THE SPECTRAL INDEX DISTRIBUTION OF CYGNUS A

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Abstract. High dynamic range maps of Cygnus A at 2.7 and 5 GHz have been used to investigate the variation of spectral index over the extended parts of the source. Although both components show a steepening of spectral index away from the hotspots there is a marked asymmetry between the two components. This is interpreted as being due to a higher value of magnetic field in the S_f component.

We have recently reobserved Cygnus A with the Cambridge 5-km telescope at 5 GHz and 2.7 GHz in order to investigate the variation of spectral index over the extended parts of the source. Previous measurements (Hargrave & Ryle 1974; De Young, Hogg & Wilkes 1979; Dreher 1979) have indicated a steepening of the spectral index away from the hotspots but were limited by dynamic range or signal/noise to areas in the vicinity of the hotspots. Winter et al. (1980) were able to map the emission at 151.5 MHz across the whole source, but due to the absence of quadrature phase information, had to assume source symmetry. These earlier measurments have been generally consistent with synchrotron ageing of electrons left behind by the outward motion of the hotspots.

The new data consist of a 64-spacing map at 2.7 GHz and a 128-spacing map at 5 GHz. Separate measurements were made of I-Q and Q-U, providing both total intensity and polarisation distributions. The oversampling of the U-V plane (by a factor of $\sim$ 2) results in a virtually constant offset of the zero level over the area of the source, facilitating spectral comparisons. Standard point-source calibrators were used to determine system phases and the total source flux-density at each frequency has been normalised to the values given by Baars et al. (1977).

In addition to the standard Fourier inversion the data have

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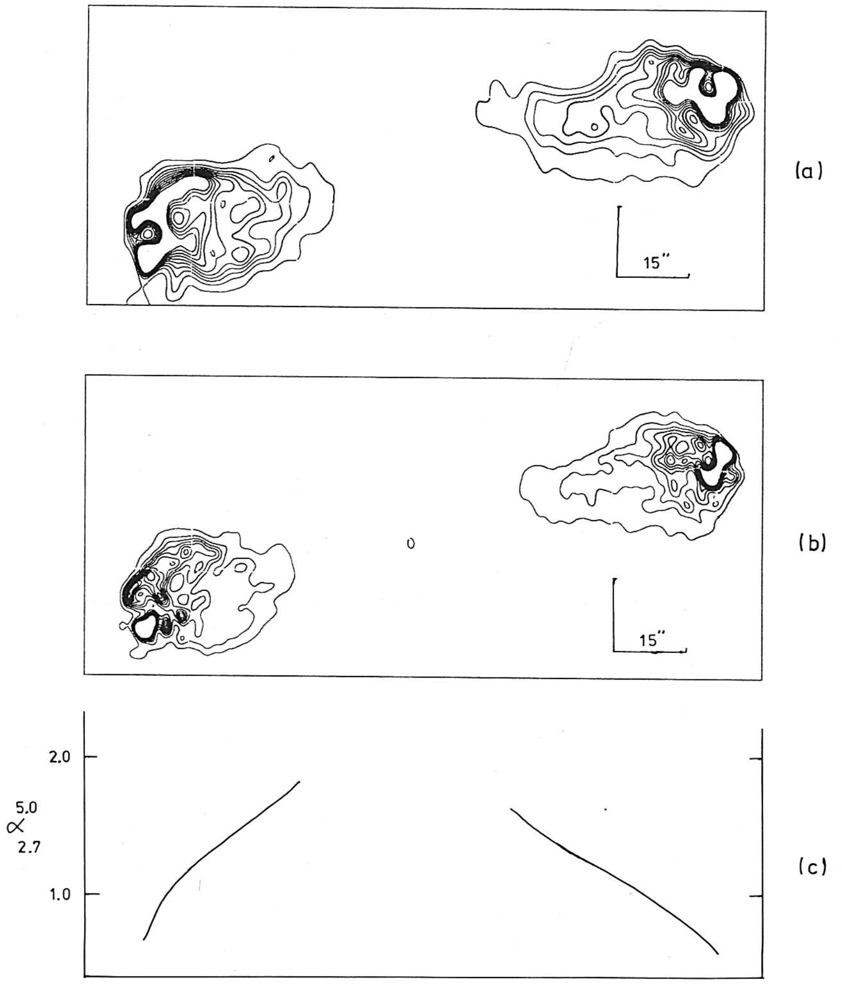

Figure 1. (a) and (b). Total intensity maps of Cygnus A at 2.7 GHz and 5 GHz. The lowest contour is at 44 mJy arcsec^{-2} and the contour interval 88 mJy arcsec $^{-2}$. (c) The variation of spectral index along the source axis.

been analysed by a two-stage maximum-entropy (ME) technique. At first ME map was used to re-determine values for the mean phase and x-y coordinates of the 8 telescopes for each 12-hour observation. A new ME map was then made incorporating these corrections. Tests on artificially perturbed data showed that this process rapidly converges to the original (i.e. 'correct') values. Two iterations were made on the 5 GHz data and one at 2.7 GHz. The resulting maps of total intensity are shown in

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Fig. 1 (a) and (b), the first contour being at 44 mJy arcsec^{-2} and the contour interval 88 mJy arcsec^{-2} on each map. The central component has flux densities of 0.82±0.15 Jy and 0.89±0.10 Jy at 2.7 and 5 GHz respectively. These values do not differ significantly from those obtained in previous observations (at 2.7 GHz in 1976 and at 5 GHz in 1973) and do not confirm the variation found using the RATAN 600 telescope over a similar period (Soboleva 1981).

For spectral index comparison the ME maps have each been convolved to a resolution of 4 x 6 arcsec. The variation of spectral index along the major axis of the source, on the same scale as the contour maps, is shown in Fig. 1 (c). Both components show the trend of spectral index found in previous observations but there is a pronounced difference between the rate of variation in the two components, the S_f component having a more rapid steepening away from the hotspot. In addition the N_p component has a marked curvature away from the source axis which is even more obvious in the lower contours of the 2.7 GHz map, the emission near the central component lying at an angle of $\sim 45^o$ to the line of the hotspots. The source asymmetries could be the result of a higher value of magnetic field in the S_f component which may be related to the much higher rotation measure found for this component (Mitton 1973). This would explain the more rapid steepening of spectral index and, because of the lower energy density in the N_p component, make this component more susceptible to distortion. Since the energy density in the extended region of this component is comparable with that in the gas which gives rise to the extended X-ray emission (Fabbioni et al. 1979) this distortion could be due to bouyancy effects.

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