2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

The Polarization Performance of MingantU SpEctral Radioheliograph

Cang Su[(1) (2)], Wei Wang [(1) (2)], and Yihua Yan [(1) (2)]
(1) National Astronomical Observatories, Chinese Academy of Sciences
(2) CAS Key Laboratory of Solar Activity, National Astronomical Observatories

Abstract

The MUSER(MingantU SpEctral Radioheliograph) is a new radio interferometric array for solar delicated, which will be used to image the Sun with high spatial resolution, high time resolution and high frequency resolution. The antenna works with ultra-wide band dual-circular polarized feed to obtain high quality dual circular polarized image of the Sun. So we must have well in hand the polarization capability of the antenna. In this paper, we will introduce several aspect of the polarization performance of the antenna and the brief measure method.

1. Introduction

The MingantU SpEctral Radioheliograph (MUSER) is an advanced new generation solar radio observing equipment, which uses the synthetic aperture technology with two-dimensional imaging capability. MUSER is capable of observing dynamic properties of solar activity in corona simultaneously at both decimeter and centimeter wavelengths at higher frequency, temporal and spatial resolution[1]. The scientific objectives of these observations include high energy transient phenomena, coronal magnetic field and structure of Solar atmosphere, confirming the Solar flares and source region of coronal mass ejection(CME) [2], so we can understand the Solar dynamic transition zone and corona.

The MUSER frequency range is 0.4-15GHz which is composed by MUSER-I and MUSER-II. The MUSER-I contains 40 antennas of 4.5m diameter covering 400MHz to 2GHz, and the MUSER-II contains 60 antennas of 2m diameter covering 2GHz to 15GHz. The whole 100 antennas of both MUSER arrays are located on 3 log-spiral arms, and the maximum baseline length is about 3 km. The solar radio signal detected by the antenna is transmitted to the indoor unit by optical fibers. With the analogous unit and digital unit the signals are converted, digitized, quantized and correlated[3].

MUSER's main objective is to obtain the solar image with high quality include the left hand circular polarization and the right hand circular polarization, so the polarization performance of the antenna is very important. Then i will introduce the circular polarization degree, the polarization leakage terms and the axial ratio of MUSER-I.

2. MUSER's Polarization Performance

2.1 Circular Polarization Degree

When using antenna (with dual circular polarized outputs) to observe a weakly polarized or unpolarized source, the circular polarization degree can indicate the polarization of the antenna, which is defined as:

$$\delta = \frac{P_R - P_L}{P_R + P_L} \qquad (1).$$

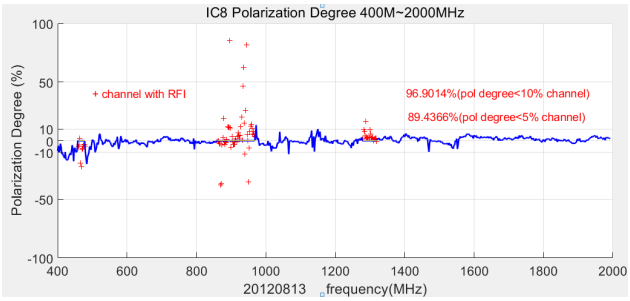

Figure 1. The circular polarization degree of IC8.

Figure1 is one of the measured result, which indicated that 89.4% of the frequency band the circular polarization degree is less than 0.05.

2.2 Polarization Leakage Terms

The polarization leakage terms are often described as the leakage of the orthogonal polarization into the antenna and represent the instrumental polarization which are represent by D terms. When observing unpolarized radiation from a source located at the phase tracking center for equatorial mount antenna with circularly polarized feed and $|D| \ll 1$, then the outputs of an interferometer in terms of the leakage terms can be represented as follows:

$$V_{rmrn} = g_{rm} g_{rn}^{*} I \qquad (2)$$
$$V_{lmln} = g_{lm} g_{ln}^{*} I \qquad (3)$$
$$V_{rmln} = g_{rm} g_{ln}^{*} (D_{rm} + D_{ln}^{*}) I \qquad (4)$$
$$V_{lmrn} = g_{lm} g_{rn}^{*} (D_{lm} + D_{rn}^{*}) I \qquad (5)$$

where subscripts r and l indicate two orthogonal polarization, subscripts m and n represent two antennas, v indicates the correlator output for ideal antenna[4][5]. One of the results is shown as figure 2.

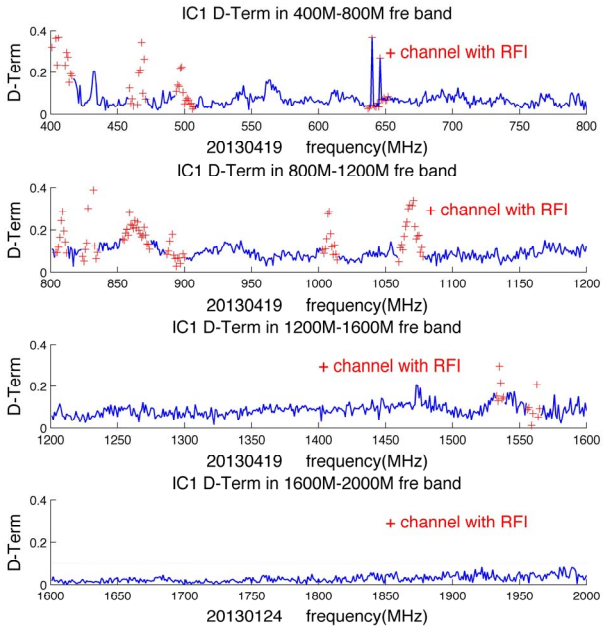

Figure 2. The leakage terms of IC1.

Figure.2 shows the leakage terms in 400 MHz to 2000 MHz frequency band, 94.8% frequency band of the leakage terms is below 0.1.

2.3 Axial Ratio

AR (Axis Ratio) is an important parameter for measuring feed's polarization, which is defined as the ratio of the lengths of the major and minor axes of the polarization ellipse. The AR of antenna IB1 and IC1 is shown as figure 3.

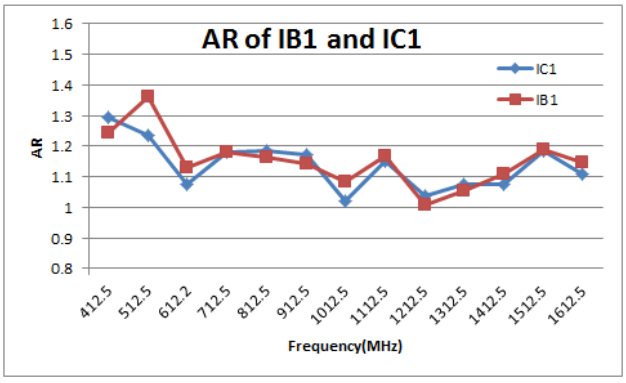

Figure 3. The AR of IB1 and IC1.

As is figure 3 shown, most of the frequency band the AR is less than 1.2.

3. Evaluation

According to the measured results including circular polarization degree, polarization leakage terms and axis ratio, it is indicated that MUSER's feeds have nearly perfect circular polarization and they can provide powerful tools to probe Solar phenomena.

6. Acknowledgements

The authors are supported by the Yong Researcher Grant of National Astronomical Observatories, Chinese Academy of Sciences and NSFC grants(Nos.: 11573043, 11790305, 11773043) .

7. References

1. Y. Yan, J. Zhang, W. Wang, F. Liu, Z.J. Chen, & et al, "The Chinese Spectral Radioheliograph-CSRH," *Earth Moon Planet*, 2009, pp. 97-100.

2. Y.H. Yan, W. Wang, F. Liu & et al, "Radio imaging-spectroscopy observations of the Sun in decimetricand centimetric wavelengths," *IAU SYMPOSIUN No.294 CAMBRIDGE UNIVERSITY*, 2013, pp. 489-494.

3. W. Wang, Y.H. Yan, D.H. Liu, Z.J. Chen, C. Su, & et al., "Calibration and Data Processing for a Chinese Spectral Radioheliograph in the DecimeterWave Range," *PASJ*, 2013, pp. S18-1-S18-5.

4. A. Richard Thompson, James M. Moran., George W. Swenson, Jr., "Interferometry and Synthesis in Radio Astronomy," *Wiley-Interscience Publication, UnitedStates*, 2001, pp. 105.

5. Rick Perley, "Measurements of C-Band EVLA Antenna Polarization," *EVLA Memo 131*, 2009.