SOUTHERN HEMISPHERE SOLAR RADIO HELIOGRAPH

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ABSTRACT

The Brazilian Decimetric Array (BDA) is being developed at National Institute for Space Research (INPE) as an international collaborative program. Initially, the BDA will operate in the tuneable frequency range of 1.2 - 1.7 GHz and later its range will be extended to 2.7 and 5.0 GHz. The initial planned baseline for BDA 'T' array is 256 x 144 m and will be extended to 2.2 x 1.1 km. In this paper, we present the results of developments concerning the prototype of BDA (PBDA). The PBDA will initially operate in the frequency range of 1.2 - 1.7 GHz, with a five-antenna array, using 4-meter parabolic dishes with altitude and azimuth mountings and complete tracking capability. The spatial resolution for solar images with the PBDA will be about 3.5 arc-minutes leading to a sensitivity of $\approx 2 \times 10^4$ mJy/beam for an integration time of 1 sec. The array will be installed at -22° 41' 19" latitude and 45° 0' 22" W longitude and it is under operation between 9 and 21 UT for continuous solar flux monitoring. Details of the PBDA system are presented.

Key words: Radio; Heliograph; Decimetric wavelengths.

1. INTRODUCTION

A team of Brazilian scientists is coordinating efforts to develop the Brazilian Decimetric Array (BDA). The BDA is a 38-element radiotelescope, which employs modern radio interferometry techniques to work in the frequency range of 1.2 - 1.7, 2.7 and 5.0 GHz with a final baseline of 2.2 km. This instrument will allow obtaining radio images from the sun with a spatial resolution of around 4x6 arc-seconds with time resolution of 100 ms (Sawant et al., 1998; Sawant et al., 2000a; and Sawant et al., 2000b). In the central region of the "T" array, 32 steerable antennas of each 4-meter diameter will be installed. Initially, this array will operate in a frequency band of 1.2-1.7 GHz with maximum spatial resolution of 3x4 arc-minutes for solar and non-solar observations. BDA is being developed in three phases. Details of the first phase are given here.

2. PHASE I

The phase I is critical since the main electronic parts will have to be produced and tested intensively. The main technical purpose of this phase is to specify, build and test a prototype of five 4-m steerable antennas, the 3 stage PLL analog receiver consisting of feed, LNA, LO synthesizers, filters, SSB video stage etc, and optimise cost and technical performance. The digital part of the BDA system is being developed at the Indian Institute of Astrophysics (IIA), India. GMRT (Swarup, 1998) experts have developed the hardware and software of the 38 synchronous antennas driving system at NCRA-TIFR jointly with INTELTEK Automation Private Ltd. Company, in Pune, India. The alt-azimuth tracking system was tested at NCRA-TIFR, Pune Campus, India, in May-June 2001 by BDA team members with NCRA and INTELTEK scientists and engineers. Pointing and tracking accuracies have found to be less than 3 arc-minutes. These accuracies are being presently substantially improved.

Five 4-meter diameter mesh type antennas with alt-az mount and with complete tracking system are being put into operation mainly for engineering tests. A low noise preamplifier (NF = 1.3 dB, Gain =

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22dB), a crossed log-periodic broadband feeder with VSWR of about 1.2 - 1.3 having cross polarization response better than 26 dB, and phase-locked synthesizer based receivers operating in the frequency range of 1.2-1.7 GHz with video output of 0-2 MHz SSB have been developed and are being tested for field conditions.

Walsh switching, to minimize the cross talk among the outputs of the receivers, digital system, A/D conversion for a given output, IF 2.5MHz, delay tracking for baselines of 256 meter in steps of 0.1 microseconds as a function of elevation and hour angle are being developed at IIA. The correlator system designed for PBDA is one bit correlator. The 32 channel digital corellator to make complex correlations of 6 antennas including the two measurements of total power have been developed at IIA. Also, necessary interfaces, software for initial data acquisition and preliminary analysis have been developed (Ramesh et al., 1998).

Pairs of antennas are being tested in analogue interferometer mode. After successful tests, the digital system will be coupled to the five antennas developed by the IIA group.

3. SCIENTIFIC AIMS OF THE BDA PHASE I - SOLAR PHYSICS

At present, by using the BSS (Sawant et al., 2001) observations simultaneously with X-ray and at other wavelengths, efforts are made to investigate following fundamental problems in solar physics at INPE: spatial determination of acceleration regions where energy is released, acceleration of particles, chromospheric evaporation, transportation of high-energy particles, mechanisms of plasma emission. The BDA-phase I will provide positional information for long-lasting intense flares. This will enable decimetric activity to be associated with X-ray more accurately and hence will able to investigate above mentioned problems in a better way.

4. THE ARRAY CHARACTERISTICS FOR PHASE I

There will be two antennas in the western arm (O1, O2), two at the eastern arm (L1, L2) and a single antenna placed at the southern position (S1). The minimum distances between each antenna mechanical structure are eight meters among the O2, O1 and L1, L2 antennas, and between S1 antenna and the geometric centre of the east-west axis which contains both western and eastern arms, as shown in Figure 1.

5. OBSERVATIONAL PROCEDURES WITH BDA PHASE I

In a first approach, the minimum antenna separation will be used, then the Sun can be used as a far field signal source to assess the phase and frequency stability of the overall system and obtain the first visibilities for various software tests and individual modules of the system. Our simulations show that the first secondary sidelobe is about 63% lower than the main beam (Figure 2). Therefore effects of grating sidelobes and interference on sidelobes over the main solar disc can be estimated to allow suitable software corrections in the solar images to be obtained with maximum entropy with the BDA.

The first interferometric visibilities from this array will be used to test the microwave receivers and the software for data calibration, as the antennas will be so close together that the sun will not be resolved spatially by the innermost ensemble of antennas of the BDA.

After these tests, the antennas will be moved apart so that their relative positions will be 8 times, i.e baselines will be 256 x 144 meter in east-west and south directions. Hence, spatial resolution will be 3x4 minutes of arc at 1.5 GHz. Hence these antennas will have capabilities of solar imaging to monitor the relative position and radio flux intensities of various intense active solar regions.

With this approach, the BDA phase I can be used to obtain the positions and intensities of the strongest solar flares detected by the Brazilian Solar Spectroscope (BSS) and to compare their positions in the solar disk with X-ray images produced by solar satellites like the RHESSI within the given solar period of activity.

6. SENSITIVITY IN FLUX DENSITY OF BDA-PHASE I

With an expected total system temperature of 50 K (6 dB total noise figure), the sensitivity will be about 1 Jy/beam for a total observing time of 10 minutes of continuum solar observations at 1.4 GHz. The sensitivity calculations for BDA-phase I has been described by Sawant et al. (2000b) and according to the equations presented by Thompson, Moran and Swenson (1991).

7. CONCLUSIONS

For the five elements interferometer almost all subsystems are developed and tested. The antennas are installed in the field site. Soon, the software of the tracking system will be installed and pairs of antennas will be tested for its inteferometric aspect in analog mode. After satisfactory tests, the digital part

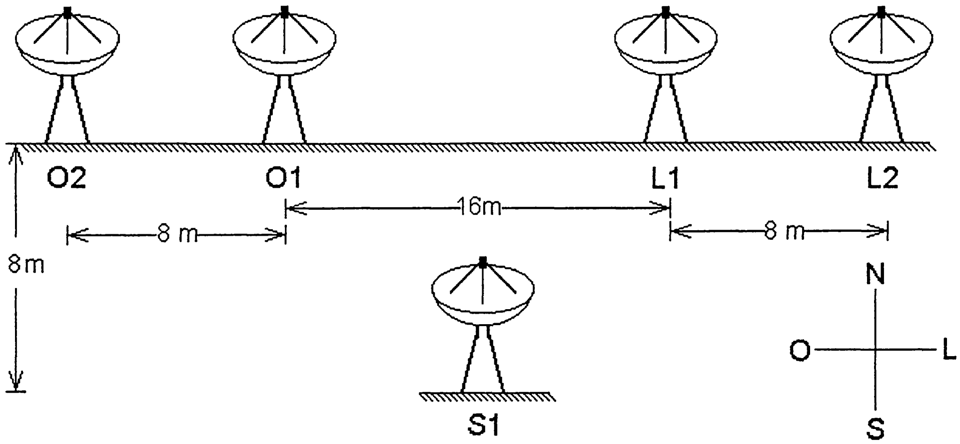

Figure 1. Distribution of the five solar-tracking antennas, which will compose the array of the Brazilian Decimetric Array-phase I.

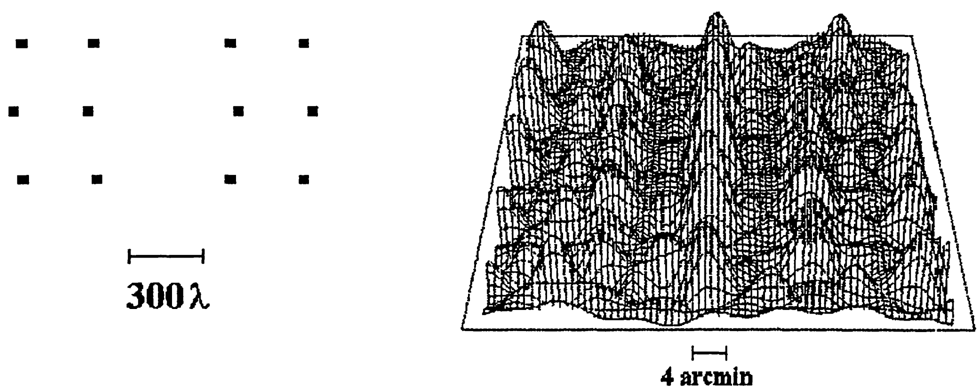

Figure 2. Instantaneous "UV" diagram shows the redundant spacings, which are useful for phase and amplitude studies of various parts of the BDA. The 5-element synthesized antenna beam is also shown for solar transit.

will be coupled. Solar flare observation will be carried out from months of October/November 2002.

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