Bull. Spec. Astrophys. Obs., 1996, 40, 125–127

On observations of diffuse optical emission along the axis of double radio sources of RC catalog at the 6 m optical telescope

Yu.N. Parijskij, N.S. Soboleva, O.V. Verkhodanov, A.I. Kopylov, O.P. Zhelenkova

Special Astrophysical Observatory of the Russian AS, Nizhnij Arkhyz 357147, Russia

Received February 15, 1996; accepted May 7, 1996.

Abstract. Estimates of magnitudes of the diffuse emission in distant radio galaxies, identified with RC catalog objects, are presented. The estimates are based on the assumption that emission may be due to inverse Compton scattering of microwave background photons with relativistic electrons. The procedure of reduction of the data obtained with the 6 m telescope to isolate the diffuse emission with MIDAS operations is described. From the observational data available at present the upper limits of magnitudes and magnetic field parameters of the objects under study are estimated. It is shown that the diffuse emission for the radio galaxies with spectral indices of about 1 ($S \sim \nu^{-\alpha}$) and flux densities of about 50 mJy at 7.6 cm is expected to be brighter than 23^m in the R–filter or 26.5^m per $arcsec^2$ when the magnetic field parameter $\epsilon = 1/3$. Detection of the diffuse emission could be an additional factor to search for exactly the distant objects, and also could give information about microwave background radiation.

Key words: radio galaxies: inverse Compton scattering – observations

1. Introduction

The great number of radio sources from the RC-catalog (Parijskij et al., 1991) being currently identified optically at the 6 m telescope of SAO RAS (Kopylov et al., 1995) allow identified objects to be studied statistically. Taking into account that our sample includes only steep spectrum sources, identified with distant ($z \geq 2$) radio galaxies of FRII type, the objects under study must be of similar nature. Distant radio galaxies up to $z \sim 4$ are generally classical double radio sources, in which radio lobes and hot spots account for most of the emission. The emission line and continuum emission regions are mainly located along the radio axis (so called alignment effect), the morphology of continuum and line emission being alike.

There are two types of alignment (McCarthy, 1993; Daly, 1992b) of optical emission with the radio axis (i.e. when optically emitting regions are concentrated in a cone of 10 degrees along the radio axis): in the former case the continuum and line emission regions are extended as well as the components of a radio source (e.g., 3C 368), in the latter the optically emitted structures do not follow radio structures (e.g., 3C 68.2), despite they are located along the radio source axis and the maxima of the optical and radio emission do not coincide.

Several models have been developed to explain this alignment effect. The most popular one is "non-stellar" which is based on the inverse Compton scattering of relic photons of microwave background radiation with relativistic electrons (Daly, 1992a; 1992b), which are indicated to exist by "radio bridges" along the axis of the radio source. It is in the distant radio galaxies that inverse Compton (IC) scattering between relativistic electrons and relic photons may play an important role, because the scattered radiation depends on the microwave background energy density growing with increasing redshift. IC scattering may produce ultraviolet continuum with steep spectrum which can be a source of powerful emission lines (Daly, 1992a).

Based on the ROSAT data, some authors (Feigelson et al., 1995) provided strong evidence for the existence of IC scattering of the microwave background photons into the X–ray band by relativistic electrons in diffuse lobes of radio galaxies.

Detection of diffuse emission in the RC catalog subsample objects could be additional evidence that might prove helpful in searching for exactly the distant objects and also provide information on the microwave background radiation (Parijskij et al., 1995).

Hereafter are given estimates of apparent magnitudes of the diffuse radiation for the RC catalog ob-

Table 1: *Values ν_{14} for different wavelength ranges*

Range	UV(1-4r)	B	V	R	I	K
ν_{14}	131-133	6.8	5.5	4.3	3.3	1.4

Table 2:

α	$b(s)/a(s)$
0.7	80
1.0	160
1.5	420

jects in the suggestion of the IC scattering mechanism (Daly, 1992b).

2. Estimation of apparent magnitudes for RC catalog objects

We estimated typical flux densities for scattered radiation using the following formula (Daly, 1992b):

$$\frac{f_{IC}(\nu_{14})}{f_r(v_r)} \cong 1.6 \times 10^{-12} \epsilon^{-(1+\alpha)} \cdot (1+z)^{(}1-\alpha) \times \frac{b(s)}{a(s)} \cdot \left(\frac{7.5x10^3}{\nu_{14}} \cdot \frac{\nu_r}{178\mathrm{MHz}}\right)^{\alpha}, \quad (1)$$

where $\nu_{14} \equiv \nu/(10^{14})$ Hz, and the magnetic field is parameterized as $B_{\perp} \equiv \epsilon 3.3(1+z)^2 \mu$Gs supposing that $T_{bgd} = 2.75K$, ν_r equals 3.96 GHz (7.6 cm), z is the redshift, α is the spectral index ($S \sim \nu^{-\alpha}$). The values for ν_{14} taken from (Daly, 1992b) are presented in Table 1, while the values for $b(s)/a(s)$, $s = 2\alpha + 1$ vs α are listed in Table 2. and values $b(s)/a(s), s = 2\alpha + 1$, vs α are following (see Table 2).

Assuming that the medium spectral index for the studied RC catalog objects is about 1.0, let us estimate the expected magnitudes using formula (1). Flux densities are converted to magnitudes using the following formula (von Hoerner, 1974):

$$S = 10^{a-0.4m}$$

for $a = 3.6$.

Then we have Table 3 (next page).

3. 6 m telescope observational data

Observations of the RC catalog radio sources with the 6 m optical telescope are described in details in Kopylov et al. (1995). Now the procedures of data reduction to isolate objects of diffuse nature in the 6 m telescope frames are given.

To detect the diffuse emission we used the sc called "morphological averaging" for objects of close nature. We selected 13 objects with a separation of radio components ranging from 8″ to 60″. The stars were removed using standard procedure.

The images were converted to a common scale with normalizing them to "the largest angular size" (L.A.S) and rotating the major axis to one positional angle (the procedure of linearization with rotation in MIDAS – rebin/rotate). After that the flat component of background and noise of unresolved sources, estimated as "3 medians – 2 means", were subtracted from each frame. The frames were reduced to the dimensional represantation $X \times Y = 60 \times 120$. The step on the ordinate was equal for all images. The step on the abscissa axis was varied with initial number of points prior to the dimension conversion. Thus, the exact pixel size on the ordinate axis was 0.2″, while the mean value of the step on the abscissa totaled 0.24″.

4. Discussion

With median averaging at the level of 3σ (1σ corresponds to 31.8 mag per pixel) no excess diffuse optical emission has been detected, which suggests the absence of the emission at the level of 30.6^m per pixel or 27.3^m per square second of arc.

The absence of the predicted emission (Daly, 1992a) may be due to the weaker magnetic fields ($\epsilon = 1$), for which the expected magnitude is brighter than 28.5^m for our data. Or this may be explained by the nonuniform sample of radio galaxies.

It is contemplated that the techniques of data reduction will be improved and new observational data used. The accuracy is expcted to be improved by 1-2 magnitudes.

Advance in this kind of investigation will make it possible to asses ground based telescopes and to state that the ground based facilities are nearly comparable in sensitivity to space telescopes, because it is restricted by the galactic cirrus clouds (Guhathakurta and Tyson, 1989) with a surface brightness of about $30-31^m$ per $arcsec^2$ in the B–filter or about $29-30^m$ per $arcsec^2$ in the R–filter.

This work is supported by the grants of Russian Fundamental Research Foundation 95-02-03783 and 96-02-106597A and "Astronomy" program project 2-296.

References

Daly R.A.: 1992a, Astrophys. J., **386**, L9-L12.

Daly R.A.: 1992b, Astrophys. J., **399**, 426-443.

Feigelson E., Laurent-Muehleisen S., Kollgard R., Fomalont E.: 1995, Astrophys. J.Lett., in press.

Table 3: *Expected integral visible magnitudes in V and R for RC sources*

7.6 cm flux density, Jy	expected flux density in V-color	magnitude, V-color	expected flux density in R-color	magnitude R-color
0.05	$3.82 \cdot 10^{-7}$	25.0	$4.89 \cdot 10^{-7}$	24.8
0.1	$7.64 \cdot 10^{-7}$	24.2	$9.78 \cdot 10^{-7}$	24.0

Guhathakurta P., Tyson J.A., 1989, Astrophys. J., **346**, 773-793.

Kopylov A.I., Goss W.M., Parijskij Yu.N., Soboleva N.S., Temirova A.V., Zhelenkova O.P., Vitkovskij Val.V., Naugolnaya M.N., Verkhodanov O.V.: 1995, Astron. Zh.(Russia), **72**, 613.

McCarthy P.J.: 1993, Ann.Rev.Astrophys., **31**, 639.

Parijskij Yu.N., Bursov N.N., Lipovka N.M., Soboleva N.S., Temirova A.V.: 1991, Astron. Astrophys. Suppl. Ser., **87**, 1.

Parijskij Yu.N., Soboleva N.S., Verkhodanov O.V., Kopylov A.I., Zhelenkova O.P.: 1995, in Book of Theses of the 26th Radio astronomical conference, St.Petersburg, Institute of Apply Astronomy, 62.

Von Hoerner S.: 1974, Cosmology, in: Galactic and Extragalactic Radio Astronomy, eds.: G.L. Verschuur and K.I. Kellerman, transl. to Russian eds.: Yu.N.Parijskij and I.V.Gosachinskij, Moscow: "Mir", 1976.