BRAZILIAN DECIMETRIC ARRAY

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ABSTRACT

In its present configuration, the Brazilian Decimetric Array (BDA) consists five alt-azimuth mounted parabolic mesh type dish antennas of 4 m diameter each, and is located at Cachoeira Paulista (Longitude: 45° 00′ 20″ W; Latitude: 22° 41′ 19″ S) in Brazil. The antennas are arranged along the E-W direction and the longest baseline is 216 m. Initial observations of Sun and a few strong sidereal radio sources were carried out during November-December 2004 at a frequency of 1.6 GHz . The temporal and spatial resolution was 100 ms and 1.5 arc min, respectively. The observed fringe rate for different baselines in the array is in good agreement with the theoretical values. We synthesized one-dimensional brightness distribution of the Sun using the data obtained on December 11, 2004. It corresponds well with the solar image obtained at other wavelengths. The BDA, in its final configuration, will be a 38-element radio telescope. The central part of the array will consist of 32 antennas laid out in the shape of a 'T' with dimensions of 400 m in the E-W direction and 180 m in the S direction, respectively. The maximum baseline length in either direction will be 2.5 and 1.25 km. The planned operating frequencies are 1.2 – 1.7, 2.7 and 5.6 GHz and is scheduled to be completed in 2007. The array will have a spatial resolution of ~ 5 arc second at 5.6 GHz.

1. INTRODUCTION

INPE's Interplanetary Physics Group have developed the following radio telescopes in the past: (i) Variable Frequency Millimeter Wave Radiometer [1], and (ii) Brazilian Solar Spectroscope [2,3]. A team of scientists and engineers initiated the design and planning of the BDA project in the year 2000 [4] to produce high spatial and time resolution images of Sun, galactic and extra-galactic radio sources (the last two particularly in the Southern hemisphere) in the decimetric wavelength range with good dynamic range.

2. THE PHASES OF BDA

The development of the prototype of the BDA project (called PBDA) with five antennas started in December 2001 at the INPE campus in São José dos Campos (SJC), Brazil. The main objective was to develop various electrical, mechanical and electronic subsystems; test them in real conditions of operation; and optimise, estimate the cost of various subsystems required for the next stages. This was successfully completed in 2003 (Fig. 1). The five-element interferometer was then transferred and set-up at the INPE campus in Cachoeira Paulista (CP), Brazil, with baselines up to 216 meters in the E-W direction (Fig. 2). Solar and non-solar observations were carried out with the array during November-December 2004 for about 48 hours. The final phase of the BDA will have 38 antennas and is expected to be ready by the end of 2007.

3. BRIEF DESCRIPTION OF INSTRUMENTATION

The PBDA consists of five alt–azimuth mounted mesh type parabolic dish antennas (A1-A5). Dual polarized log-periodic feed operating in the frequency range of 1.2 – 1.7 GHz with a gain of ~8 dB is mounted at the prime focus of each dish. The latter has a f/d ratio of 0.38. LNAs with noise figure ~1.5 dB, gain ~25 db, VSWR ~1.2 and inter-modulation ~ -30 dB in the above frequency range are connected to two ports of the log periodic feed. The outputs from the above set up are combined and down converted to an IF of 70 MHz (the latter in a enclosure at the base of the tower of each antenna) in two steps. The IF signal is transmitted to the control room located at a distance of ~125 m by shielded coaxial cables, where it is 'Walsh switched' and further down converted (3rd) to the base band (0–2.5 MHz). This output is passed through a hybrid for generating inphase (0°) and quadrature (90°) outputs. These signal are then

digitised at a rate of 5 MHz, passed through Walsh demodulators, delay lines and finally to a 32-channel correlator. Two channels of the correlator system are used for total power measurement. The local oscillators used for the down conversion (totally 3) at different stages in the analog receiver are generated using a standard Rubidium clock of 10 MHz in the control room, and are synchronised in phase. This LO reference signal is sent to all antennas (for the 1st and 2nd down conversion) from the control building. The 3rd down conversion is done in the control cabin itself.

Fig. 1. Prototype five-element array in INPE-SJC. The array is in the E-W direction and the baseline separation between adjacent antennas is 8 m. The trailer near the bottom left corner is used as the control cabin.

Fig. 2. Prototype five-element array in INPE-CP. The antennas are in the E-W direction and the longest baseline length is 216 m. The antenna (A5) in the near side is the east end of the array.

4. SCIENCE WITH BDA

4.1 Solar Physics

Two types of solar emission are generally observed in the decimetric wavelength range: (i) broadband gyrosynchrotron radiation and (ii) plamsa radiation that give rise to group of narrow band fine structures. These are closely associated with the pre-flare phase and impulsive phase of the solar flares, respectively. The BDA will provide positional information of the sources of these emissions. This will help in correlated studies of X-ray and radio data, and

hence we will able to investigate the fundamental problems like the energy release and particle acceleration in solar flares [5,6,7,8].

4.2 Observations of Radio Galaxies, Quasars and BL Lacertae objects

Observing powerful and extensive extragalactic radio sources is necessary for studying the energy sources of these objects. The study of extragalactic sources that show quasi-periodic variability in the decimetric wavelength range is important from the point of understanding the nature of these sources. Again, observations and monitoring of quasars in the above wavelength range is very much required [9].

5. INITIAL OBSERVATIONS WITH PBDA

During the period from 22 November 2004 to 11 December 2004, observations of Sun and a few strong sidereal sources were carried out with the PBDA at Cachoeira Paulista. The observing frequency was 1.6 GHz. The temporal and spatial resolution was 1.6 s and 1.5 arc min, respectively. Sun was observed for a total of 37 hours and sidereal sources like Cygnus-A, Crab Nebula, Taurus-A and Centaurus-A were observed for 11 hours. The expected and observed spatial resolutions for various baselines are given in Table 1. By using amplitude and phase calibration, E-W one-dimensional brightness temperature distribution of the Sun was synthesized using the data obtained on December 11, 2004 (Fig. 3). It is compared with the 195 Å image of the solar corona obtained around the same time with the Extreme ultra-violet Imaging Telescope (EIT) onboard the Solar and Heliospheric Observatory (SoHO) (Fig. 4).

Table 1: Baseline separation, expected and observed spatial resolution at 1.6 GHz for PBDA

ANTENNA MULTIPLICATION	BASELINE (m)	SPATIAL RESOLUTION (arc min)	
		MEASURED	EXPECTED
A1 × A2	18	36.4	35.8
A1 × A3	36	18.2	17.9
A1 × A4	54	12.2	11.9
A1 × A5	72	9.05	8.95
A2 × A3	90	7.26	7.16
A2 × A4	108	6.10	5.96
A2 × A5	126	5.20	5.11
A3 × A4	144	4.61	4.47
A3 × A5	216	3.02	2.98

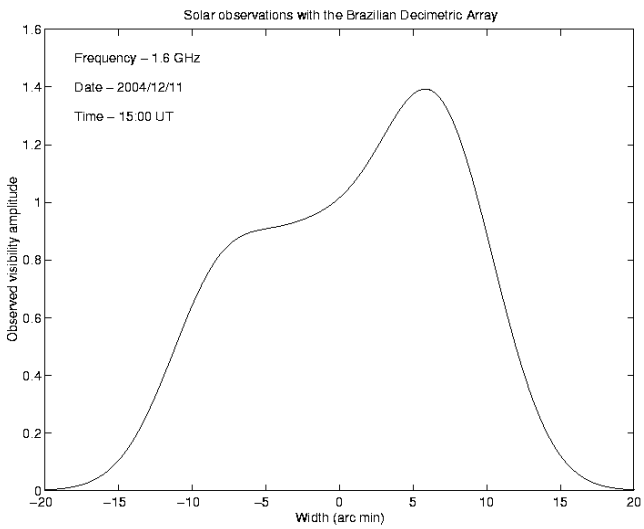
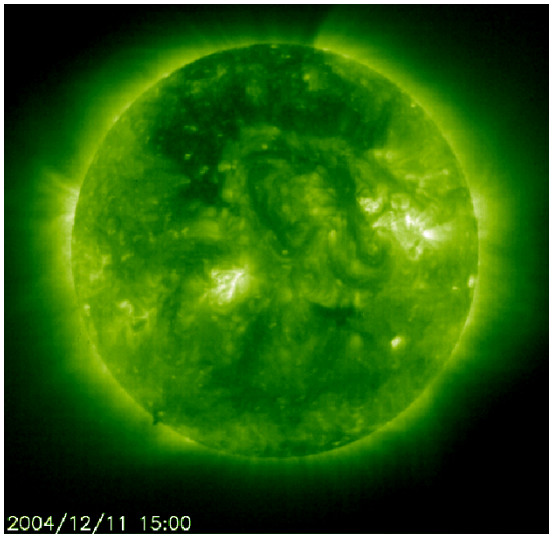
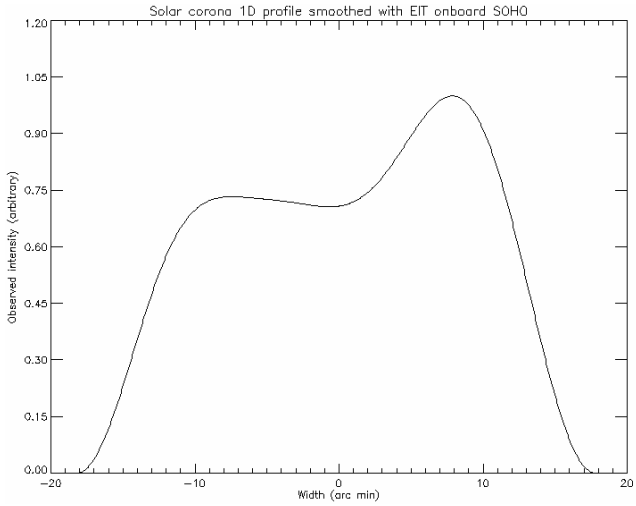


Fig. 3. E-W one-dimensional brightness distribution of Sun obtained with the PBDA at 15:00 UT on Dec. 11, 2004.



(a)



(b)

Fig. 4. (a) 195 Å image of the solar corona obtained on December 11, 2004 at 15:00 UT with the Extreme ultra-violet Imaging Telescope onboard the Solar and Heliospheric Observatory (SoHO). (b) E-W one-dimensional brightness distribution of the Sun generated by integrating the SOHO-EIT image in Fig. 4a along the N-S direction of the Sun, and smoothing in the E-W direction using the PBDA beam at 1.6 GHz. One can notice that the synthesized one-dimensional brightness distribution in Fig. 3 agrees reasonably well with this image.

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