Revista Mexicana de Astronomía y Astrofísica Serie de Conferencias (RMxAC), **56**, 131–133 (2024)

https://doi.org/10.22201/ia.14052059p.2024.56.24

FIRST POLARIZATION MEASUREMENTS WITH THE NEW DIGITAL RECEIVER OF THE E. BAJAJA RADIO TELESCOPE AT THE ARGENTINE INSTITUTE OF RADIOASTRONOMY

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RESUMEN

Describimos los procedimientos seguidos para calibrar las capacidades polarimétricas del nuevo receptor digital del telescopio de radio de 30 metros Esteban Bajaja, ubicado en el Instituto Argentino de Radioastronomía (IAR). El objetivo fue optimizar la determinación de los parámetros de Stokes asociados con fuentes de radio polarizadas, a través de una caracterización adecuada de los errores instrumentales. Para tal propósito, se llevó a cabo una campaña de observación dirigida a fuentes de calibración, tanto polarizadas como no polarizadas, y así corregir las propiedades instrumentales y la estabilidad del sistema. Además, desarrollamos el software para el análisis de datos.

ABSTRACT

We describe the procedures followed to calibrate the polarimetric capabilities of the new digital receiver of the 30-m radio telescope Esteban Bajaja, located at the Instituto Argentino de Radioastronomía (IAR). The goal was to optimize the determination of the Stokes parameters associated with polarized radio sources with an adequate characterization of the instrumental errors. An observational campaign targeting at calibration sources, both polarized and unpolarized, was conducted to fix the instrumental properties and the stability of the system. We developed the software for the data analysis.

Key Words: Instrumentation: detectors — Instrumentation: polarimeters — Methods: observational — Techniques: polarimetric — Radio continuum: general

1. INTRODUCTION

Polarization surveys were conducted in the northern and southern skies following the initial detection of linear polarization in the early 1960s (Westerhout et al. 1962) (Wielebinski et al. 1962). These early surveys, primarily performed at frequencies of 408 MHz and 1.4 GHz, had limited sampling and sensitivity. However, they provided essential zero-level determination. Despite their age, these data remain valuable for present experiments with limited telescope time or instrumental constraints. A recent survey at 1.42 GHz (Wolleben et al. 2006((@) has been recently added to the list of large-scale polarization sky surveys, offering denser sampling and improved sensitivity compared to earlier surveys.

While the northern sky has been extensively studied, the southern sky has received much less attention, with most observations conducted so far using the Parkes 64-m telescope. The early polarization data in the southern sky were collected at 408 MHz (Mathewson & Milne 1965), with additional measurements at 620 MHz and 1.41 GHz (Mathewson et al. 1966).

Galactic polarization surveys have gained increasing interest in recent years, as they reveal unique large-scale features not observed in total intensity data. The polarization structures are affected from Faraday rotation effects, so its measurement can provide insights into the properties the Galactic magneto-ionic medium. Moreover, it has been recognized that sensitive studies of the cosmic microwave background, aimed at detecting polarization signals from the early universe, may be affected by polarized Galactic synchrotron radiation as a dominant foreground.

As part of the "Beca de Estímulo a las Vocaciones Científicas" awarded by CIN, a proposal was made to restore the polarization capabilities to the instruments at the Instituto Argentino de Radioastronomía (IAR).

To accomplish this, the Esteban Bajaja radio telescope located at IAR was employed. Operating at a system temperature of 90 K and with a band-

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IAR's 60th anniversary: Prospects for low-frequency radio astronomy in South America (November 15-18, 2022)
Editors: Paula Benaglia and Ileana Andruchow - DOI: https://doi.org/10.22201/ia.14052059p.2024.56.24

width of 400 MHz, centered at a frequency of 1435 MHz, it served as the primary instrument for the study.

Observation campaigns were carried out on the sources PKS 0915-11 (Hydra A), PKS 0518-45 (Pictor A), and PKS 0043-42, aiming to reproduce the findings in literature. These sources were selected as benchmark cases to assess the degree of polarization in other objects during future observations.

2. OBSERVATIONS AND DATA REDUCTION

The first step in determining our ability to observe polarized sources is to determine the instrumental errors of our radio telescope. For this, a non-polarized calibrating source and two polarized calibrating sources with different polarization indices were selected. In this way, when observing the non-polarized source, the calibration factors are determined, the channels are then applied to the polarized sources, and then a final result can be obtained.

2.1. *Instrument Description*

The measurements were made with the E. Bajaja radio telescope at the central frequency of 1400 MHz with 400 MHz of digitization bandwidth in each polarization. The digitization was carried out using a ROACH plate (CASPER group), which in spectrometry mode generates spectra with an integration time of 450 milliseconds. Each spectrum is processed to eliminate possible electromagnetic interference prior to obtaining the integrated total power. The system also has a noise diode that injects the same power at the feeder for each polarization channel for amplitude calibration.

2.2. *Measurements*

The radio sources observed were:

- 0915-11, 42.5 Jy, Hydra A, non-polarized
- 0518-45, 65.1 Jy, Pictor A $\sim$ 3% bias
- 0043-42, 7.5 Jy, $\sim$ 10% bias

Each source was scanned in a North-South and East-West direction, for a period of 3 hours each, generating 80 scans that were processed and averaged, thus obtaining one scan in each direction for later correction. The flux values of the sources were extracted from Testori et al. (2001).

Fig.1 depicts the antenna scanning process. The Y-axis line corresponds to the N-S scan, the X-axis line represents the E-W scan, and the diagonal line indicates the orientation change during the scan. Note that the N-S line is thicker because the antenna is tracking the source as it's naturally moving across the sky.

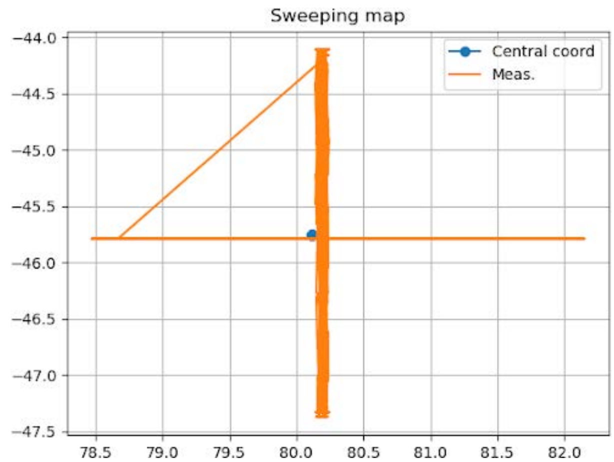

Fig. 1. A graphical representation that illustrates the antenna scanning process for observing a central source. The antenna scanned in the North-South (Y-axis) and East-West (X-axis) directions. See text for more details.

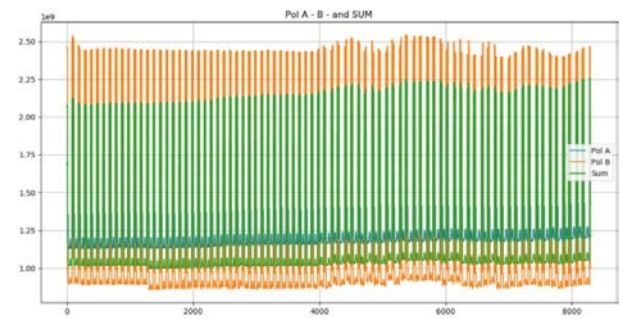

Fig. 2. Shown here is 0915-11, 42.5 Jy, Hydra A, non-polarized. From this measurement we obtain the polarization fitting parameters, which are applied to the three observed sources.

3. RESULTS

We display in Fig. 2 the preliminary results obtained without processing and previous to the application of the calibration factor. We then measured the flux (Fig. 3) and the polarization degree for each source, calibrating the measurements using the instrumental polarization found. The results are showed in Table 1.

4. CONCLUSIONS

It was possible to carry out a programmed campaign measuring three sources with different characteristics. These are the first measurements in polarization made at IAR after 30 years (Luna et al. 1993).

It was possible to obtain a set of adjustment parameters which could be applied in the same way to the three sources, thus obtaining the expected results for the calibrating sources.

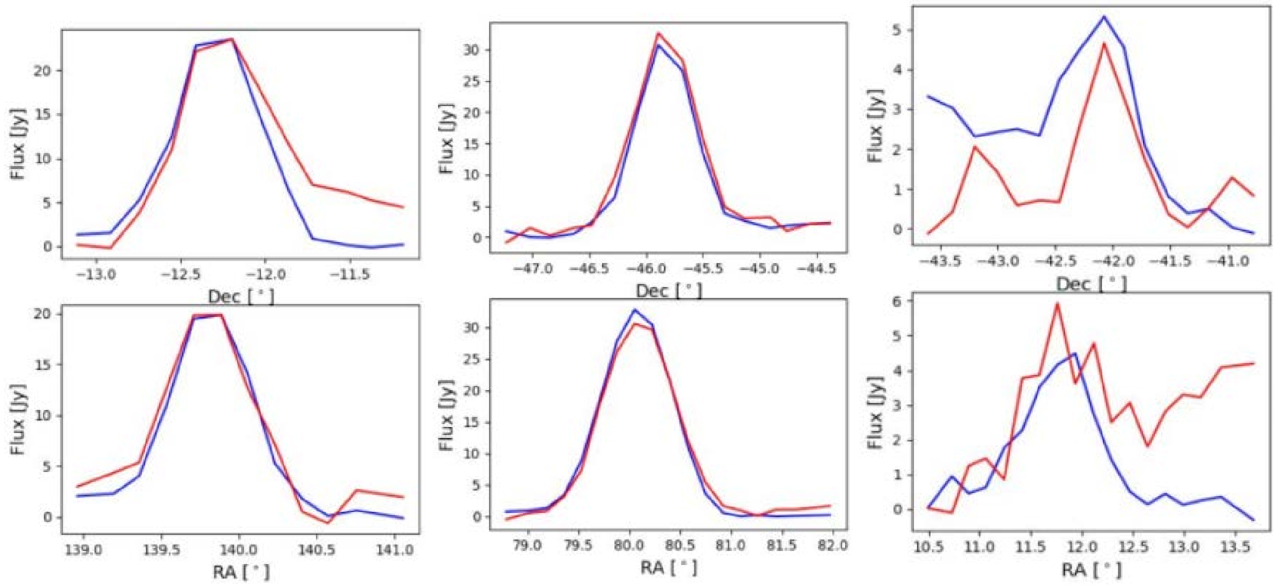

Fig. 3. From left to right, the fluxes obtained for the Hydra A, Pictor A and PKS 0043-42 sources. Each color represents the two branchs of the antenna receiver.

TABLE 1

THE POLARIZATION DEGREE FOR EACH SOURCE FOUND IN THE LITERATURE (Tabara & Inoue 1980) IS SHOWN, AS WELL AS THE MEASUREMENTS OBTAINED IN OUR WORK.

	Literature	Meassured
Hydra A	0%	∼ 0%
Pictor A	∼ 3%	∼ 2.5% – 3 %
PKS 0043-42	∼ 10%	∼ 10%

The next stage of the project aims at observing another set of polarized sources to verify this result and obtain the polarization angle, through a more elaborate data process.

REFERENCES

Luna, H. G., Martinez, R. E., Combi, J. A., Romero, G. E. 1993, A&A, 269, 77

Mathewson, D. S. & Milne, D. K. 1965, Australian Journal of Physics, 18, 635

Mathewson, D. S.m Broten, N. W., Cole, D. J. 1966, Australian Journal of Physics, 19, 93

Tabara, H. & Inoue, M. 1980, A&AS, 39, 379

Testori, J. C. and Reich, P. and Bava, et al., 2001, A&A, 368, 1123

Westerhout, G., Seeger, Ch. L., Brouw, W. N., Tinbergen, J. 1962, Bull. Astron. Inst. Netherlands, 16, 187

Wielebinski, R., Shakeshaft, J. R., Pauliny-Toth, I. I. K. 1962, The Observatory, 82, 158

Wolleben, M., Landecker, T. L., Reich, W., Wielebinski, R. 2006, A&A, 448, 411

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Editors: Paula Benaglia and Ileana Andruchow - DOI: https://doi.org/10.22201/ia.14052059p.2024.56.24