THE TWO COMPONENTS OF THE RADIO SOURCE W 49*

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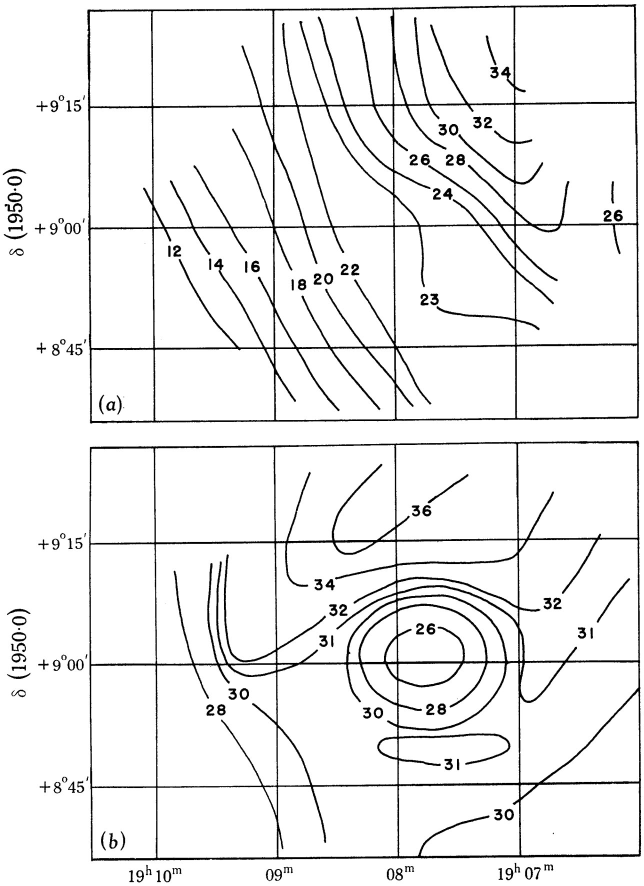
The radio source W 49 (3C 398), originally observed by Westerhout (1958), has two components. Pauliny-Toth and Wade concluded that component A has a thermal



Figs. 1(a) and 1(b).—Equal-velocity contour diagrams. Unit = 1·4 degK in T_a (1·75 degK in T_b). (a) V_r = −5·5 km/sec, (b) V_r = +1·5.

spectrum, but component B is nonthermal (Baars and Mezger 1966). Gol'nev, Lipovka, and Pariiskii (1966) suggested that the nonthermal component has a relatively flat

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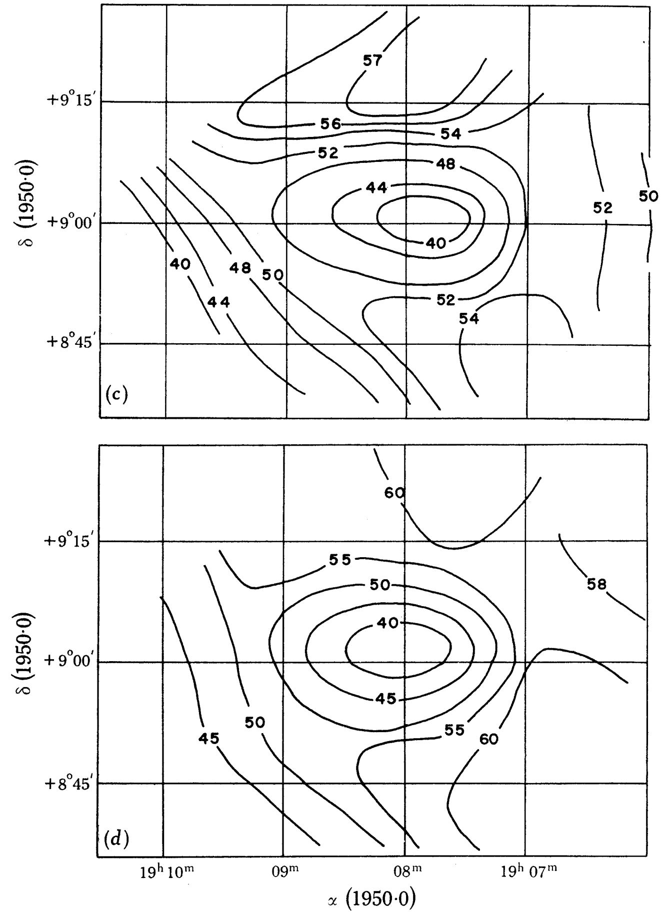
spectrum with a spectral index of less than 0·5. From observations of 21 cm hydrogen-line absorption Akabane and Kerr (1965) derived a distance of about 15 kpc (for a Sun–centre distance of 10 kpc). Their track of observations was along the galactic equator, and this distance must therefore refer to the thermal component A. So far, the distance of component B has not been directly estimated. Here we attempt to obtain information about its distance by the same method as was used by Akabane and Kerr (1965).



Figs. 1(*c*) and 1(*d*).—Equal-velocity contour diagrams. Unit = 1·4 degK in T_a (1·75 degK in T_b). (*c*) $V_r = +8 \cdot 5$, (*d*) $V_r = +15 \cdot 5$.

Hydrogen-line profiles have been recorded with the Parkes telescope and a bandwidth of 36 kHz at 18 points around W 49, in an attempt to separate the absorption effects for the two components. However, the resolving power of the aerial, with a half-power beamwidth of 14 min of arc, is not sufficient to resolve the two components, which are about 13′ apart. As a result, the absorption troughs in the equal-velocity contour maps (Figs. 1(*a*)–(*d*)) do not show separate depressions for the two components of W 49, but some of the contours are clearly elliptical in shape.

We have used the absorption results to derive the optical depth of the 21 cm neutral hydrogen line for the two points $\alpha = 19^h08^m30^s$, $\delta = +9°03'\cdot5$ and $\alpha = 19^h09^m38^s$, $\delta = 9°03'\cdot5$ (1966·1), which are very close to the positions of components A and B, respectively. The background continuum temperatures at these two points in the absence of absorption were obtained from observations near the 21 cm line with the same telescope (Akabane 1966). At each frequency, the absorption dips at the

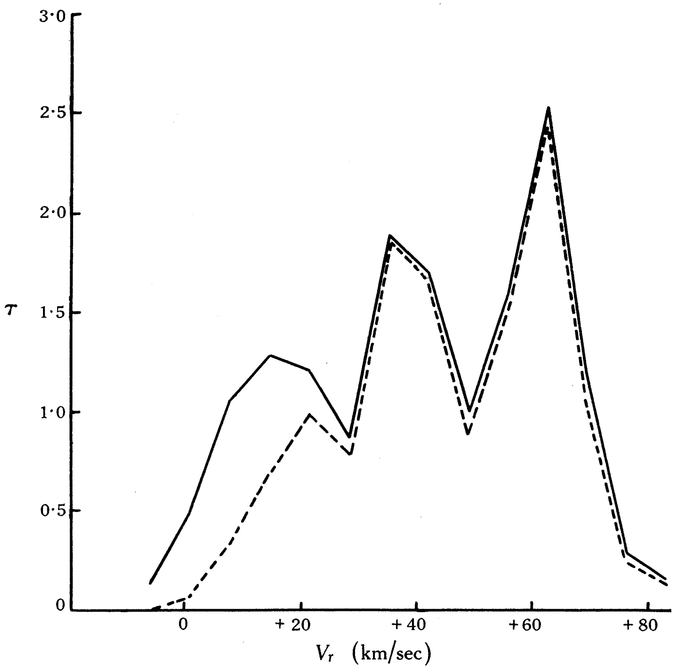


Fig. 2.—Optical depth in the directions of components A and B.
——— A: $\alpha = 19^h07^m44^s$, $\delta = 9°2'\cdot0$ (1950·0)
- - - - - B: $\alpha = 19^h08^m58^s$, $\delta = 9°2'\cdot0$.

points A and B were estimated by comparing the observed absorption profile with the "expected" emission profile, obtained in the usual manner by interpolating between profiles at surrounding points.

Figure 2 shows the optical depths for the two points A and B as a function of radial velocity. The three peaks correspond to the spiral arms of the Galaxy seen in this direction. The optical depths agree fairly well with each other for the two higher velocity peaks, but there is a distinct difference for the peak with a velocity between 0 and +20 km/sec. The reality of this difference can be seen in Figure 3, where the difference between the optical depths at points A and B is plotted against the radial velocity. The main source of error in the determination of the optical depths is the uncertainty in the expected profile. At each frequency we have examined several different possibilities for the expected profiles and have estimated the size of the error. As this type of error should be fairly similar at the two points A and B, it should be less important when the difference between the optical depths at the two points is being considered. The extent of the error thus estimated is shown as a bar on each point in Figure 3.

Further evidence of the difference between the two points can be found in the equal-velocity contour diagrams of Figure 1. Elongated contours can be seen on the 21 cm absorption contour maps for radial velocities larger than $+8\cdot5$ km/sec, while at a velocity of $+1\cdot5$ km/sec the structure is simpler, as the absorption in front of the component B has disappeared.

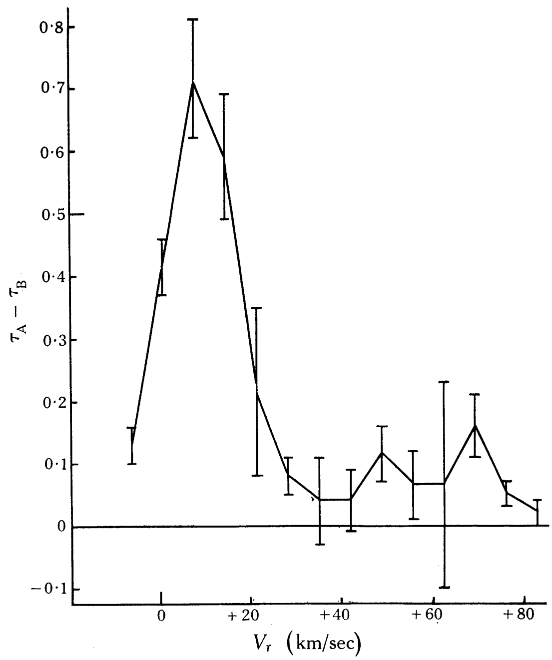


Fig 3.—The difference between the optical depths in directions A and B. The bars indicate the estimated errors arising from uncertainty in the expected profiles.

The observed difference between the apparent optical depths at the positions of A and B can be accepted as real, unless there is some improbably large difference between the hydrogen distributions along the two lines of sight, which are only 13 min of arc apart. Moreover, the observed difference between the optical depths must be a lower limit, because the two components of the source are not completely resolved in these observations and the absorption profile at the position of B (Fig. 2) must contain a contribution from the stronger component A.

The difference in optical depth can be attributed to the farthest inner arm in this direction, which is probably the continuation of the Orion arm. The fact that the difference exists over the whole range of radial velocities from zero to +20 km/sec suggests that component B is at the near edge of the arm, whereas component A is at the far side (see Fig. 4). The difference between the numbers of hydrogen atoms in the directions of A and B can be roughly estimated from the area between the two absorption profiles, if we assume that the absorbing clouds are optically thin and have the same harmonic mean temperature as the hydrogen responsible for the emission,

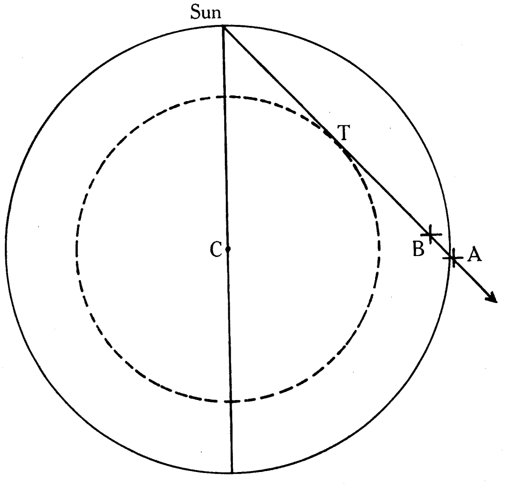


Fig. 4.—Suggested positions for the two components A and B of W 49.

about 150°. These assumptions are weak, but the calculation should give the right order of magnitude. The result obtained for the lower limit of the difference in numbers of atoms is 3×10^{21} in a 1 cm^2 column. This is a typical value for a path through a spiral arm.

From these arguments, we conclude that the source W 49 is not a physically related double source. As is shown in Figure 4, component B appears to lie nearer to us than component A by about 1 kpc.

The present observations were made by one of the authors (F.J.K.) at Parkes, and the other authors have carried out the main reduction and study of the observational results. The authors are grateful to Dr. M. Morimoto (Tokyo Astronomical Observatory) for his helpful discussion in making a model of the double source.

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