0.6 GHz mapping of extended radio galaxies. II. Edge-darkened double sources

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Summary. — Radio observations made with the Westerbork telescope at 0.6 GHz are presented for 8 edge-darkened double sources: NGC315, NGC326, 3C31, 3C130, B0915 + 320, HB13, NGC6251 and 3C449. Previously observed Westerbork data at 1.4 GHz are convolved for comparison with the 0.6 GHz observational data. Besides maps of the total intensity and linear polarization structure, the distributions of the spectral index, the depolarization and the rotation of the polarization position angle between 0.6 GHz and 1.4 GHz have been derived. Integrated values for the total intensity and the polarization are also given.

Key words: galaxies: active — galaxies: radio — polarization — radio sources.

1. Introduction.

This is the second of a series of papers describing 0.6 GHz observations with the 3 km Westerbork Synthesis Radio Telescope (WSRT) of a sample of 30 extended extragalactic radio sources. Additional convolved 1.4 GHz observations obtained previously with the 1.5 km WSRT are also included, to enable a dual frequency comparison.

The entire sample is representative of the various morphological types found among galaxies (e.g. Miley, 1980). It is limited to radio sources larger than 200 arcsec with declinations above 25°.

The first paper describes the observations of 9 edge-brightened double sources (Jägers, 1987: Paper I). The present one deals with 8 narrow edge-darkened double sources: 0055 + 300 (NGC315), 0055 + 266 (NGC326), 0104 + 321 (3C31), 0448 + 520 (3C130), 0915 + 320 (B2), 1029 + 570 (HB13), 1637 + 826 (NGC6251) and 2229 + 391 (3C449).

2. Observations and data reduction.

The 8 radio sources were observed with the 3 km WSRT at a frequency of 608.5 MHz. The calibration and reduction of the observational data have been described in paper I. The parameters of these 0.6 GHz observations are listed in Table I.

Column 1: the source name.
Column 2: an alternative source name.
Column 3, 4: the centre of the observed field in equatorial coordinates (1950.0). The diameter of the primary beam (FWHM) at 0.6 GHz is 1.4 degrees.
Column 5, 6: the centre of the observed field in galactic coordinates.
Column 7: the date of observation. Every line represents an observation of 1 × 12 h.
Column 8: the receivers used. The sensitivity of the receivers was improved at the end of 1981. The «old» receivers had a system noise temperature of about 350 K compared with a system noise temperature of about 100 K for the «new» receivers. The frequency of the observations is 608.5 MHz with a bandwidth of 2.5 MHz. NGC315 was observed on 82 055 in the «Line mode» with 8 channels with a frequency separation of 0.3125 MHz. The central frequency was 608.5 MHz.
Column 9, 10, 11: the interferometer configuration including: shortest baseline — increment — longest baseline for the 1 or 2 × 12 h observation.
Column 12: the halfpower width of the synthesized beam.
Column 13, 14: the RMS noise and the confusion level in the total intensity map.

One of the reasons for observing the radio sources at 0.6 GHz was to make a comparison with 1.4 GHz data. For 7 of the 8 sources 1.4 GHz observations made with the 1.5 km WSRT were available. No. 1.4 GHz WSRT observations were available for NGC6251. The remaining 7 sources were observed at least 12 hours except for...
NGC326 and B0915 + 320 for which only «short cut» observations are available (5 × 15 minutes and 4 × 12 minutes respectively). Because of its large size NGC315 had been observed in two separate fields, the East and the West lobes respectively. Both fields were combined after the data reduction. Relevant parameters of the 1.4 GHz observations are listed in table II.  
Column 1: the source name.  
Column 2: an alternative source name.  
Column 3, 4: the exact frequency and bandwidth of the 1.4 GHz observation.  
Column 5: the year of observation.  
Column 6, 7: the RMS noise and the confusion level in the total intensity maps, determined from the convolved maps.  
Column 8: notes on the references corresponding to the 1.4 GHz full resolution maps. See the notes to table II. 3C449 was reobserved in 1976. Older observations were published by Högbom and Carlsson in 1974.  
To make a satisfactory comparison between the intensity maps at the two different frequencies as described in paper I the 1.4 GHz observations were reduced again to obtain an effective resolution equal to that of the 0.6 GHz observations. The UV coverages (in wavelengths) at both frequencies were equalized as well as possible. The maps were restored, after cleaning, with a similar Gaussian beam.  
The resultant maps were used to compare the intensity distributions at both frequencies.

3. Results.

Figures 1 to 8 show the results.

In each case panel (a) shows a contour plot of the total intensity distribution of the radio source at 0.6 GHz. The dashed contours represent «negative» brightnesses. Superimposed on each map are the position angles of the electric vectors of the linearly polarized intensity with arbitrary lengths. An ellipse represents the half power intensity of the synthesized beam, and a cross marks the positions of the optical galaxy identified with the radio sources.  
Panel (b) shows a contour plot of the linearly polarized intensity distribution at 0.6 GHz superimposed on a two-level gray scale plot of the total intensity distribution. Panel (c) shows a gray scale plot of the distribution of percentage polarization at 0.6 GHz superimposed on a two-contour plot of the total intensity distribution. Note that for the percentage polarization the first gray values represent upper limits i.e. they indicate regions where the percentage polarization is smaller than the indicated value. Higher levels represent absolute values.

Panels (d), (e) and (f) show the same quantities as panels (a), (b) and (c) at 1.4 GHz, i.e. the total intensity distributions, the intensity of the linear polarization and the percentage polarization.

The panels (g), (h) and (i) show the distributions of the spectral index, the depolarization and the rotation of the electric vector superimposed on two-level plots of the total intensity distribution at 0.6 GHz.

Panel (j) shows plots of the spectral index variation along the radio source. The lower panel shows the integrated (parallel to the minor axis) total intensity along the major axis of the radio source at 0.6 GHz (thick line) and 1.4 GHz (thin line). The two lines have been normalized to the maximum of the 0.6 GHz curve. The upper panel shows spectral index variations. Values with uncertainties larger than 1.0 are omitted. 0 marks the position of the optical galaxy. The points in the curves are not independent as they reflect the values with a separation of one grid-point. In general each independent beam comprises 2.8 points in both dimensions.

Table III lists the integrated values for the total intensity, the percentage of linear polarization and the position angle of the electric vector at 0.6 GHz and 1.4 GHz for each source. The integrated values have been determined by summing the pixel intensities in the appropriate part of the maps and dividing by the volume in the synthesized beam. This was done for the $I$, $Q$ and $U$-maps. The values for the integrated percentage polarization and the polarization position angles have been calculated using the integrated $I$, $Q$ and $U$ values.

The uncertainties in the various quantities have been determined using the RMS noise levels and the confusion levels as given in tables I and II. As mentioned previously the integrated percentage polarization can be small even though there is locally significant polarization, leading to an uncertainty larger than the value itself. In these cases an upper limit has been given which is the sum of the value and its uncertainty. The corresponding position angles are then enclosed in brackets.

4. Notes on individual sources.

**NGC315**: VLA observations at 4885 MHz and 1465 MHz and 1.5 km WSRT observations at 610 MHz of NGC315 were presented by Bridle et al. (1979). A curved, highly polarized radio jet links the unresolved source in the galactic core to the peak of a resolved lobe northwest of the galaxy. A weaker counter jet points from the core towards the peak of a more diffuse lobe. The northern lobe curves back near the galaxy and appears to merge with an amorphous large scale emission feature extending southward from NGC315 approximately perpendicular to the jet/counter jet system. The total extent of NGC315 is more than 1.5″ (~1.7 Mpc, $H_0 = 75$ km s$^{-1}$ Mpc$^{-1}$) and it is one of the largest extragalactic radio sources known.

Willis et al. (1981) present multifrequency observations with the 1.5 km WSRT. The 3 km WSRT observations at
0.6 GHz show that NGC315 is extremely highly polarized at this low frequency, the extended lobes as well as the jets. The percentage polarization increases to more than 50% in the middle of the elongated structure and even larger at the lateral edges. There is considerable small-scale structure in the polarization distribution, and its position angle changes along the radio structure.

The distribution of spectral index, $\alpha$, in the western part of NGC315 is very irregular. Peaks in the total intensity distribution coincide with dips in the spectral index. In the eastern part of NGC315 a continuous steepening in the spectrum is visible to the end of the large peak, whereafter $\alpha$ is varying at a high value, going from south to north.

**NGC326**: The 3 km WSRT observations at 0.6 GHz had relatively low dynamic range and the map of NGC326 was distorted by a residual grating ring from a strong radio source to the South-West which could not be completely removed. NGC326 was not found to be significantly polarized at 0.6 GHz.

Ekers et al. (1978) made 1.5 km WSRT observations of NGC326 at 5 GHz and interpreted the morphology as due to the effect of a precessing central machine on the projected trajectories of two radio jets.

**3C31**: 3C31 is the prototype narrow edge-darkened double radio source. Fomalont et al. (1980) presented Very Large Array (VLA) observations at 1480 MHz and 4885 MHz showing two radio jets « emanating » from a nuclear radio component. Blandford and Icke (1978) demonstrated that the projected shape of these jets may be produced by a dynamical interaction between NGC383, the parent galaxy of 3C31 and its neighbour NGC382. Strom et al. (1983) presented a detailed multifrequency comparison of 3C31 including the 3 km WSRT observations at 0.6 GHz and the 1.5 km WSRT observations at 1.4 GHz.

The total extent of 3C31 at 0.6 GHz is $\sim$ 40 arcmin. The two unresolved components at both edges of the radio source are probably background sources.

The polarization structure is very asymmetric at both frequencies. In particular, the northern half of the radio source shows significant polarization. A lot of small scale structure is visible at 0.6 GHz towards the lateral edges.

The source is seen to extent further at 0.6 GHz than at 1.4 GHz. This is consistent with the observed general tendency for the spectral index $\alpha$ to increase towards the outer edges of the radio source.

**3C130**: Jägers and De Grijp (1985) have presented 1465 MHz VLA observations of 3C130 showing two oppositely directed jets and a nuclear radio component. The morphology of 3C130 can be well reproduced, assuming the parent galaxy of 3C130 and a nearby companion galaxy orbit around each other coupled with the effect of buoyancy due to the intracluster medium.

Van Breugel and Jägers (1982) show 1.5 km WSRT observations of 3C130 at 4.9 GHz and 0.6 GHz.

The new 3 km WSRT observations of 3C130 at 0.6 GHz reveal a remarkable polarization structure. At both sides of the two main peaks in total intensity there are peaks in the polarization intensity distribution. The centres of the peaks in total intensity are hardly polarized. The polarization structure is symmetrical with respect to the optical galaxy. The position angles of the polarization are constant along each of the four polarization components. At 1.4 GHz the polarization distribution is very asymmetric showing much more polarization in the northeastern part of the radio source than in the southwestern part. The polarization vector rotates along the northeastern part.

The distribution of spectral index between 0.6 GHz and 1.4 GHz is tilted in the northwest direction due to phase errors in the 1.4 GHz observation which are clearly visible in the plot of total intensity. As the shift apparently is in the northeast direction the distribution of the spectral index along the source may be trustworthy. It shows a clear increase in spectral index along the radio source going from the core towards the outer edges.

**B2 0915 + 320**: VLA observations at 4.9 GHz by Fomalont and Bridle (1978) of the radio source 0915 + 320 show that the extended radio structure has an almost-collinear, bifurcated distribution with the highest-brightness regions on the inner part of the radio lobes. The 0.6 GHz WSRT observations show a total extent for 0915 + 320 of $\sim$ 8 arcmin more or less symmetrical about the associated parent galaxy. The polarized intensity shows several peaks which are situated close to the edges of the peaks in total intensity. The polarization distribution shows a clear increase in percentage towards the edges of the radio source.

**HB13**: A 5 km Cambridge map of HB13 at 2695 MHz (Masson, 1979) shows a weak jet extending to the south. No visible counter jet is present. The radio source remains very narrow along its entire length. Masson suggests that the southern part of the radio source is strongly polarized and that the position angle of the polarization changes at the sharp bend.

The morphology of HB13 is very difficult to explain simply as a consequence of motion of the parent galaxy together with the effects of buoyancy. At 1.4 GHz both the northern and southern parts of HB13 are highly polarized. Locally the percentage polarization is more than 50%. In the northern part there appears to be a lot of depolarization between 0.6 GHz and 1.4 GHz. Except for a few small spots the northern part is not significantly polarized at 0.6 GHz. The southern part on the other hand is still highly polarized at 0.6 GHz with peaks of 20-30%. As Masson already pointed out the position angle of the polarization sharply change at the southern bend. Probably as a result of this, there is a dip in the
polarization distribution at the bend in the radio source. The rotation of the polarization position angles between 0.6 GHz and 1.4 GHz on both sides of the southern bend is about the same. Towards the lateral edges of HB13 the percentage polarization increases. The centre including the southern jet is weakly polarized.

The spectral index, $\alpha$, along HB13 follows a fickle distribution. Towards the centre the spectral index decreases from both sides. In the southern part $\alpha$ is $\sim 1.0$ except for a small dip at the first peak in total intensity. In the northern part $\alpha$ fluctuates but the signal to noise ratio decreases considerably. At peaks in the total intensity $\alpha$ seems to increase towards the values found for $\alpha$ in the southern part of HB13.

$\textit{NGC6251}$: The giant radio source NGC6251 has been studied by many investigators (e.g. Bridle and Perley, 1983; Saunders et al., 1981; Waggett et al., 1977). They show it to have a large double structure and a long radio jet. There is evidence (Bridle and Perley, 1983) for a weak counter jet. At a resolution of $\sim 1$ arcmin the two extended lobes are well resolved. The jet is highly polarized.

The new 3 km WSRT observations of NGC6251 at 0.6 GHz show a well resolved extended component at the northwest. There is weak evidence for the existence of the counter jet. The southeast component is hardly visible due to the high resolution, the primary beam attenuation and the confusion from non-removable grating rings produced by the northwestern part of the radio source. A few background radio sources have been removed from the map.

Not only the radio jet in NGC6251 is highly polarized, but also the extended emission with values up to 40-50%.

$\textit{3C449}$: High resolution observations of 3C449 with the VLA at 1465 MHz and 4885 MHz by Perley et al. (1979) show the presence of two highly collimated symmetrical jets on each side of an unresolved core. The jets show considerable fine scale structure and polarization. Bysetedt and Högrom (1979) presented 1.5 km WSRT observations at 1415 MHz and 4995 MHz of the radio source and used roughly the same dynamical model as Jägers and De Grijp (1985) to explain the wobbly structure of 3C449.

The 3 km WSRT observations of 3C449 at 0.6 GHz show a total extent for the radio source of more than 20 arcmin with a rather sharp outer edge at the south. Peaks in the polarization distribution at 0.6 GHz occur at the edges of the radio source and along the edges of the ridge of emission coinciding with the radio jets. To the north a polarization feature is visible similar to those seen in 3C130 at 0.6 GHz: two peaks at both edges of the narrow radio source with little polarization in between.

At 1.4 GHz 3C449 is polarized almost everywhere with locally several peaks. The percentage polarization (large scale structure) seems to increase towards the outer edges from the centre.

The depolarization along the source is rather large. The run of the spectral index, $\alpha$, shows an increase in $\alpha$ towards the outer edges from the centre, except for the peaks in the integrated emission where $\alpha$ decreases significantly.

Acknowledgements.

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References

### Table I. — Observational parameters.

<table>
<thead>
<tr>
<th>Source Name</th>
<th>Alternative Name</th>
<th>Field Centre RA(1950) DEC(1950)</th>
<th>Field Centre M S D M S</th>
<th>Observing Receiver IR Day</th>
<th>Interferometer M</th>
<th>Halfpower RMS mJy/bm</th>
<th>Confusion Level 1-map mJy/bm</th>
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<td>0055+300</td>
<td>NCG315</td>
<td>00 55 00 30 00 00</td>
<td>124.5 -32.0</td>
<td>80 264</td>
<td>old</td>
<td>36 36 2736</td>
<td>29 x 58 0.1 1.25</td>
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<td>NCG326</td>
<td>00 55 45 26 35 45</td>
<td>124.8 -36.0</td>
<td>82 025</td>
<td>new</td>
<td>36 36 2736</td>
<td>29 x 55 0.7 20.0</td>
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<td>JC311</td>
<td>01 04 24 32 00 00</td>
<td>126.8 -30.3</td>
<td>80 325</td>
<td>old</td>
<td>36 36 2736</td>
<td>29 x 55 1.1 2.5</td>
</tr>
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<td>JC130</td>
<td>04 58 00 52 00 00</td>
<td>155.4 5.1</td>
<td>82 021</td>
<td>new</td>
<td>36 36 2736</td>
<td>29 x 37 0.4 4.0</td>
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<td>B2</td>
<td>09 15 58 32 04 15</td>
<td>193.7 44.0</td>
<td>82 020</td>
<td>new</td>
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<td>29 x 55 0.4 2.0</td>
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<td>HB13</td>
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<td>153.0 51.5</td>
<td>82 029</td>
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<td>29 x 35 0.3 3.0</td>
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<td>16 37 82 82 25 00</td>
<td>115.5 31.2</td>
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<td>new</td>
<td>36 36 2736</td>
<td>29 x 29 0.4 2.5</td>
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<td>old</td>
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<td>29 x 46 0.5 5.0</td>
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<td></td>
<td>22 29 36 36 06 00</td>
<td>95.4 -15.9</td>
<td>80 265</td>
<td>new</td>
<td>36 36 2736</td>
<td>29 x 46 0.5 5.0</td>
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(a) Line mode.

### Table II. — Relevant parameters of the additional 1.4 GHz observations.

<table>
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<th>Source Name</th>
<th>Alternative Name</th>
<th>Frequency and Bandwidth MHz MHz</th>
<th>Year of Observation</th>
<th>RMS Noise Observation mJy/bm</th>
<th>Confusion Notes</th>
<th>Level 1-map mJy/bm</th>
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<td>4.3</td>
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<tr>
<td>0104+31</td>
<td>JC311</td>
<td>1415 4 1971/1972</td>
<td>0.7</td>
<td>3.0 e</td>
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<tr>
<td>0458+520</td>
<td>JC130</td>
<td>1412.625 10 1978</td>
<td>0.3</td>
<td>1.5 d</td>
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<td></td>
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<tr>
<td>0915+310</td>
<td>B2</td>
<td>1415 4 1970/1974</td>
<td>2.4</td>
<td>5.0 b</td>
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<td></td>
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<tr>
<td>1029+570</td>
<td>HB13</td>
<td>1412 10 1979</td>
<td>0.2</td>
<td>1.0 e</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1637+826</td>
<td>NCG6251</td>
<td>r</td>
<td></td>
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<td></td>
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<tr>
<td>2229+391</td>
<td>JC449</td>
<td>1415 4 1976</td>
<td>0.3</td>
<td>2.0 g</td>
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Notes to table II:

(f) no observations.

### Table III. — Integrated values.

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<th>Source Name</th>
<th>Alternative Name</th>
<th>Total Flux Density Jy</th>
<th>Percentage Polarisation %</th>
<th>Polarisation Position Angle Degrees</th>
<th>Total Flux Density Jy</th>
<th>Percentage Polarisation %</th>
<th>Polarisation Position Angle Degrees</th>
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<td>0055+300</td>
<td>NCG315</td>
<td>6.29 ± 0.20</td>
<td>1.6 ± 0.4</td>
<td>107 ± 8</td>
<td>3.09 ± 0.08</td>
<td>7.8 ± 0.6</td>
<td>109 ± 3</td>
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<td>0055+266</td>
<td>NCG326</td>
<td>3.31 ± 0.26</td>
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<td>(33 ± 60)</td>
<td>1.34 ± 0.07</td>
<td>5.4</td>
<td>(162 ± 94)</td>
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<td>0104+31</td>
<td>JC311</td>
<td>9.51 ± 0.14</td>
<td>0.9</td>
<td>(63 ± 52)</td>
<td>5.23 ± 0.17</td>
<td>3.9 ± 0.8</td>
<td>162 ± 5</td>
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<td>0458+520</td>
<td>JC130</td>
<td>6.88 ± 0.12</td>
<td>0.3</td>
<td>(121 ± 45)</td>
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<td>0.2</td>
<td>(155 ± 93)</td>
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<td>0915+310</td>
<td>B2</td>
<td>0.49 ± 0.04</td>
<td>1.6 ± 1.5</td>
<td>53 ± 26</td>
<td>0.22 ± 0.10</td>
<td>29.2</td>
<td>(140 ± 87)</td>
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<td>1029+570</td>
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<td>1.09 ± 0.10</td>
<td>4.9 ± 1.5</td>
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<td>NCG6251</td>
<td>5.00 ± 0.22</td>
<td>6.0 ± 0.8</td>
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<td>30 ± 5</td>
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<td>2229+391</td>
<td>JC449</td>
<td>5.84 ± 0.20</td>
<td>0.4</td>
<td>(40 ± 200)</td>
<td>3.18 ± 0.08</td>
<td>2.4 ± 0.4</td>
<td>30 ± 5</td>
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Figure 1. 

(a) The total intensity distribution of NGC315 at 0.6 GHz. The contour levels are –2.5, 1.25, 2.5, 5, 10, 20, 40, 80, 160, 320 and 640 mJy/beam. (b) The linearly polarized intensity distribution of NGC315 at 0.6 GHz. The contour levels are 1, 2, 4, 8 and 16 mJy/beam.
Figure 1. — (c) The distribution of the percentage polarization of NGC315 at 0.6 GHz. The two levels in the total intensity contour map are 1.25 and 10 mJy/beam. (d) The total intensity distribution of NGC315 at 1.4 GHz. The contour levels are -2, 1, 2, 4, 8, 16, 32, 64, 128, 256 and 512 mJy/beam.
FIGURE 1. — (c) The linearly polarized intensity distribution of NGC315 at 1.4 GHz. The contour levels are 0.75, 1.5, 3, 6 and 12 mJy/beam. (f) The distribution of the percentage polarization of NGC315 at 1.4 GHz. The two levels in the total intensity contour map are 1 and 8 mJy/beam.
Figure 1. — (g) The distribution of the spectral index of NGC315 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 1.25 and 10 mJy/beam. (h) The distribution of the depolarization of NGC315 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 1.25 and 10 mJy/beam.
Figure 1. — (i) The distribution of the rotation of the polarization position angle of NGC315 between 0.6 GHz and 1.4 GHz measured from North towards the East. The two levels in the total intensity contour map at 0.6 GHz are 1.25 and 10 mJy/beam. (j) The spectral index variations along the major axis of NGC315 between 0.6 GHz and 1.4 GHz. The lower panel shows the (integrated) total intensity along the radio source at 0.6 GHz (thick line) and at 1.4 GHz (thin line). The upper panel shows the variations of the spectral index along the radio source.
FIGURE 2. — (a) The total intensity distribution of NGC326 at 0.6 GHz. The contour levels are −20, 20, 40, 80, 120, 160, 240, 320, 480 and 640 mJy/beam. (b) The linearly polarized intensity distribution of NGC326 at 0.6 GHz. The contour levels are 1, 1.5 and 2 mJy/beam. (c) The distribution of the percentage polarization of NGC326 at 0.6 GHz. The two levels in the total intensity contour map are 40 and 240 mJy/beam. (d) The total intensity distribution of NGC326 at 1.4 GHz. The contour levels are −5, 5, 10, 20, 40, 80, 120, 160, 240 and 320 mJy/beam. (e) The linearly polarized intensity distribution of NGC326 at 1.4 GHz. The contour levels are 2.5, 5, 7.5 and 10 mJy/beam. (f) The distribution of the percentage polarization of NGC326 at 1.4 GHz. The two levels in the total intensity contour map are 10 and 120 mJy/beam.
FIGURE 3(a). — The total intensity distribution of 3C31 at 0.6 GHz. The contour levels are −5, 2.5, 5, 10, 20, 40, 80, 160, 320 and 640 mJy/beam.

FIGURE 3(b). — The linearly polarized intensity distribution of 3C31 at 0.6 GHz. The contour levels are 2.5, 5 and 10 mJy/beam.
Figure 3(c). — The distribution of the percentage polarization of 3C31 at 0.6 GHz. The two levels in the total intensity contour map are 5 and 80 mJy/beam.

Figure 3(d). — The total intensity distribution of 3C31 at 1.4 GHz. The contour levels are – 6, 3, 6, 12, 24, 48, 96, 192 and 384 mJy/beam.
Figure 3(e). — The linearly polarized intensity distribution of 3C31 at 1.4 GHz. The contour levels are 2.5, 5, 10 and 20 mJy/beam.

Figure 3(f). — The distribution of the percentage polarization of 3C31 at 1.4 GHz. The two levels in the total intensity contour map are 6 and 96 mJy/beam.
0.6 GHz MAPPING OF EXTENDED RADIO GALAXIES

Figure 3(g). — The distribution of the spectral of 3C31 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 5 and 80 mJy/beam.

Figure 3(h). — The distribution of the depolarization of 3C31 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 5 and 80 mJy/beam.
Figure 3(i). — The distribution of the rotation of the polarization position angle of 3C31 between 0.6 GHz and 1.4 GHz measured from the North towards the East. The two levels in the total intensity contour map at 0.6 GHz are 5 and 80 mJy/beam.

Figure 3(j). — The spectral index variations along the major axis of 3C31 between 0.6 GHz and 1.4 GHz. The lower panel shows the (integrated) total intensity along the radio source at 0.6 GHz (thick line) and at 1.4 GHz (thin line). The upper panel shows the variations of the spectral index along the radio source.
Figure 4.—(a) The total intensity distribution of 3C130 at 0.6 GHz. The contour levels are $-4, 4, 8, 16, 32, 64, 128, 256, 384, 512$ and 768 mJy/beam. (b) The linearly polarized intensity distribution of 3C130 at 0.6 GHz. The contour levels are $1.5, 2, 2.5, 3, 3.5$ and 4 mJy/beam. (c) The distribution of the percentage polarization of 3C130 at 0.6 GHz. The two levels in the total intensity contour map are 16 and 256 mJy/beam. (d) The total intensity distribution of 3C130 at 1.4 GHz. The contour levels are $-1.5, 1.5, 3, 6, 12, 24, 48, 96, 192$ and 384 mJy/beam.
Figure 4. — (e) The linearly polarized intensity distribution of 3C130 at 1.4 GHz. The contour levels are 0.75, 1.5, 3 and 6 mJy/beam. (f) The distribution of the percentage polarization of 3C130 at 1.4 GHz. The two levels in the total intensity contour map are 6 and 96 mJy/beam. (g) The distribution of the spectral index of 3C130 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 16 and 156 mJy/beam. (h) The distribution of the depolarization of 3C130 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 16 and 256 mJy/beam.
FIGURE 4. — (i) The distribution of the rotation of the polarization position angle of 3C130 between 0.6 GHz and 1.4 GHz measured from the North towards the East. The two levels in the total intensity contour map at 0.6 GHz are 16 and 256 mJy/beam.

(j) The spectral index variations along the major axis of 3C130 between 0.6 GHz and 1.4 GHz. The lower panel shows the (integrated) total intensity along the radio source at 0.6 GHz (thick line) and at 1.4 GHz (thin line). The upper panel shows the variations of the spectral index along the radio source.
FIGURE 5(a). — The total intensity distribution of B0915 + 320 at 0.6 GHz. The contour levels are – 2, 2, 4, 8, 16, 32, 64 and 128 mJy/beam.

FIGURE 5(b). — The linearly polarized intensity distribution of B0915 + 320 at 0.6 GHz. The contour levels are 0.75, 1.5, 2.25, 3, 3.75 and 4.5 mJy/beam.
0.6 GHz MAPPING OF EXTENDED RADIO GALAXIES

**Figure 5(c).** The distribution of the percentage polarization of B0915 + 320 at 0.6 GHz. The two levels in the total intensity contour map are 4 and 32 mJy/beam.

**Figure 5(d).** The total intensity distribution of B0915 + 320 at 1.4 GHz. The contour levels are -5, 5, 10, 20, 40 and 60 mJy/beam.
Figure 5(e). — The linearly polarized intensity distribution of B0915 + 320 at 1.4 GHz. The contour levels are 2, 3, 4, 5 and 6 mJy/beam.

Figure 5(f). — The distribution of the percentage polarization of B0915 + 320 at 1.4 GHz. The two levels in the total intensity contour map are 10 and 40 mJy/beam.
FIGURE 6(a). — The total intensity distribution of HB13 at 0.6 GHz. The contour levels are – 3, 3, 6, 12, 18, 24, 36, 48, 72 and 96 mJy/beam.

FIGURE 6(b). — The linearly polarized intensity distribution of HB13 at 0.6 GHz. The contour levels are 1, 2, 4 and 8 mJy/beam.
FIGURE 6(c). — The distribution of the percentage polarization of HB13 at 0.6 GHz. The two levels in the total intensity contour map are 6 and 24 mJy/beam.

FIGURE 6(d). — The total intensity distribution of HB13 at 1.4 GHz. The contour levels are -1, 1, 2, 4, 8, 16 and 32 mJy/beam.
Figure 6(e). — The linearly polarized intensity distribution of HB13 at 1.4 GHz. The contour levels are 0.5, 1, 2 and 4 mJy/beam.

Figure 6(f). — The distribution of the percentage polarization of HB13 at 1.4 GHz. The two levels in the total intensity contour map are 2 and 8 mJy/beam.
FIGURE 6(g). — The distribution of the spectral index of HB13 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 6 and 24 mJy/beam.

FIGURE 6(h). — The distribution of the depolarization of HB13 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 6 and 24 mJy/beam.
Figure 6(i). — The distribution of the rotation of the polarization position angle of HB13 between 0.6 GHz and 1.4 GHz measured from the North towards the East. The two levels in the total intensity contour map at 0.6 GHz are 6 and 24 mJy/beam.

Figure 6(j). — The spectral index variations along the major axis of HB13 between 0.6 GHz and 1.4 GHz. The lower panel shows the (integrated) total intensity along the radio source at 0.6 GHz (thick line) and at 1.4 GHz (thin line). The upper panel shows the variations of the spectral index along the radio source.
Figure 7. — (a) The total intensity distribution of NGC6251 at 0.6 GHz. The contour levels are 5, 2.5, 5, 10, 20, 40, 80, 160 and 320 mJy/beam. (b) The linearly polarized intensity distribution of NGC6251 at 0.6 GHz. The contour levels are 1.25, 2.5, 5, 10 and 20 mJy/beam. (c) The distribution of the percentage polarization of NGC6251 at 0.6 GHz. The two levels in the total intensity contour map are 5 and 20 mJy/beam.
FIGURE 7 (continued).
FIGURE 8(a). — The total intensity distribution of 3C449 at 0.6 GHz. The contour levels are \(-5, 5, 10, 20, 40, 80, 160, 320\) and \(640\) mJy/beam.

FIGURE 8(b). — The linearly polarized intensity distribution of 3C449 at 0.6 GHz. The contour levels are \(1, 1.5, 2, 2.5, 3\) and \(3.5\) mJy/beam.
Figure 8(c). — The distribution of the percentage polarization of 3C449 at 0.6 GHz. The two levels in the total intensity contour map are 10 and 80 mJy/beam.

Figure 8(d). — The total intensity distribution of 3C449 at 1.4 GHz. The contour levels are 2, 2, 4, 8, 16, 32, 64, 128 and 256 mJy/beam.
The linearly polarized intensity distribution of 3C449 at 1.4 GHz. The contour levels are 1.25, 2.5, 5, 10, 20 and 40 mJy/beam.

The distribution of the percentage polarization of 3C449 at 1.4 GHz. The two levels in the total intensity contour map are 4 and 32 mJy/beam.
Figure 8(g). — The distribution of the spectral index of 3C449 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 10 and 80 mJy/beam.

Figure 8(h). — The distribution of the depolarization of 3C449 between 0.6 GHz and 1.4 GHz. The two levels in the total intensity contour map at 0.6 GHz are 10 and 80 mJy/beam.
Figure 8(i). — The distribution of the rotation of the polarization position angle of 3C449 between 0.6 GHz and 1.4 GHz measured from the North towards the East. The two levels in the total intensity contour map at 0.6 GHz are 10 and 80 mJy/beam.

Figure 8(j). — The spectral index variations along the major axis of 3C449 between 0.6 GHz and 1.4 GHz. The lower panel shows the (integrated) total intensity along the radio source at 0.6 GHz (thick line) and at 1.4 GHz (thin line). The upper panel shows the variations of the spectral index along the radio source.