Giant radio galaxies: problems of understanding and problems for CMB?

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Abstract: Giant radio galaxies (GRGs) are considered as the largest single objects in the Universe. They have sizes up to 12 Mpc. The reasons of this is still unclear. However, several groups study these galaxies and explain the their properties by core–jet energy and environment. In this poster contribution, we describe our plans in the investigation of GRGs. We consider a problem of confusion of multipole ranges describing scales of GRGs and S-Z effect. Using the CATS data base, radio telescope RATAN-600 (SAO RAS) and Indian ARIES optical 104-cm telescope, the complex study of GRGs is suggested.

1. Introduction

Giant radio galaxies, with linear sizes larger than 1 Mpc (H_0 = 70.1 km/s/Mpc, $\Omega_\Lambda = 0.721$, $\Omega_m = 0.279$; Komatsu et al., 2008), even up to 12 Mpc, are the largest single objects in the surrounding Universe. Comparing with ordinary galaxy population, giant radio galaxies (GRGs) are sufficiently rare. May be, that is one of the reasons why these objects are still not well studied and their physical evolution is not well understood. Several groups (Jamrozy et al., 2005, 2008; Konar et al., 2004, 2008; Lara et al., 2001, 2004; Machalski et al., 2006; Saripalli et al., 2004; Schoenmakers et al., 2000, 2001) continue investigation of their properties trying to explain their huge sizes. As was discussed by Jamrozy et al. (2005) the influence of GRGs on the ambient medium is correspondingly wider than of ordinary radio galaxies being less a one or two orders than GRGs. The important fact is that GRGs have sizes comparable to those of clusters of galaxies or larger. Therefore, Jamrozy et al. consider them playing an important role in the process of large-scale structure formation in the Universe.

For the last years, several radio surveys covered large sky areas like the Westerbork Northern Sky Survey (WENSS) (Rengelink et al., 1997) or NRAO VLA Sky Survey (NVSS) (Condon et al., 1998) have been finished. And they have given a new impulse to search and study for new objects of this type. All catalogs of such the surveys are stored in the CATS database[1] (Verkhodanov et al., 2005) which gives a possibility to extend the current list of giant radio galaxies.

On the other hand, new data of the cosmic microwave background (CMB) observations (Hinshaw et al., 2008) are accessible for astronomical community via legacy of NASA archive[2] . This gives us a good chance to estimate both the flux density from these objects at millimeter waves and the integral contribution and possible confusion of population of these objects at CMB maps.

2. What are the giant radio galaxies?

GRGs are the radio galaxies mostly of FRII morphological type (Fanaroff, Riley, 1974) with linear sizes larger than 1 Mpc identifying with giant elliptical galaxies and quasars. The main problem connected with GRGs and wide discussed in the literature is the explanation of their size. There are two dominating points of view on the nature of this feature.

At the beginning, it is necessary to note the orientation effect when GRGs and ordinary RGs are the same objects but having different projections can not explain the situation. Schoenmakers et al. (2001) have shown it with a complete sample of 26 low redshift ($z \leq 0.3$) giant radio galaxies from the WENSS survey, selected at flux densities above 1 Jy at 325 MHz. They have used 10.5 GHz observations with the 100-m Effelsberg telescope together with similar data of the remaining eight sources, are combined with data from the WENSS, NVSS and GB6 surveys to study the radio properties of the lobes of these sources at arcminute resolution. Investigating different radio source properties (radio source asymmetries, equipartition energy densities in the lobes, the presence of lobe pressure evolution with redshift, the spectral age and the density of the environments of these sources), they have shown that the armlength asymmetries of GRGs are slightly

[1] http://cats.sao.ru
[2] http://lambda.gsfc.nasa.gov

larger than those of smaller sized 3CR radio galaxies and that these are difficult to explain as arising from orientation effects only.

One of the two main explanations is that the size of these radio galaxies is due to the core-jet energy. Another one is that the size is due to the environment properties of the galaxy groups. Schoenmakers et al. (2001) have concluded that these objects could be the product of evolution the oldest members of the group of relatively high power radio sources whose radio powers have evolved to their currently observed lower values. For sources which could be used in a spectral ageing analysis, they found that the lobes of the GRGs are overpressured with respect to their environment, and argued that any evolution of lobe pressure with redshift in these large sources should be due to selection effects. we find spectral ages which are large, typically a few times 10^7 yr. This indicates that such large spectral ages are common for this class of radio source. Jamrozy et al. (2008) have studied the maximum spectral ages and estimated their values for the detected radio emission in the lobes of GRGs samples in the range from about 6 to 46 Myr with a median value of 23 Myr using the classical equipartition fields. Objects of such ages look significantly older than smaller sources. In all but one source Jamrozy et al. have found that the spectral age gradually increases with distance from the hotspot regions, confirming that acceleration of the particles mainly occurs in the hotspots, and most of the GRGs do not exhibit zero spectral ages in the hotspots, as is the case in earlier studies of smaller sources. They have concluded that this could be largely due to contamination by more extended emission because of relatively modest resolutions. The injection spectral indices range was estimated as from 0.55 to 0.88 with a median value of ~0.6. Jamrozy et al. (2008) have shown that the injection spectral index appears to be correlated both with luminosity and/or redshift and with linear size. Lara et al. (2004) have presented a detailed study of own new sample of large angular size FR I and FR II radio galaxies and compared the properties of these two classes. The have confirmed that a pure morphology based distinction of FR Is and FR IIs has corresponded to a break in total radio power. The radio cores in FR Is have been also weaker than in FR IIs despite of not a well defined break power. Lara et al. (2004) have detected that asymmetry in the structure of the sample members should be the consequence of anisotropies in the medium where the lobes expanded, with orientation playing a minor role. And analyzing the sub-sample of giant radio galaxies, they have not found evidence that these large objects require higher core powers. They have concluded that results have been consistent with giant radio galaxies being the older population of normal FR I and FR II objects evolving in low density environments. Comparing results from their sample with predictions from the radio luminosity function, authors have not find evidence of a possible FR II to FR I evolution.

Finishing this paragraph we note that despite the GRGs discussion is continued in the literature, the phenomenon is still unclear. Physical properties of GRGs (radio lobe asymmetries, equipartition energy densities in the lobes, the presence of lobe pressure evolution with redshift, the spectral age) and their environments as well as history the parent galaxy formation is still under interest.

3. Confusion factor

Here we would like to put our attention to another interesting moment of the GRGs problem. WMAP results (Hinshaw et al., 2008; Komatsu et al., 2008) and preparation of Planck mission launch in2008 (Planck Collaboration, 2006) give a special interest to the Sunyaev-Zeldovich effect (1972) which is due to the Compton scattering of relic photons by free electrons in the hot intergalactic gas in clusters of galaxies and considered now as a powerful probe of cosmology. Komatsu & Seljak (2002) calculated the angular power spectrum $C(\ell)$ of the Sunyaev-Zeldovich (SZ) effect and showed that $C(\ell) \sim \sigma_8^7(\Omega_b h)^2$, and it is almost independent of all of the other cosmological parameters. The predicted power spectrum has no free parameters and fits all of the published hydrodynamic simulation results to better than a factor of 2 for $2000 < \ell < 10000$. Thus, it gives the angular scales similar to GRGs scales (4'- 6' or $\ell \sim 2500$).

We can use the Lara et al. (2001) data for number of radio galaxies of angular sizes larger than 4' and of flux densities higher than 200 mJy, and spectral indices in the range from - 1.2 up to - 0.2 with declination $\delta > 60°$. Then, in millimeter wave range, we should have at least $1.5 \cdot 10^3$ objects of 1 ÷ 100 mJy on the entire sphere. In the integral average on a sphere, they can give a bias which was not yet considered in the estimation of the angular power spectrum of the S-Z effect.

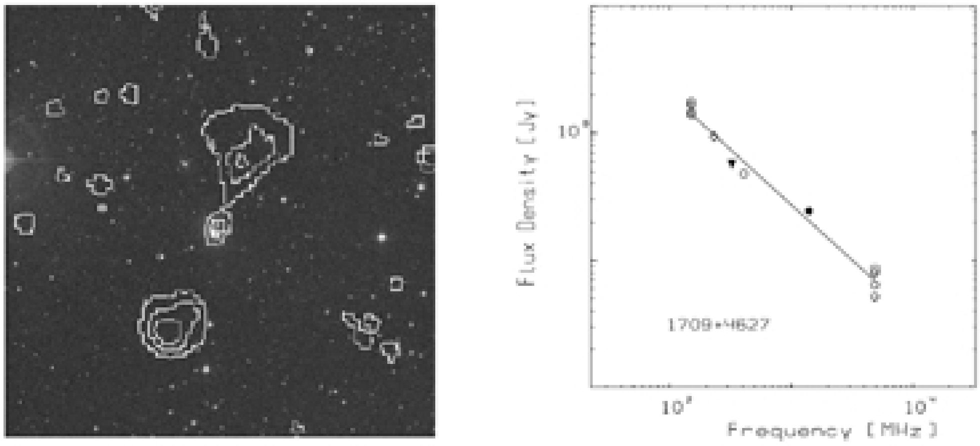

Fig.1. Example of a giant radio galaxy B1709+464. Left: NVSS radio source overlaid over DSS image. Right: integrated continuum radio spectrum of B1709+464.

Another inconvenient feature of confusion of GRGs contribution and CMB radiation is that the GRGs have mostly the same extended shape (Fig 1). It means that their distribution on a sphere creates own picture of minima and maxima which is imprinted in the CMB. This factor can give some confusion for background/foreground separation at high multipoles ($\ell \sim 2500$) due to different spectral index.

4. Some plans

So, to the approaches mentioned above in the study of GRGs, we plan to concentrate our research interest in several directions to solve the following problems.

- Increase a number of objects in the list of GRGs selecting double sources with axial structure in 6'-area in the WENSS, NVSS, SUMSS radio catalogues down to 100 mJy using CATS database (Verkhodanov et al., 2005).
- Using flux densities in millimeter wave range and positions of selected GRGs, to put them on to a sphere with a corresponding multipole resolution factor and to estimate actual integral contribution of such type of sources to angular power spectrum at high ℓ. Special procedure "*mappat"* in the CMB analysis package GLESP[1] (Doroshkevich et al., 2005; Verkhodanov et al., 2005) has been created for such type simulations.
- Using observational photometry data of GRG host galaxies with 104-cm Carl Zeiss telescope of Aryabhatta Research Institute of Observational Sciences (India) and SDSS data (Abazajian K. et al., 2003), we accurately estimate ages of host galaxies and compare features of their evolution with "ordinary" radio galaxies in the SED system *http://sed.sao.ru* (Verkhodanov et al., 2000).
- Using multifrequency radio telescope RATAN-600 (SAO RAS), we can measure the distribution of a spectral index value along the radio axis to estimate energy in GRGs jets.

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