MPC-SCALE RADIO JETS

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Giant radio galaxies, with jets larger than 0.5 Mpc, represent the biggest single objects in the universe. The largest known radio source is J1420-0545 with a size of 4.7 Mpc while the highest-redshift giant radio galaxy known so far is J1145-0033 at a redshift of 2.055. They are rare among the entire population of radio galaxies and to date, there are about 300 giants known. Morphologically, most of giants resemble powerful Fanaroff–Riley type II objects. Physical evolution of giant radio galaxies is not well understood though for many years they have been of special interest for several reasons. These are useful for studying a number of astrophysical problems which include probing the late stages of evolution of radio sources and constraining orientation-dependent unified schemes. Since giants have about 10 to 100 times larger jets than normal radio galaxies, their influence on the ambient medium is correspondingly wider and is pronounced on scales comparable to those of clusters of galaxies or larger.

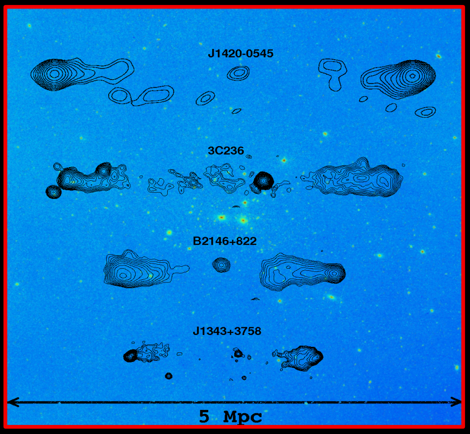

Figure 1. The four largest radio galaxies. The record holder, J1420-0545, has a size of 4.7 Mpc (Machalski et al., 2008).

The typical sizes of radio galaxies, which are initially located inside their parent galaxies, are of an order of tens of kiloparsecs, and in extreme cases can reach even up to several megaparsecs - which exceeds in size even some clusters of galaxies. We know today of about 300 such megaparsec giant objects (called giant radio galaxies, GRGs; for some examples see Fig. 1). There is a number of factors considered to be responsible for so large size of these radio sources. The analytical models describing the evolution of radio galaxies (e.g. Kaiser & Alexander, 1999), show that the dynamic structure of a source is a function of time, external medium density, and jet power. In the paper by Subrahmanyan et al. (1996), which presents research on several bright GRGs, it is postulated that the giants can become so large, because they had several jet activity periods of their central AGN (Saikia & Jamrozy 2009; for an example of a giant with multiple jet activity periods see Fig. 2).

Mean values of GRGs' physical parameters

synch. age	~40 *10^6 yrs
volume	10^{65} m^3
magnetic field	3 μG
lobe preasure	10^{-8} dyn m^{-2}
jet power	7*10^{45} erg s^{-1}
total energy	4*10^{61} erg
outer densities	10^{-5} cm^{-3}

GRGs have

- high energy content,
- large ordered magnetic field structures (often on scales > 100 kpc),
- absence of strong large-scale shocks,
- very low upper limits on their internal thermal plasma densities,
- direct and efficient conversion of force-free magnetic field to particle energy.

Consequences of GRGs energetic outflows

- ISM/IGM cloud compression and triggering of starformation,
- formation of a population of baryon-rich, dark-matter-deficient dwarf galaxies from the mass swept out in the IGM by outflows from quasars,
- IGM pollution by magnetic field and particles.

For several years GRGs were not supposed to be found at redshifts higher than z~1, because of the expected strong density increase of intergalactic medium (IGM). However, Law-Green et al. (1995) discovered 4C39.24 hosted by a galaxy located at z=1.883. Besides galaxies also quasar host giant radio structures. Kuźmicz, Kuligowska & Jamrozy (2011) noticed the most distant giant, J1145-0033, hosted by a quasar located at z=2.055. Radio quasars, which are on average more luminous than radio galaxies, should have higher lobe expansion speeds than radio galaxies and, assuming similar mean lifetimes of both these types of AGNs, radio quasars have the potential to reach larger size. A sample of 45 giant radio quasars was analysed by Kuźmicz & Jamrozy (2012).

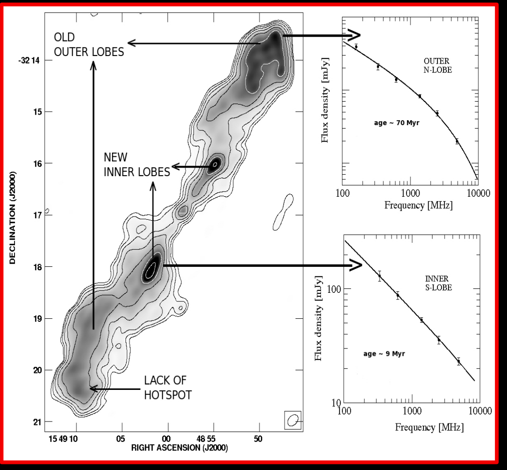

Figure 2. Left panel: 5000-MHz VLA image of the double-double GRG J1548-3216 (PKS 1545-321). **Right panel:** spectra of the outer northern lobe, fitted with the Jaffe-Perola model of synchrotron losses, and of the inner southern lobe, fitted with the continuous injection model. The age of the respective structures is also indicated. For details, see Machalski et al. (2010).

The large angular sizes of GRGs (at least of those located at low redshift) provide a great opportunity to study their physical conditions in several different locations (independent points) within their lobes. GRGs are not easy to be identified at the modern interferometric radio survey maps available. Detecting steep-spectrum and low surface-brightness radio-bridges connecting the radio core with hot spots for distant GRSs is a quite challenging task but it would be possibly facilitated with the advent of novel low-frequency telescopes such as the Low Frequency Array (LOFAR) and the Square Kilometre Array (SKA).

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