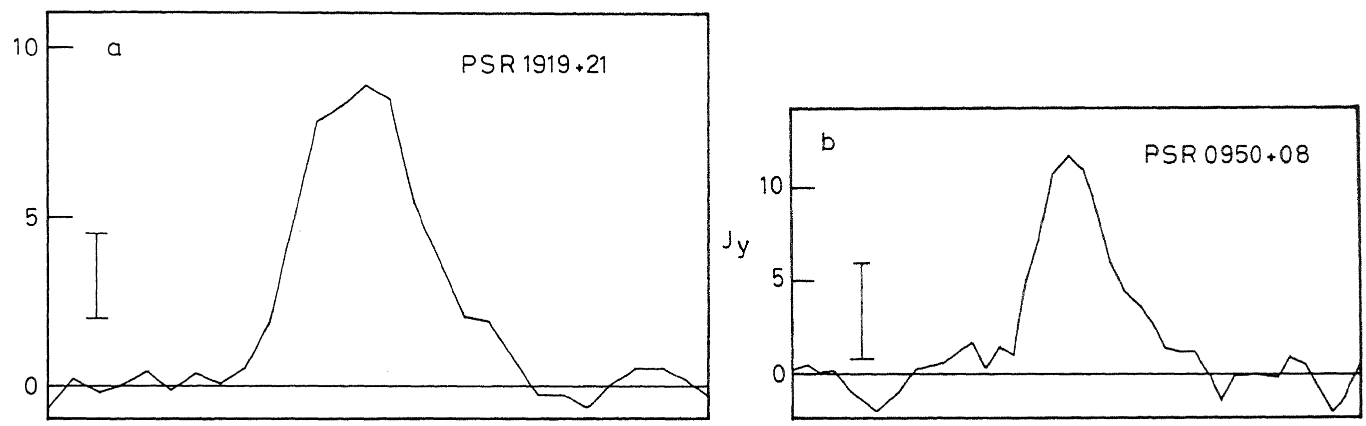

Figure 4. Pulsar profiles (a) PSR 1919+21. Observed at 34.5 MHz with a 16 channel receiver with channel bandwidth 60 kHz and channel separation 40 kHz. Time constant is 100 millisec. Observed characteristics: Average flux = 1.91 ± 0.3 Jy; Pulse energy = $(2555 \pm 400)\ 10^{-29}\ \mathrm{J\ m^{-2}\ Hz^{-1}}$; Pulse width $W_{0.5} = 265$ millisec; error bar = 5 sigma. (b) PSR 0950+08 observed with a bandwidth of 30 kHz and time constant of 10 millisec. Observed characteristics: Average flux = 1.82 ± 0.45 Jy; Pulse energy = $460 \pm 115\ 10^{-29}\ \mathrm{J\ m^{-2}\ Hz^{-1}}$; pulse width $W_{0.5} = 29$ ms; error bar = 5 sigma.

High resolution one-dimensional observations are made with a compound grating interferometer with an E–W fan beam of three arcmin. It consists of four grating units placed at intervals of $\simeq 1.4$ km (length of the E–W array) on a E–W base line starting from the western end of the E–W array as shown in Fig. 1. Each grating unit comprises of 8 yagi antennas and the outputs of each one of them is multiplied with the EW array output to synthesize the fan beam.

We also have a broadband array usable in the frequency range 30 MHz to 70 MHz mainly for solar observations a photograph of which is shown in Fig. 7. The basic element of this array is a biconical dipole with a VSWR $\leqslant 2$ in the above frequency range. The array consists of 64 elements arranged in a matrix of 4×16 along E–W and N–S respectively. The dipoles are placed inside a corner reflector and accept N–S polarization. The array is split up into northern and southern groups of eight rows each. The eight rows of each group are combined in a branched feeder system and delay shifters are introduced at appropriate places, to steer the response of the array to $\pm 45°$ of the zenith in the N–S direction. The position of the beam formed is independent of frequency allowing simultaneous observation of a radio source over the full bandwidth of the system. This array is also used in transit mode and the available observing times range from 26 minutes at 65 MHz to about an hour at 35 MHz. The effective collecting area is about 2000 m^2 and the sensitivity is better than 100 Jy at 65 MHz for a bandwidth of 1 MHz and 1 s integration time.

Acousto-Optic Spectrograph

An acousto-optic Spectrograph (AOS) provides high time and frequency resolution for studies of radio bursts from the sun. The AOS has a bandwidth of 30 MHz with 1760 channels, the frequency resolution is about 30 kHz. The spectrograph is interfaced via an A/D

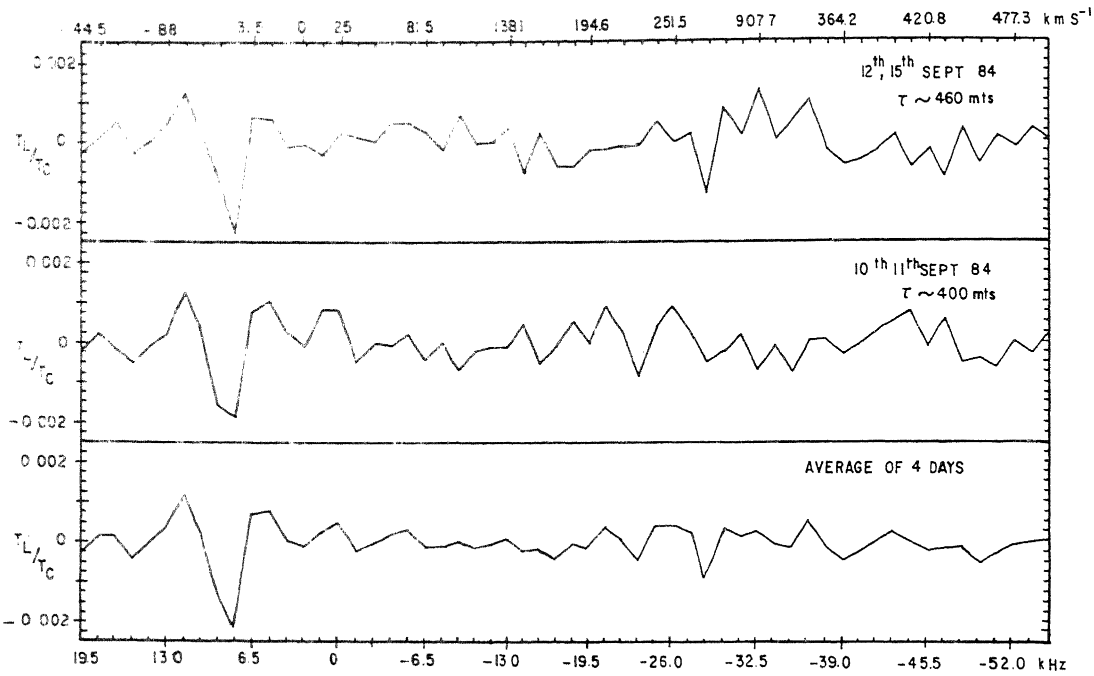

Figure 5. Observed profiles of low frequency recombination lines C 574α and C 575α at 34.5 MHz in the direction of Cas A.

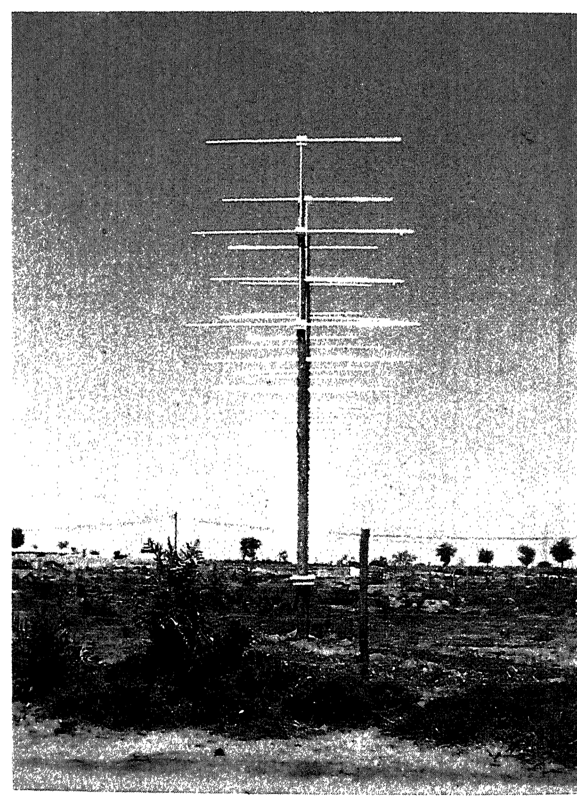

Figure 6. North array of 64 Yagis.

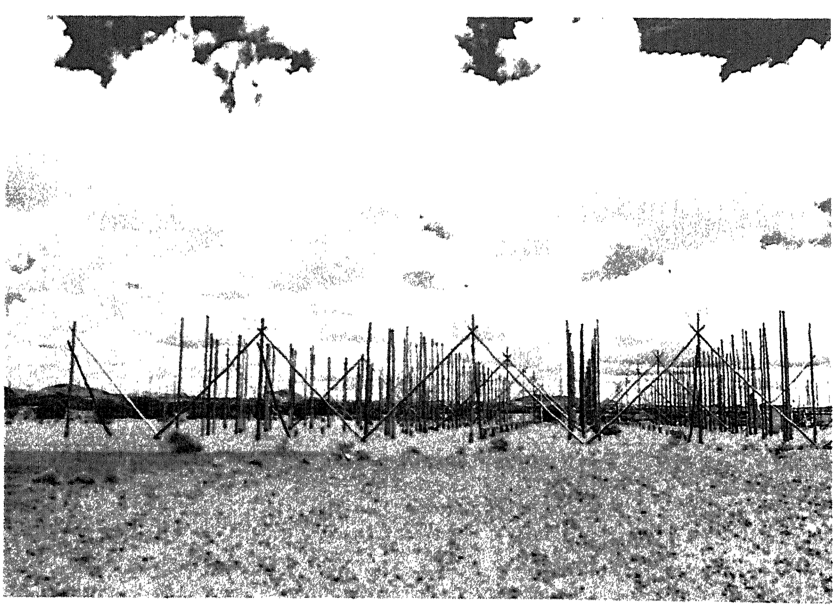

Figure 7. Broadband array of 64 biconical antennas.

converter and a memory bank to VAX 11/730 computer. All its 1760 channels are scanned every 250 millisec and the data is recorded either on the userdisk of the computer or magnetic tape unit. Software has been developed for processing the data and provides 3-D plots of the radio bursts (frequency, time and intensity), contour maps and drift rates etc. A typical record obtained with this system is shown in Fig. 8.

Data Acquisition System

A microprocessor-based data acquisition and recording system enables analog signals of bandwidths up to 30 kHz with 12 bit digitization to be acquired and recorded on magnetic tape units. The system can accept data up to 64 single ended channels (32 differential) at a maximum rate of 25 microsec per channel. The system software allows interactive programming of various features like sampling rate, number of channels, and error logging etc. Diagnostic software is available for board-level diagnostics.

Computer System

The VAX 11/730 system is available for off-line processing and data acquisition with the AOS system. It is supported by a 32 bit high speed microprogrammed central processing unit, 1 Mb RAM memory, 4 K ROM memory for control programs and two cartridge tape drives. Two drives of 20 Mb virtual memory and a tape drive which records at densities of 800/1600 bytes per inch are also available.

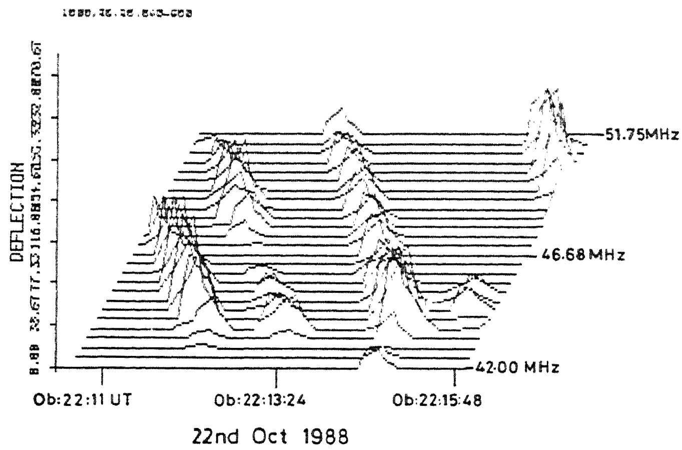

Figure 8. Profiles of solar radio bursts obtained with the acousto-optic Spectrograph between 42.00 MHz and 51.75 MHz.

Acknowledgements

The low-frequency radio astronomy project at Gauribidanur owes its existence to the keen interest and kind support of Prof. V. Radhakrishnan. The pulsar profiles are obtained by A. A. Deshpande, low frequency recombination line observations are made by N. Udayshankar, and the solar radio burst profiles are due to P. S. Ramkumar and K. R. Subramanian. S. Aswathappa, Abdul Hameed, C. Nanje Gowda and G. N. Rajasekhara have contributed significantly to the various aspects of the work at Gauribidanur.

from the director

Both the 102 cm Zeiss and the 234 cm Vainu Bappu telescope at Kavalur have started their observing programmes this year with new powerful detector systems. Both employ CCD arrays which intrinsically have quantum efficiencies thirty to fifty times better than those of best photographic emulsions. These systems have enabled observers to reach the sky brightness limit in exposures of a few minutes only.

The system used at the Cassegrain focus of the 102 cm telescope employs an ultraviolet-sensitive coated Thomson CCD chip. The coating extends the spectral response of the detectors below 400 nanometres, where quantum efficiencies exceeding 20 per cent are found. The system is complete with its own computer system for control, display, and storage of images formed. The entire unit has been supplied and installed by M/s Photometrics Limited of U.S.A. The image processing facilities already set up on the Comtal system with the VAX 11/780 computer provides the remaining steps for probing the frontiers of present day astronomy.

The unit employed at the prime focus of the VBT has been rigged up in our laboratories from basic imported components. The CCD chip is GEC P8603 in a liquid-nitrogen-cooled dewar; the control electronics at the device level has been supplied by Astromed Limited, Cambridge. Software for the image data acquisition and processing has been developed in our laboratories using an IBM PC. At the *f*/3.25 prime focus of the VBT this has provided a very convenient tool for reaching fainter limits in our observing capabilities.

J. C. Bhattacharyya

newsline

J. Hanumath Sastri is serving as a member of INSCOSTEP (Indian National Committee for Scientific Committee on Solar & Terrestrial Physics) of Indian National Science Academy for a three-year term from July 1988.

R. K. Kochhar has been appointed a member of the Indian National Science Academy's National Commission for the compilation of the History of Science in India.

P. Venkatakrishnan has been appointed a member of the organizing committee for IAU working group on High Angular Resolution Interferometry, 1988–1991.

out of context

The red [Fe x] λ 6374 coronal line is the strongest line in the spectrum which has—to our knowledge—not been found yet in any other astronomical object.

ESO Messenger (1988) No. 54, p. 36.

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Stars in our galaxy are believed to explode as supernovae about once every twenty years or so on average. The reason why they are not seen is . . . . .

The Quest for SS433 (1986), Adam Hilger, Bristol, p. 10.

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