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A study of double-double radio sources from the FIRST survey

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Abstract. Proctor (2011) reported 242 sources as DDRGs (Double double radio galaxies) based only on their radio structures as seen in the FIRST (Faint Images of the Radio Sky at Twenty centimeters) survey. To find out new samples of DDRGs, we investigate their radio morphologies as well as the positions of their optical hosts. Out of 242 sources, we identified only 23 sources which are good examples of DDRGs, along with 63 sources, which require further observations to confirm their episodic nature.

Keywords : galaxies: active – galaxies: jets – galaxies: nuclei – radio continuum: galaxies

1. Introduction

"Double-double radio galaxies" (DDRGs) are the sub class of FRII type radio sources, and they are the best evidence for episodic activity of the active galactic nuclei (AGN). In such sources a pair of young radio lobes are seen nearer to the nucleus along with the old faded and more distant radio lobes (Schoenmakers et al. 2000). In most of the DDRGs the inner doubles are well aligned with the outer doubles. The linear size of the inner double varies from few pc to kpc range where as the linear size of the outer double varies from few hundred kpc to Mpc range. Most of the DDRGs are associated with typical giant elliptical galaxies having old stellar population. However, there are some exceptional cases where spiral-host with young star formation have been also reported. The number of sources with multiple episodes of jet activity is still small and shows wide range of time scales ($\sim 10^5$ to $\sim 10^8$yr) of episodic activity. Till date a few dozen good examples of recurrent activities of AGNs have been identified (Saikia & Jamrozy 2009). Only two sources are currently known, where the signature of three distinct episodic activities have been discovered (Brocksopp et

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al. 2007; Hota et al. 2011). It is important to identify more DDRGs to clarify several unanswered questions about their restarting of nuclear activity, time scales between two episodes of AGN activity, propagation of jets in different media and their interaction with different external environments. To find out more possible examples of DDRGS we examined the radio morphology and optical host position of 242 sources which were classified as possible DDRGs by Proctor (2011).

2. Classification of DDRGs

We used the Sloan Digital Sky Survey (SDSS) Data Release 8 (DR8) to identify optical hosts. The fields which are not covered in DR8, are cross identified through the Digital Sky Survey (DSS) R-band images. The sources which show two distinct cycles of activity with compact hot-spots in the inner lobes are presumed to belong in the good sample of DDRGs. For these type of sources we consider the optical object to be identified with the radio core component or it should lies close to the axis defined by the inner doubles. With this methodology we classified 23 promising DDRGs (See Fig. 1) from Proctor (2011) list. For those, where the optical positions are not identified or more reliable radio structures are needed have been classified as candidate DDRGs. We identified about 63 candidate DDRGs which need further deep optical observation or high resolution radio observation to confirm their episodic nature. The present study is based on the work by Nandi & Saikia (2012). The complete lists of these DDRGs and candidate DDRGs can be obtained from this paper.

3. Results and discussions

The overall projected linear sizes of these samples are quite small in comparison to other known DDRGs. For our new sample the median values of the inner and outer doubles are respectively ∼75 and 530 kpc, which are significantly less than the values reported by Saikia & Jamrozy (2009). For large objects (scale size ∼1Mpc) the time scale between successive episodes of jet activity is $\sim 10^7$ yr to $\sim 10^8$ yr. It has been also reported that the smaller sources like 3C293 (Joshi et al. 2011) or 4C02.27 (Jamrozy et al. 2009) show time scale of episodic activity $\sim 10^5$ yr which is significantly lesser than the most other known DDRGs. These smaller size FIRST DDRGs will help us explore the range of time scales of episodic nuclear activity. The symmetry parameters of the inner and outer doubles of these 23 DDRGs have also been examined. We find the armlength and the flux density ratios of the inner doubles to the outer doubles are not significantly different (Fig.2). This is worth to mention that unlike Schoenmakers et al. (2000) the combine sample of Saikia et al. (2006) and Nandi & Saikia (2012) does not show any strong inverse correlation between the ratio of the luminosities of the outer double to that of the inner one versus the projected linear size of the inner double.

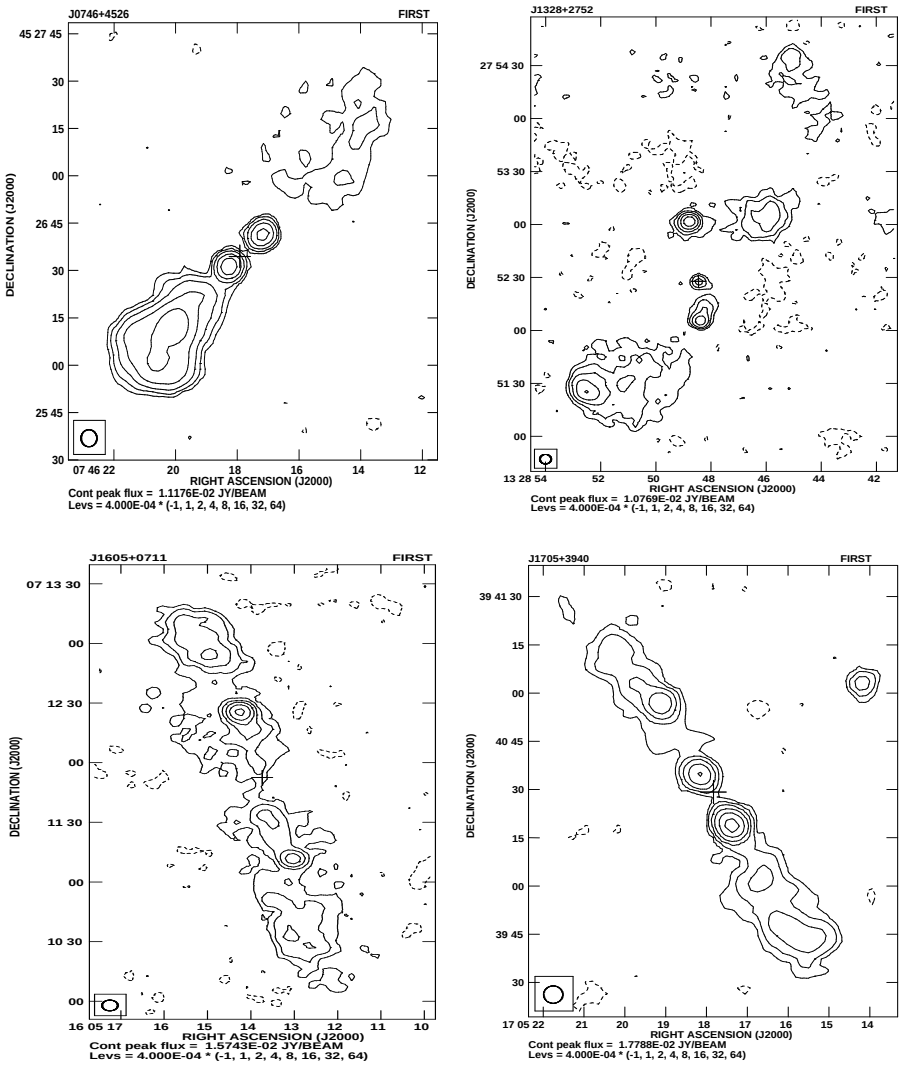

Figure 1. Examples of few sources which we have classified as DDRGs. The plus marks are the position of the optical hosts. The images of all 23 new DDRGs are given in Nandi & Saikia (2012)

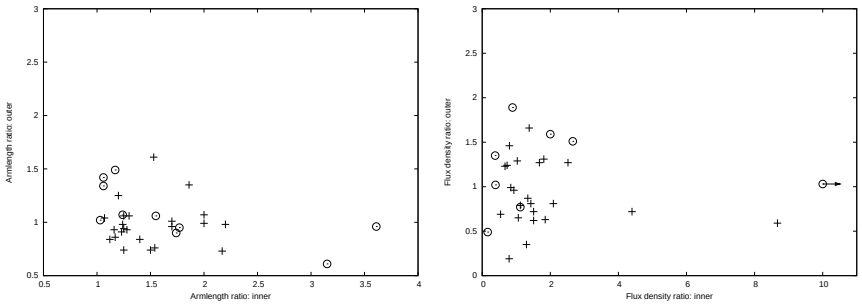

Figure 2. The arm-length ratio of the outer double vs the arm-length ratio of the inner double (left panel). The flux density ratio of outer double vs flux density ratio of inner double (right panel). The plus marks represent the DDRGs identified from the FIRST survey (Nandi & Saikia 2012), while the open circles represent those from Saikia et al. (2006).

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