PAPER 60

THE STRUCTURE OF THE CASSIOPEIA *A* AND CYGNUS *A* RADIO SOURCES MEASURED AT 127 MC/S AND 3000 MC/S

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1. 127-MC/S MEASUREMENTS WITH PHASE SENSITIVE INTERFEROMETER (JENNISON AND LATHAM)

The brightness distribution across the Cassiopeia A source in position angle 90 degrees consists of a primary region of emission 4.1 minutes of arc in width, with a much fainter extension offset from the main region of emission and having a brightness of only 10 per cent of that of the main component. Measurements were made up to the third maximum of the transform (2160 λ), and the position of the first zero was determined at 840 λ.

The observed amplitude of the visibility function is plotted in Fig. 1, in which the vertical lines represent the errors associated with each point. The phase of the visibility function is plotted in Fig. 2. From this function it is clear that the points at 1540 λ and 2150 λ lie in the second and third maxima. The shaded portion in Fig. 2 encloses the range of brightness distributions lying between the two illustrated in Fig. 4. Fig. 3 shows the residual to the phase function after subtracting the major symmetrical component; the asymmetry apparent in the neighborhood of 500 λ is seen to coincide with a depression in the amplitude function (Fig. 1). The depression is caused by a

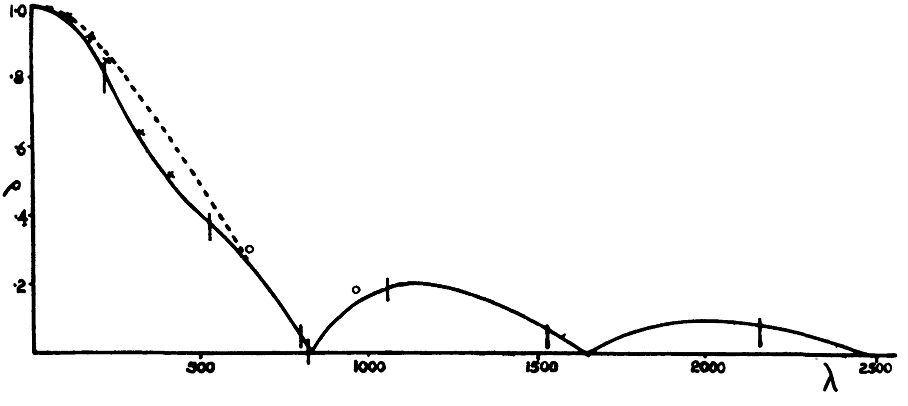

FIG. 1. Cassiopeia A, amplitude of the visibility function at 127 Mc/s in position angle 90°. The vertical lines represent the readings taken in 1956 with the phase sensitive interferometer. The circles are readings by Jennison and Das Gupta and the crosses are readings by Smith.

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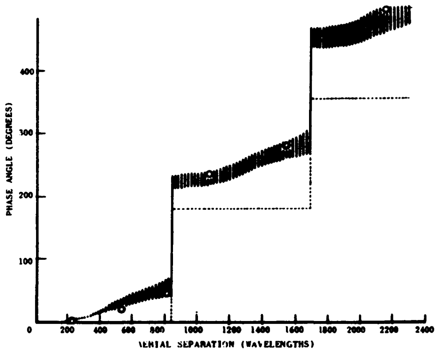

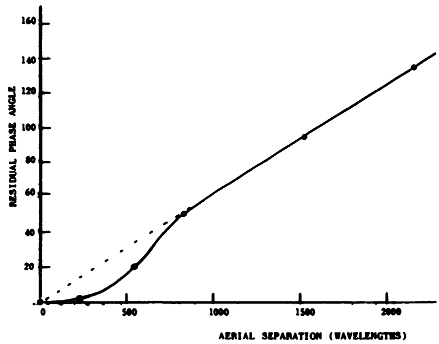

FIG. 2 (*left*). Cassiopeia A, phase of the visibility function at 127 Mc/s, position angle 90°, epoch 1956. The shaded area is contained between the transformations of the two distributions shown in Fig. 4. The dotted line represents the phase of a symmetrical source.

FIG. 3 (*right*). Cassiopeia A, residual phase after subtraction of major component.

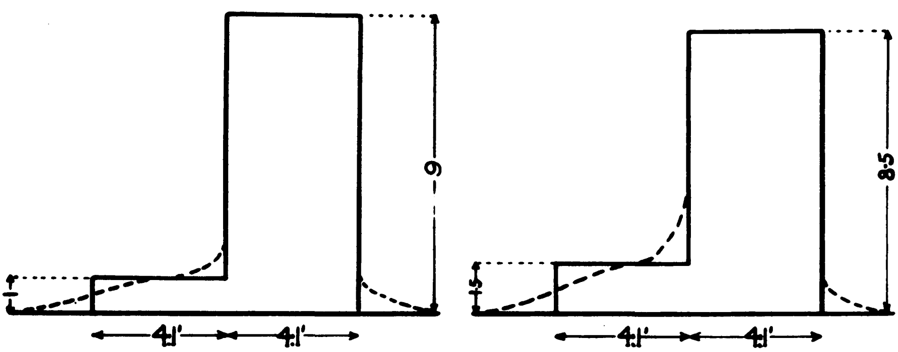

FIG. 4. Cassiopeia A, limiting brightness distributions at 127 Mc/s in position angle 90°.

faint extension of the radio emission observed as a projection into position angle 90 degrees.

The brightness distribution across Cygnus A in position angle 90 degrees consists of two intense sources of almost equal brightness. The closest fit to the transform within the errors of the present measurements is given by a source consisting of two objects whose brightnesses differ by 20 per cent, separated by 82 seconds of arc in position angle 97 degrees. The brighter component, designated the α component, leads in right ascension. The position of the major axis was determined in a separate series of experiments on the same frequency. The observed amplitude of the visibility function in position angle 90 degrees is plotted in Fig. 5 and the phase is plotted in Fig. 6. Both models of the brightness distribution shown in Fig. 7 satisfy the experimental points, and it is not possible within the present range of measurements to differentiate between them. The ordinates in Fig. 7 are arbitrary units of brightness, they do not refer to the source diameter in the direction

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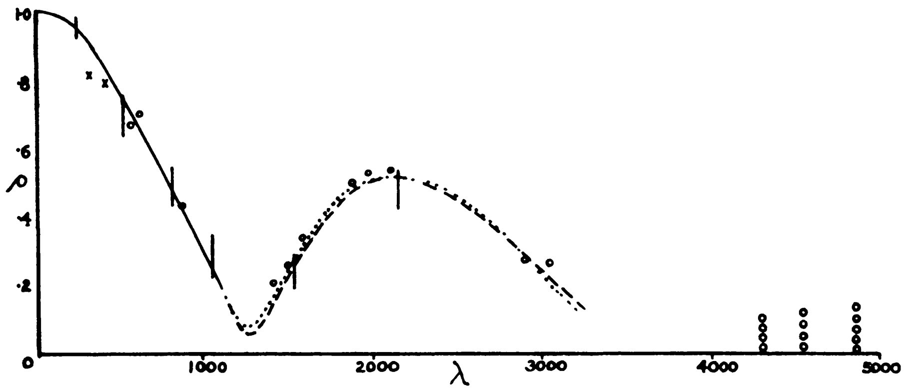

FIG. 5. Cygnus A, amplitude of visibility function at 127 Mc/s in position angle 90°. The vertical lines represent readings taken with the phase sensitive interferometer. The crosses are readings by Smith and the circles are readings by Jennison and Das Gupta, the readings between 4000 and 5000 wavelengths were zero in the latter measurements of the function ρ^2, on conversion to ρ the errors are as shown. The two curves refer to the alternative brightness distributions in Fig. 7.

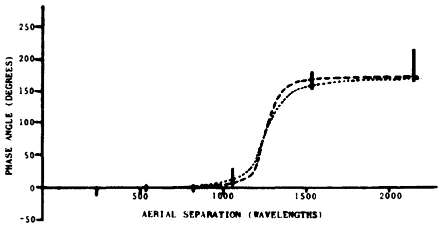

FIG. 6. Cygnus A, phase of the visibility function at 127 Mc/s, in position angle 90°. The vertical lines refer to the observed readings whilst the two curves correspond to the two distributions in Fig. 7.

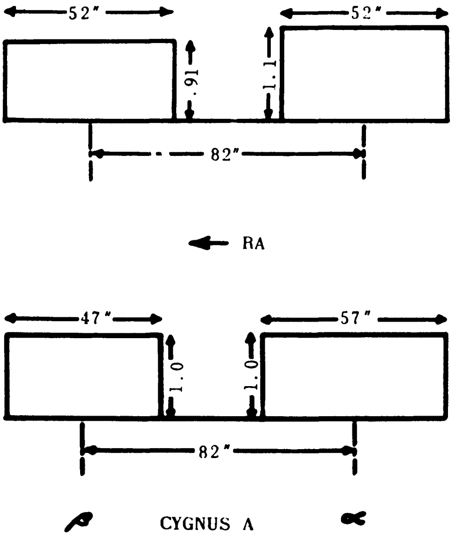

FIG. 7. Cygnus A, alternative primary brightness distributions at 127 Mc/s in position angle 90°.

of the minor axis. Previous measurement of the angular diameter in position angle 177 degrees by Jennison and Das Gupta [1, 2] indicates that along the minor axis the diameter is less than 30 seconds of arc. Fig. 8 shows the fringe-amplitude variation (corrected for aerial pattern) against time relative to the transit of the source, which is observed with an interferometer system having an approximate N-S baseline. The major axis of the source appears to lie in position angle 97 degrees.

A description of the phase-sensitive interferometer and the details of the method have been given by Jennison [3]. A brief description was given

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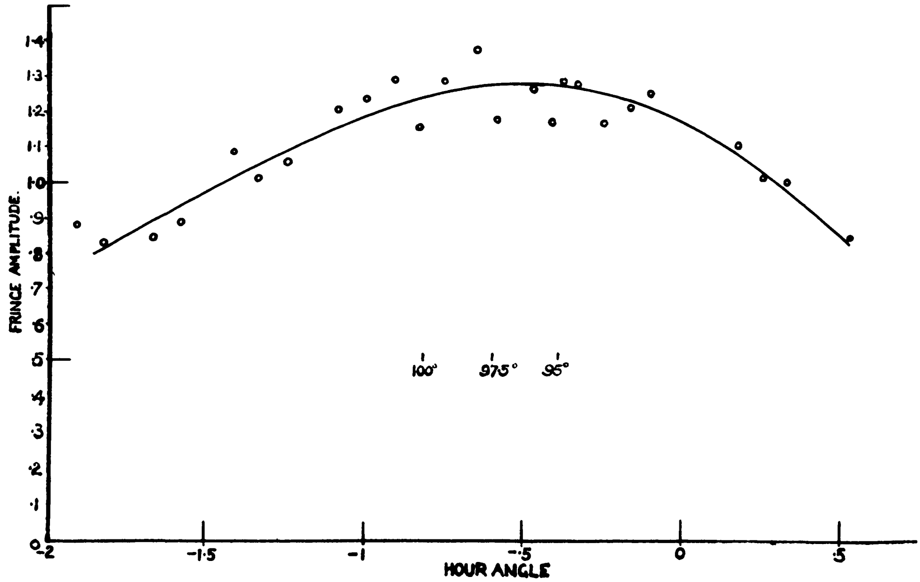

FIG. 8. Cygnus A, 127 Mc/s. Variation of fringe visibility with position of source for the determination of the position angle of the major axis. Azimuth of the baseline of the interferometer 177°. The scale in the center of the diagram gives the position angle corresponding to the maximum fringe visibility.

at the Jodrell Bank symposium [4], though it contains a slight typographical error; *for* "the sum of the patterns AB and AC" *read* "sum of the patterns AB and BC."

2. 3000 MC/S MEASUREMENTS (ROWSON)

The brightness distribution across Cassiopeia has been measured in both 0- and 90-degree position angles. Measurements in both directions were made up to the region of the second maximum of the transform. Within the error of the measurements, the distribution was uniform over a disk of angular diameter 4.4 minutes of arc.

The apparatus used in these measurements was not phase-sensitive and only the amplitude of the visibility function was recorded; the functions for the E-W and N-S baselines are shown in Figs. 9 and 10, respectively.

The major axis of the Cygnus source was determined by a method similar to the one at 127 Mc/s, but separate measurements were made on three baselines differing slightly in both azimuth and length. The three sets of readings are plotted separately in Fig. 11, in which the left-hand peak in each case lines up to give the same reading for the minor axis. The right-hand peak is caused by the resolution of the double structure along the major axis. The measurements indicate that on a 10-cm wavelength the major axis lies in position angle 109 degrees.

The brightness distribution across Cygnus A was measured in the positions of both the major and the minor axes. The source was not completely resolved in the direction of the minor axis even at the maximum baseline of

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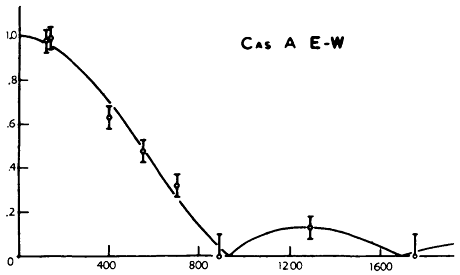
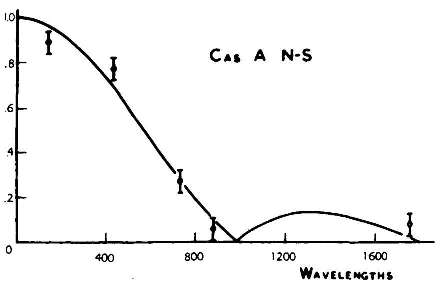




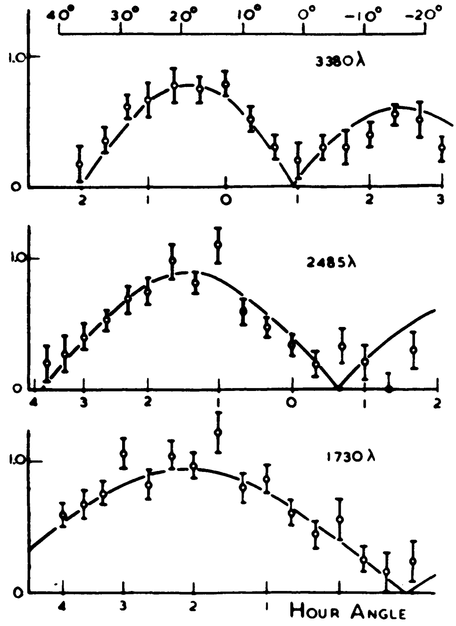
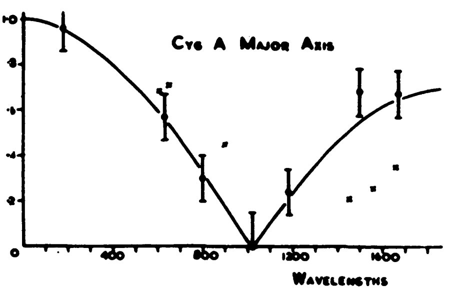


FIG. 9 (*above left*). Cassiopeia A, 3000 Mc/s, amplitude of visibility function east-west, epoch 1957–58.

FIG. 10 (*below left*). Cassiopeia A, 3000 Mc/s, amplitude of visibility function north-south.

FIG. 11 (*right*). Cygnus A, 3000 Mc/s, determination of axis, similar to Fig. 8 (127 Mc/s), but measurements are here shown on three baselines of differing length and azimuth. The scale at the top gives the position angle of the minor axis from the position of the left-hand maximum.



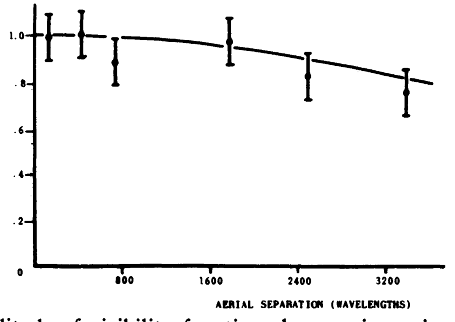


FIG. 12 (*left*). Cygnus A, 3000 Mc/s, amplitude of visibility function along major axis. The crosses are readings from the paper by Jennison and Das Gupta.

FIG. 13 (*right*). Cygnus A, 3000 Mc/s, amplitude of visibility function along minor axis.

3400 λ though the measurements indicated that in this direction the diameter of the source was probably of the order of 20 seconds of arc. The brightness distribution of the source in the position of the major axis is consistent with two centers of emission of a size similar to the emitting regions at meter wavelengths but spaced apart by 1′41″ between their centers. The visibility functions (amplitude only) along the major and minor axes are plotted in Figs. 12 and 13, respectively.

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3. COMPARISON OF THE BRIGHTNESS DISTRIBUTIONS

A comparison of the brightness distributions of the two sources at 127 Mc/s and 3000 Mc/s shows that the diameter of the Cassiopeia source appears to be comparable within the limits of error at the two frequencies. The axis of Cygnus source appears to be slightly rotated while its components are slightly further separated and more condensed at 3000 Mc/s than at the lower frequency.

REFERENCES

[1] Jennison, R. C., and Das Gupta, M. K. *Nature*, **172**, 996, 1953.
[2] Jennison, R. C., and Das Gupta, M. K. *Phil. Mag.* **1** (Ser. 8), 55, 1956.
[3] Jennison, R. C. *M.N.R.A.S.* **111**, 1958.
[4] Jennison, R. C. *Radio Astronomy* (I.A.U. Symposium No. 4, 1955). Cambridge, England, 1957, p. 159.

Discussion

Laffineur: I have studied the two sources Cassiopeia A and Cygnus A at the Observatoire de Haute-Provence (France), using a radio-linked two-element interferometer. The frequency was 300 Mc/s and the spacing 1090 wavelengths. Cygnus A gave much less amplitude on the record than I expected, being 0.8 that of Cassiopeia A, in disagreement with a publication of R. G. Conway dated December 1956. From the communication of R. C. Jennison I can see that my observations made in collaboration with Pierre Coupiac are in much better accordance with the new scheme of the two sources.

Bracewell: The coherence of the radiation field of a discrete source is fully specified by measurements at pairs of points spaced at certain discrete intervals (*Proc. I. R. E.* **46**, 97, 1958). In the case of a source 134 seconds in maximum extent this spacing is 1500 wavelengths. Since the interferometer spacings extended to little more than 3000 wavelengths, only three or four independent measurements of complex fringe visibility were in fact made in the direction of maximum extent, and about six independent measurements were made in all; hence there is considerable freedom in matching the data by model distributions and, in particular, the sharp boundaries and empty central space would not be implied by the data.

Jennison: The slide did not show all the readings used. In the actual analysis the readings taken with a post-detector interferometer to about 5000 wavelengths were also used. A large number of models were constructed which embraced the entire errors of the measurement. They did not differ radically and though there may be some filling of the central region, this cannot be greater than about 10 per cent of the brightness of the major components. The two models shown on the slide were selected as the two that most closely fitted the observations, and though they cannot show fine structure within the major components, they reliably indicate the general pattern of the radio brightness of the source.

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