The Metrewavelength Sky
ASI Conference Series, 2014, Vol. 13, pp 127 – 130
Edited by J. N. Chengalur & Y. Gupta

Centaurus A and Galactic centre observations with PAPER in the range 114–188 MHz

I. I. Stefan* on behalf of the PAPER collaboration
Cavendish Laboratory, 19 J. J. Thomson Ave., Cambridge, CB3 0HE, U.K.

Abstract. We present observations taken with the Precision Array for Probing the Epoch of Reionization (PAPER) of Centaurus A and the Galactic Centre in the frequency range 114 to 188 MHz. The resulting images, with a 25′ resolution, offer insights into the low frequency structure of the two fields. A spectral index map of Cen A is produced across the full band. The observations of Centaurus A and their subsequent analysis have been published in detail in Stefan et al. (2013).

Keywords : galaxies: individual: Centaurus A – instrumentation: interferometers – galaxies: active – galaxies: structure – Galaxy: centre

1. Introduction

At a distance of 3.8 Mpc (Harris, Rejkuba & Harris 2010), Centaurus A (Cen A) is by far the closest radio galaxy, showing AGN-driven radio jet structures on scales from parsecs to 200 kpc (Israel 1998). Given its proximity, and very large physical scale, Cen A has become a key tool in the study of radio source physics. However, its large angular scale ($> 10^\circ$) presents a severe challenge to radio imaging of extended features with reasonable spatial resolution. Here we present the imaging of Cen A with the Precision Array for Probing the Epoch of Reionization (PAPER, Parsons et al. 2010) array in South Africa. We also present a preliminary image of the Galactic Centre from the same instrument.

2. Observations and results

PAPER is an interferometric transit array aimed at detecting the fluctuations in the 21 cm emission from the Epoch of Reionization. But, with a field of view of $\sim 40^\circ$,

*email: iis21@cam.ac.uk

Table 1. The main properties of PAPER. The project currently consists of a 32-antenna test-array situated at NRAO, in Green Bank, USA, and a 128-antenna array in South Africa's Radio Quiet Zone (latitude of approximately 30° S). Further reference to PAPER here implies only the South African array.

Number of antennas	128 (64 for these observations)
Baselines	up to 300 m
Bandwidth	~ 80 MHz
Integration time	10.7 s
No. of channels	2048
Channel width	48.83 kHz
Field of view	40°
Resolution	15′ and 25′ across the band
Polarization	Dual capability; single for these observations

and spatial resolutions between ~ 15′ and 25′ across the band, the array is well suited to image the extended emission from Cen A. Table 1 lists the main properties of the array. We present here data taken in single polarization (E–W) on four consecutive nights (2011 July $3^{rd}/4^{th}$ – $6^{th}/7^{th}$). Full details on data selection and calibration are provided in Stefan et al. (2013).

Fifteen calibrated maps were produced, one for each 4.98 MHz-wide channel within the PAPER band. Fig. 1 shows a weighted average of the middle thirteen. It has a dynamic range of ~ 3500, as found from the ratio of the peak brightness of the core of Cen A to the r.m.s. of 0.5 Jy beam^{-1}. Cen A dominates the centre of the image and the Galactic Plane crosses it further South. The Supernova Remnant (SNR) PKS 1209−52 (e.g. Dickel & Milne 1976) is visible to the SW of Cen A, at −52° Dec, as a shell with two brightened limbs. Fig. 2 shows an image of Cen A.

A lower limit of 5 wavelengths was imposed for calibration and imaging, which means structures larger than 11.°5 are not imaged. The negative dips in the maps evince the lack of short spacing data. Cen A is surrounded by a shallow region of negative flux as are objects in the Galactic plane. These negative 'bowls' result in uncertainty in the total flux measurements of large sources, and diffuse surface brightnesses.

PAPER's large bandwidth allows for spectral index maps of the observations to be computed across the band. Incomplete reconstruction of the total flux will bias this calculation, but the small scale trends are still valid. Stefan et al. (2013) discusses in more depth both the full field and the spectral index results.

The same pipeline was used to produce an image of the Galactic Centre (Fig. 3) with data from the same observing campaign. A number of Galactic and extragalactic sources can be identified, as well as some thermal absorption regions. Further work will focus on an analysis of this data, with emphasis on the thermal absorption regions.

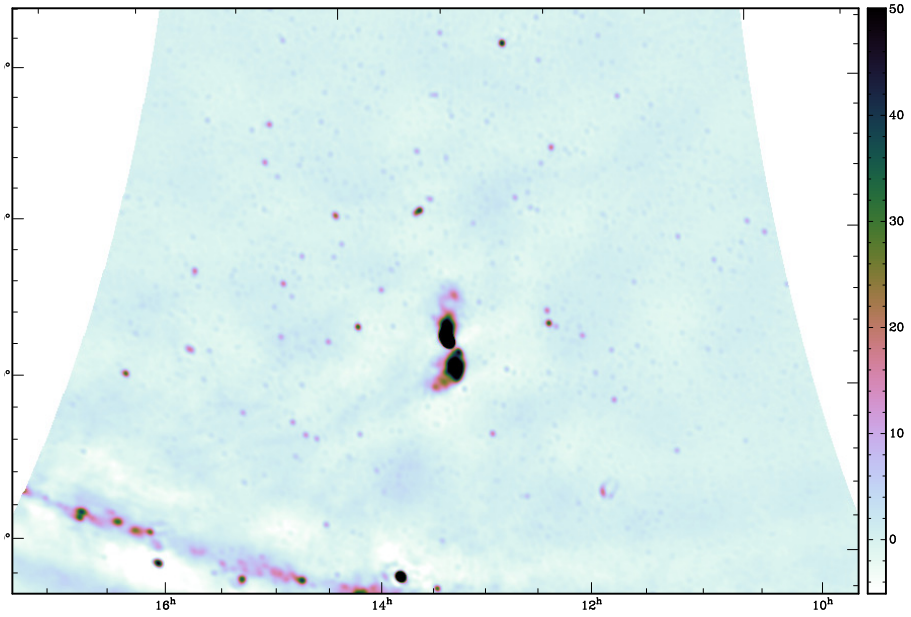

Figure 1. PAPER final image of the Centaurus A field obtained with a 25′ × 23′ FWHM Gaussian restoring beam. The 'cubehelix' (Green 2011) colour scheme is used.

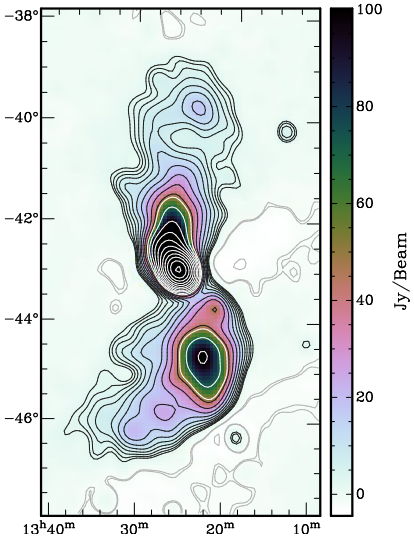

Figure 2. Contour map of Cen A from the full field image. Contour levels are a geometric progression in $\sqrt{2}$, staring from 2 Jy beam^{-1}. Negative contours are in light grey. The southern lobe shows a sharp edge along the southwestern boundary of the radio source, and more diffuse emission extending to the east in two 'prongs' of emission by about 2°. These two prongs are also seen at 1.4 GHz (see Feain et al. 2011). The northern middle lobe extends outwards from the inner lobe and curves northward into the outer lobe. In its northern half, the outer lobe curves east to form a hook-like structure. The northern lobe shows a general decline in brightness away from the core, with further brightening in the hook-like region.

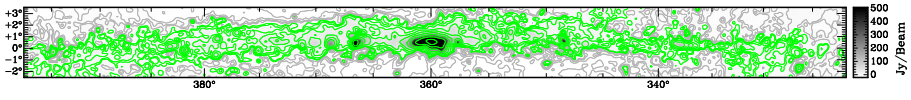

Figure 3. PAPER final image of the Galactic centre obtained with a $25' \times 23'$ FWHM Gaussian restoring beam. The image covers a surface of roughly $75° \times 5°$. Contour levels are a geometric progression in 2, staring from 2 Jy beam^{-1}. Negative contours are in light grey.

3. Conclusions

PAPER is a 128-element array in the South African Quite Zone. Although aimed at the statistical detection of the reionization signal, it is also well suited for wide-field imaging. We used PAPER data to image the Cen A and Galactic Centre fields with a resolution of $25'$. We used the array's large bandwidth to obtain a spectral index map of Cen A centered on 148 MHz. Stefan et al. (2013) provides a more in depth discussion of the Cen A field and results.

Acknowledgements

I would like to thank my supervisors Dr. Dave Green and Dr. Chris Carilli for their advice and continuous support.

The PAPER collaboration consist of: James E. Aguirre, Zaki S. Ali, Richard F. Bradley, Chris L. Carilli, David R. DeBoer, Matthew R. Dexter, Nicole E. Gugliucci, Daniel C. Jacobs, Pat Klima, Adrian Liu, David H. E. MacMahon, Jason R. Manley, David F. Moore, Aaron R. Parsons, Jonathan C. Pober and William P. Walbrugh

References

Dickel J. R., Milne D. K., 1976, AuJPh, 29, 435
Feain I. J., et al., 2011, ApJ, 740, 17
Green D. A., 2011, BASI, 39, 289
Harris G. L. H., Rejkuba M., Harris W. E., 2010, PASA, 27, 457
Israel F. P., 1998, A&ARv, 8, 237
Parsons A. R., et al., 2010, AJ, 139, 1468
Stefan I. I., et al., 2013, MNRAS, 432, 1285