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1963

SovietRxiv

Abstract

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DISTRIBUTION OF POLARIZED RADIO EMISSION IN THE SOURCE CYGNUS A FROM OBSERVATIONS AT PULKOVO

(Presented by Academician V. A. Kotelnikov, 3 V 1963)

Recently, polarization of the radio emission of Cygnus A at centimeter wavelengths was detected ([1]). Table 1 gives the values, integrated over the source, of the percentage polarization and of the position angle of the electric vector at various wavelengths.

It follows from the table that the character of the variation of the polarized emission is close to that observed for the source Taurus A: a small rotation of the position angle and a strong decrease in the percentage polarization with increasing wavelength.

Table 1

Wavelength, cm	Integrated percentage polarization	Position angle	Source
3.02	8.8 ± 1.5	$146^\circ \pm 3^\circ$	GAO, 1963
3.15	8.0 ± 1	$145^\circ \pm 5^\circ$	([1])
	7.5	143°	([2])
3.47	7.0	141°	([4])
9.45	1.9		([4])

For a detailed study of the character of the polarization of the separate components of the source Cygnus A, in February 1963 a series of polarization measurements was carried out at a wavelength of 3.02 cm with the large Pulkovo radio telescope, which has a beam width of about 55″ in the horizontal direction at half power. A radiometer with a parametric amplifier at the input was used as the receiver. In measuring the polarization, two Stokes polarization parameters, Q and U, were recorded. The magnitude of the polarized signal is determined as $\sqrt{Q^2+U^2}$, and the position angle of the electric vector θ is determined from the condition $\operatorname{tg} 2\theta = U/Q$. The observations were carried out on the meridian. The values of the parameters, averaged over 5 records, are shown in Fig. 1. A sample record is given in Fig. 2. Figure 3 gives the magnitude of the polarized signal and the position angles in each component (b), and the record of the

Fig. 1

Figure 1: Fig. 1

source in unpolarized emission (a). It follows from Fig. 3 that the percentage polarization of the weaker western component, in antenna temperature, is about 30%, and the position angle is 142°. The percentage polarization of the eastern component is about 10%, and the position angle is 158°. Thus, the percentage polarization of the weak component is much higher than that of the strong one; in addition, the position angles θ in the two components are somewhat different.

The mean percentage polarization and position angle for the source are given in Table 1 and agree well with Mayer' s values.

Comparison of the polarization characteristics presented here with the data on the polarization of the source Centaurus A ([2,3]), which in many respects is similar to the source Cygnus A, shows that:

1. A sharp difference in the percentage polarization of the components is observed both in Cygnus A and in the central double radio source Centaurus A.
2. The position angles of the components in Cygnus A, 142° and 158°, are close to the position of the supposed rotation axis of the optical galaxy (130°), whereas in the central source of Centaurus A the opposite picture is observed. However, to determine the true orientation of the magnetic field, measurements at higher frequencies are necessary.

A comparison of our data with Mayer's data shows that the difference in position angles between 3.02, 3.15, and 3.47 cm [(4)] does not exceed 2—3°, which gives an upper limit for the value of $N_e H l$ (N_e is the electron density, H is the longitudinal component of the magnetic field, l is the path length over which the plane of polarization of the electric vector is rotated)

Fig. 1

$N_e H l = 6 \cdot 10^{14}$. If we take $l = 6 \cdot 10^{26}$, $N_e = 10^{-5}$, then for the metagalactic field we obtain 10^{-7} gauss. The estimates made for the upper limit of the rotation of the position angle in the nebula make it unlikely that the disappearance of polarization at a wavelength of 9.45 cm can be explained in a homogeneous gyrotropic medium. The latter is more likely explained by the presence of small-scale inhomogeneities in the nebula itself (or in the intergalactic medium, which seems unlikely). Finally, an entirely different reason is also not excluded: the emission regions at centimeter and decimeter wavelengths do not coincide geometrically [(5)].

For further study of the properties of the interstellar medium, as well as of the source Cygnus A itself, a detailed investigation of polarization is necessary both at wavelengths shorter than 3 cm and at intermediate wavelengths between

Fig. 2.

Figure 2: Fig. 2.

Fig. 3.

Figure 3: Fig. 3.

$\lambda = 3$ cm and $\lambda = 9$ cm.

Fig. 2

Visible labels in the figure: I, U, Q; T_A (arbitrary units); right ascensions $19^h58^m30^s$, $19^h58^m00^s$.

Fig. 3

Visible labels in the figure:
a) I; "Optical object" ; T_A (arbitrary units); right ascensions $19^h58^m30^s$, $19^h58^m00^s$.

b) $\sqrt{Q^2+U^2}$, $\mathrm{tg}\,2\theta = \dfrac{U}{Q}$; T_A; E, W; 158°, 142°; $\alpha_{1963.0}$; right ascensions $19^h58^m30^s$, $19^h58^m00^s$.

Since it has recently become clear that a substantial fraction of extragalactic radio sources has appreciable polarization, the Main Astronomical Observatory plans a detailed study of all sources accessible in terms of sensitivity. Polarization measurements are needed not only for the study of the sources, but also for determining the properties of the intergalactic medium, for which observations of the most distant objects are desirable.

The authors express their gratitude to S. E. Khaikin for his interest in the work, to A. B. Berlin for his great assistance in the observations and in setting up the apparatus, and to Yu. N. Pariiskii for participation in the observations and in discussion of the results.

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Received
3 V 1963

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