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RELATIONS OF STRUCTURE COMPONENTS OF GIANT RADIO SOURCES

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ABSTRACT. Our previous estimates of physical parameters of galaxies and quasars with steep radio spectrum have showed their great radio luminosity and giant radio structure. Examination of the relations of corresponding monochromatic luminosities at different bands (from decametre to X-ray) allows estimate the comparative contribution of emission of structure components of sources. Using the sample of galaxies and quasars with steep radio spectrum from the UTR-2 catalogue we determine the contribution of emission of extensive radio lobes relatively central region, also relatively accretion disk, gas-dust torus, crown of accretion disk of given source. The particular interest has the relation of monochromatic luminosities of objects at near-infrared and X-ray bands, which corresponds to contribution of emission of gas-dust torus relatively emission of crown of accretion disk. The derived estimates of contribution of emission of components of giant sources reveal evolution effects at relations on redshift, linear size, age of examined sources.

Keywords: Galaxies – Quasars – Radio sources: giants

1. Introduction

Before (Miroshnichenko, 2012a, 2012b, 2013, 2014, 2015, 2016) we received estimates of the main physical parameters of quasars and galaxies with steep radio spectrum over the sample of sources from the UTR-2 catalogue at the decameter band. Note, that galaxies and quasars with steep low-frequency spectra have the great luminosity (by order of 10^{28} W/Hz·ster at the frequency 25 MHz) and very extended radio structure with linear size by order of 1 Mpc, and characteristic age by order of 100 million years. So, steep-spectrum radio sources are peculiar objects with giant radio structure. It is important to study relations of emission of their different structure components.

2. Examination of emission relations of structure components

It is known from the observation data, the emission of separate components of the structure of extragalactic sources, mainly, corresponds to certain frequency bands. For instance, the emission of source at low frequencies, in particular, at decametre band, characterizes the extended component of structure, radio lobes. At the same time, the emission of central part of object displays more brightly at the high radio frequencies. The emission of accretion disk of source's active nucleus is presented, mainly at the optical band. At that the X-ray emission of source is connected with crown of accretion disk. The emission of gas-dust torus surrounding accretion disk is observed at the infrared band, especially, at its near zone (near-IR). Examination of the relations of corresponding monochromatic luminosities of sources at different bands (from decametre to X-ray) allows estimate the comparative contribution of emission for structure components of sources. Note, that relation of flux densities of emission at different frequencies is identical to relation of corresponding monochromatic luminosities of a source. Also, it is important that relations of monochromatic luminosities are independent from the Universe model. Hence, these parameters allow study objectively the evolution effects for considered sources.

We consider that ratio of luminosities at 25 MHz and 5000 MHz, $lg(S_{25}/S_{5000})$, corresponds to contribution of emission of radio lobes relatively emission of the central region of source. Further, we suppose that contribution of emission of radio lobes: i) relatively of accretion disk emission – is ratio of luminosities at decameter and optical bands, $lg(S_{25}/S_{opt})$; ii) relatively of torus emission of source – is ratio of luminosities at decametre and infrared bands, $lg(S_{25}/S_{IR})$; iii) relatively of emission of accretion disk crown – is ratio of luminosities at decametre and X-ray bands, $lg(S_{25}/S_X)$. The pointed ratios are obtained for the sample of steep-spectrum sources to reveal evolution features of giant radio structures.

Earlier, we have compiled the sample of steep-spectrum sources at two fields of UTR-2 catalogue of extragalactic sources with given selection criteria (the value of spectral index at decametre band is greater than 1, the flux density of emission at frequency 25 MHz is $S_{25} > 10$ Jy (Miroshnichenko, 2012a, 2012b, 2013). Our sample contains 130 galaxies and 91 quasars, including 78 galaxies and 55 quasars with linear steep spectra (spectral type S), and 52 galaxies and 36 quasars with steepness of their low-frequency spectra after a break (spectral type C+). We consider ratios of luminosities $lg(S_{25} / S_{5000})$, $lg(S_{25} / S_{opt})$, $lg(S_{25} / S_{IR})$, $lg(S_{25} / S_X)$, $lg(S_{IR} / S_X)$, determine relationship of these parameters on redshift z, linear size R, characteristic age t. These relationships are examined in each subsample of galaxies and quasars with steep radio spectrum: G_S (galaxies with linear steep spectrum S), G_C^+ (galaxies with break steep spectrum C^+), Q_S (quasars with S spectrum), Q_C^+ (quasars with C^+ spectrum).

As it means from derived mean values of luminosity ratios for extended radio lobes, these parameters are dependent from the spectral type of sources (see Table 1).

Table 1. Mean value of luminosity ratios of different structure components of galaxies and quasars with steep radio spectra S and C^+.

		G_S	Q_S	G_{C+}	Q_{C+}
Ratio of emission of radio lobes and central region of source	<lg(S_{25}/S_{5000}>	2.19 (+-0.05)	2.08 (+-0.08)	1.74 (+-0.05)	1.69 (+-0.08)
Ratio of emission of radio lobes and accretion disk of source	<lg(S_{25}/S_{opt}>	5.64 (+-0.12)	5.33 (+-0.06)	5.15 (+-0.12)	5.00 (+-0.10)
Ratio of emission of radio lobes and torus of source	<lg(S_{25}/S_{IR}>	4.58 (+-0.17)	4.71 (+-0.14)	3.67 (+-0.19)	4.30 (+-0.11)
Ratio of emission of radio lobes and accretion disk crown of source	<lg(S_{25}/S_X>	9.03 (+-0.23)	8.45 (+-0.14)	7.89 (+-0.33)	7.78 (+-0.17)
Ratio of emission of torus and accretion disk crown of source	<lg(S_{IR}/S_X>	4.53 (+-0.36)	3.73 (+-0.18)	4.68 (+-0.47)	3.54 (+-0.20)

For example, values of ratios $<lg(S_{25}/S_{5000})>$, $<lg(S_{25}/S_{opt})>$, $<lg(S_{25}/S_{IR})>$, $<lg(S_{25}/S_X)>$ are greater for objects G_S and Q_C, then corresponding values for objects G_C^+ and Q_C^+. At ones we can conclude on greater contribution of emission of radio lobes in galaxies and quasars with linear type of steep radio spectrum. At the same time as, galaxies and quasars with steep spectrum C^+ may posses more essential torus emission and accretion disk emission. Also, one can see from the Table 1, the mean value of ratio of torus emission and accretion disk emission for galaxies of both spectral type (S and C^+) exceeds analogous value for quasars of both spectral types. This may indicate on more scaling, intensive tori in steep-spectrum galaxies in comparison with steep-spectrum quasars.

To study evolution of emission of structure components of sources with steep spectra S and C^+, it is important to examine corresponding relationships on redshift, linear size, characteristic age of sources. Emission of radio lobes relatively emission of central region of objects ($lg(S_{25}/S_{5000})$) has very weak positive trend in relationship on redshift and linear size in all four subsamples (G_S , G_C^+, Q_S , Q_C^+). Meanwhile, the trend of decrease of value $lg(S_{25}/S_{5000})$ is observed in relationship on characteristic age. The relationship of emission ratio of radio lobes and accretion disk of sources ($lg(S_{25}/S_{opt})$) on redshift z is fitted by second power polynome for subsamples G_S (with maximum at $lg(1+z) = 0{,}43$, that is, at $z = 1{,}69$) and G_C^+ (with maximum at $lg(1+z) = 0{,}28$, that is, at $z = 0{,}91$) (see Figure 1, Figure 2). Maximum of these relationships may evidence on the activity recurrence of giant sources. Linear trend of increase of $lg(S_{25}/S_{opt})$ at increase of $lg(1+z)$ is observed for subsamples of quasars Q_S and Q_C^+ (Figure 1, Figure 2). At that, the positive trend in relationship $lg(S_{25}/S_{opt})$ on source linear size R is revealed for all types of objects in our sample (see, for example, Figure 3). Thus, the contribution of emission of radio lobes increases at increase of linear size of steep-spectrum source. At that time, the examined sources display negative trend in relationship $lg(S_{25}/S_{opt})$ on characteristic age, that testifies on more intensive gas-dust torus in more old giant sources. This conclusion is confirmed by smaller mean value $<lg(S_{25}/S_{IR})>$ for G_C^+ and Q_C^+ in comparison with analogous values for G_S and Q_S (see Table 1).

Examination of mutual relationship for ratios of emission of two structure components of sample sources – contribution of emission of radio lobes relatively accretion disk emission and contribution of emission of radio lobes relatively torus emission – displays positive correlation of these parameters as well as evolution sequence of giant radio sources with steep spectrum. As one can see from Figure 4, galaxies and quasars with linear steep spectrum (S) cover region of more essential contribution of emission of radio lobes. On the other side, galaxies and quasars with steep spectrum C^+ correspond to region of smaller parameters of given structure components (see Figure 4). This peculiarity may be due to more intensive radiation of tori and accretion disks in objects with steep spectrum C^+.

It is important to consider emission of spatially close structure components in source–torus emission relatively emission of accretion disk crown ($lg(S_{IR}/S_X)$). Decrease of value $lg(S_{IR}/S_X)$ at increase z for sample sources is found in relationship of this parameter on redshift z. Probably, the X-ray emission of accretion disk crown is more intensive for early cosmological epochs.

It is interesting, that relationship $lg(S_{IR}/S_X)$ on linear size of source R has the form of two branches (see Figure 5). Also, relationship $lg(S_{IR}/S_X)$ on R for G_C^+ and Q_C^+ has the form of two branches, but more spread (Figure 6). Such evolution form of $lg(S_{IR}/S_X)$ relatively linear size may indicate on activity recurrence of objects with giant radio structure.

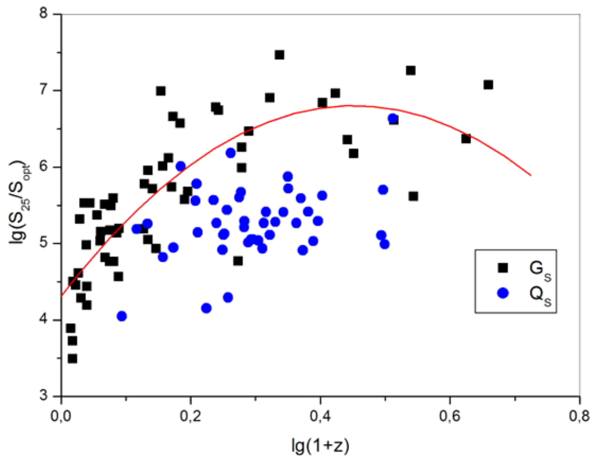

Figure 1: Ratio of emission of radio lobes and accretion disk versus redshift for galaxies and quasars with linear steep spectrum (fitting by second power polynome for G_S is marked by line)

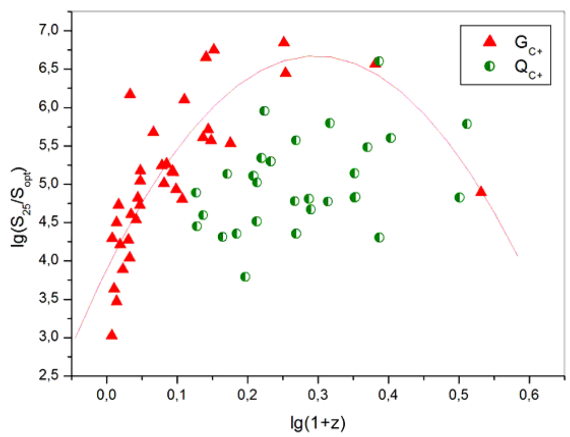

Figure 2: Ratio of emission of radio lobes and accretion disk versus redshift for galaxies and quasars with break steep spectrum (fitting by second power polynome for G_{C+} is marked by line)

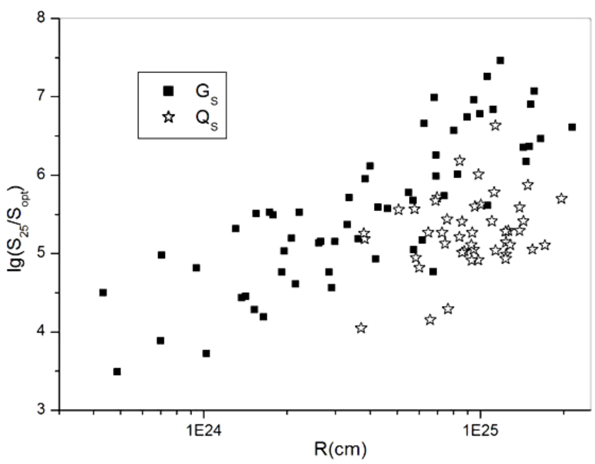

Figure 3: Ratio of emission of radio lobes and accretion disk versus linear size for galaxies and quasars with linear steep spectrum

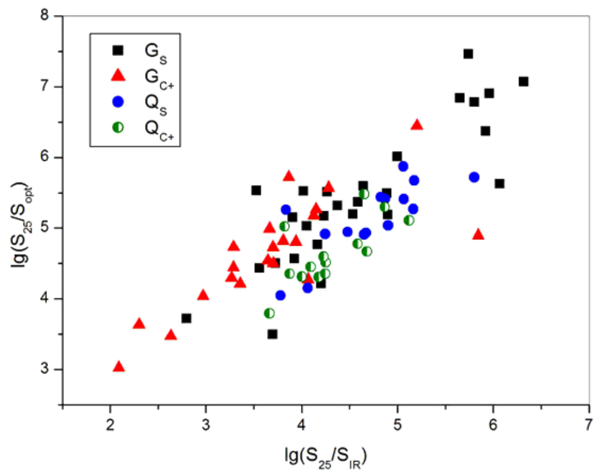

Figure 4: Ratio of emission of radio lobes and accretion disk versus ratio of emission of radio lobes and torus for galaxies and quasars with steep spectra S and C+ (evolution sequence)

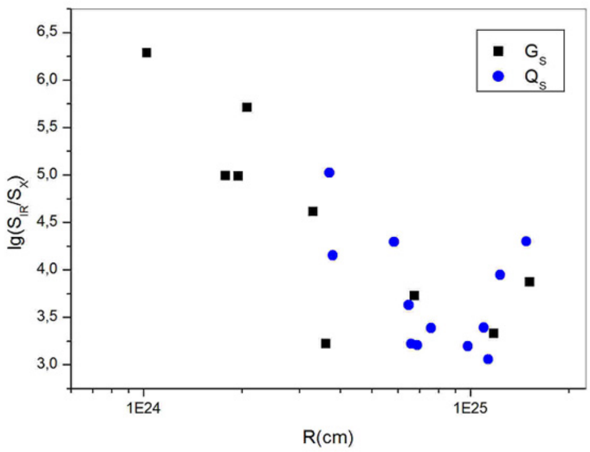

Figure 5: Ratio of emission of torus and accretion disk crown versus linear size for galaxies and quasars with linear steep spectrum

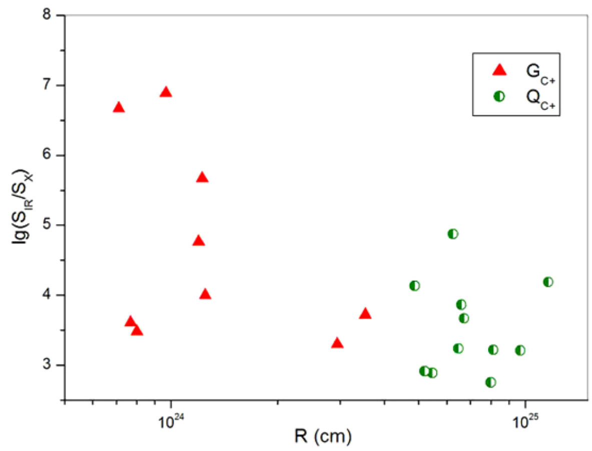

Figure 6: Ratio of emission of torus and accretion disk crown versus linear size for galaxies and quasars with break steep spectrum

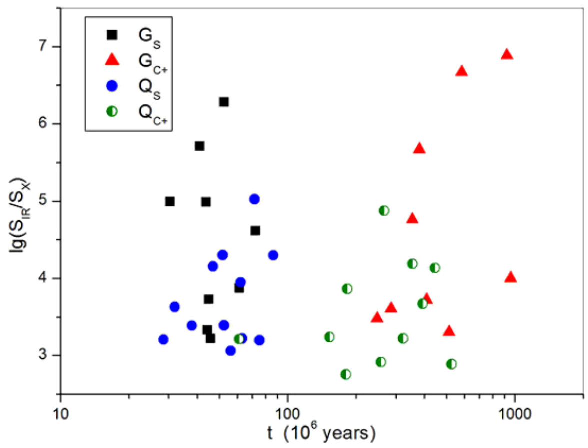

Figure 7: Ratio of emission of torus and accretion disk crown versus characteristic age for galaxies and quasars with steep spectra S and C+

The relationship of value $lg(S_{IR}/S_X)$ on characteristic age of sources t is notable (Figure 7). Sample objects of spectral type C^+ (G_C^+ and Q_C^+) cover region of greater ages in comparison with objects of spectral type S (G_S and Q_S) (see Figure 7). Radio sources with spectral type C^+ have, in average, characteristics age greater near one order, than analogous value for sources with linear steep spectrum S in our sample (Miroshnichenko, 2013). So, giant sources with steep spectrum C^+ may show more significant evolution effects in their structure components.

3. Conclusions

The comparative contribution of emission of structure components of sources is estimated for steep-spectrum galaxies and quasars from UTR-2 catalogue. This allows us to study the evolution effects of giant steep-spectrum radio sources. Main results of this study are next:

- Contribution of extended component (radio lobes) increases at the increasing of linear sizes of sources.
- Ratio of torus emission and disk crown of sources reveals two branches of evolution versus linear size and age of objects, indicating on the activity recurrence of nuclei of giant steep-spectrum sources.
- Galaxies and quasars with steep radio spectrum C^+, having great characteristic age, display greater contribution of torus emission than objects with spectrum S.
- The evolution sequence is obtained for galaxies and quasars with steep radio spectra S and C+.

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