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Emission line - radio correlation for Low Luminosity Compact sources. Evolution schemes.

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We present a radio and optical analysis of a sample of Low Luminosity Compact (LLC) objects, selected from FIRST survey and observed with MERLIN at L-band and C-band. The main criterion used for selection was luminosity of the objects and approximately one third of the CSS sources from the new sample have a value of radio luminosity comparable to FR Is.The analysis of a radio properties of LLC sources show they occupy the space in radio power versus linear size diagram below the main evolutionary path of radio objects. We suggest that many of them might be short-lived objects, and their radio emission may be disrupted several times before becoming FR IIs. The optical analysis of the LLC sources were made based on the available SDSS images and spectra. We have classified the sources as high and low excitation galaxies (HEG and LEG, respectively). The optical and radio properties of the LLC sample are in general consistent with brighter CSSs and large-scale radio sources. However, when LLC are added to the other samples, HEG and LEG seem to follow independent, parallel evolutionary tracks. LLC and luminous CSS behave like FR II sources, while FR I seem to belong to a different group of objects, concerning ionization mechanisms. Based on our results, we propose the independent, parallel evolutionary tracks for HEG and LEG sources, evolving from GPS - CSS - FR.

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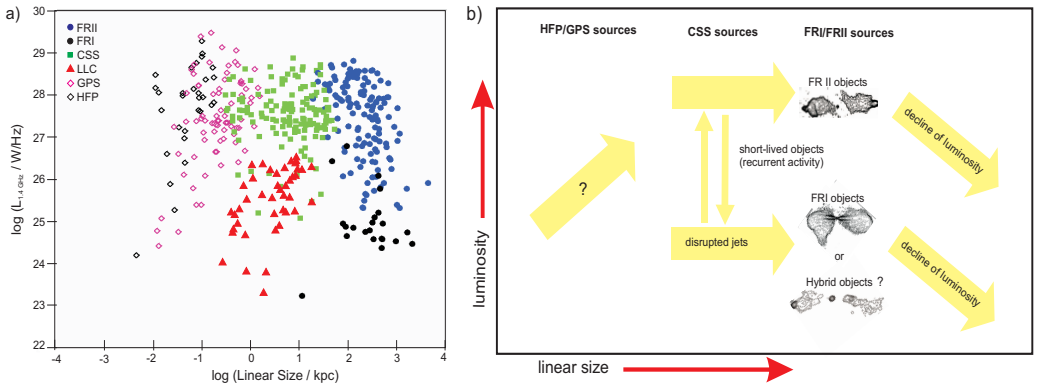

Figure 1: (a) Luminosity-size diagram for AGNs. Squares indicate CSS sources from samples of Labiano et al.(2007), Laing et al.(1983), Willott et al.(1999), Fanti et al.(2001) and Marecki et al.(2003). The diamonds indicate GPS and HFP objects from sample Labiano et al.(2007). The circles indicate FRI and FRII objects from samples of Laing et al.(1983), Buttiglione et al.(2009a,b, 2010) and Willot et al.(1999). The triangles indicate the current sample of LLC sources. (b) Evolutionary scheme of radio-loud AGNs.

1. Introduction

Radio sources are divided into two distinct morphological groups of objects: FR Is and FR IIs (Fanaroff &Riley, 1974). There is a relatively sharp luminosity boundary between them at low frequency. The nature of the FR-division is still an open issue, as are the details of the evolutionary process in which younger and smaller Gigahertz-Peaked Spectrum (GPS) and Compact Steep Spectrum (CSS) sources become large scale radio structures. The GPS and CSS sources form a well-defined class of compact radio objects and are considered to be entirely contained within the host galaxy. During their evolution the radio jets start to cross the ISM and try to leave the host galaxy. The interaction with the ISM can be very strong in GPS/CSS sources and it seems to be a crucial point in the evolution of radio sources.

In this paper we present a short summary of the obtained results of the radio observations of 44 low luminosity compact (LLC) sources and analysis of their optical properties. The details of the selection criteria and process are given in Kunert-Bajraszewska et al.(2010a), as are the detailed results of the study of their radio properties. The details of the optical analysis of the LLC sources are given in Kunert-Bajraszewska et al.(2010b). The radio observations of the whole sample were made with MERLIN at L-band and C-band. Optical data are available for 29 LLC sources and have been obtained from Sloan Digital Sky Survey (SDSS)/DR7.

2. Results of radio observations

About 70% of the observed LLC sources are galaxies and all of them are nearby objects with redshifts in the range $0.04<z<0.9$. Most of them have been resolved and about 30% of them have weak extended emission and disturbed structures when compared with the observations of higher luminosity CSS sources.We suggest that some of the sources with the breaking up structures or one-sided morphology are candidates for compact faders. We studied correlation between radio power and linear size, and redshift with a larger sample that included also published samples of compact

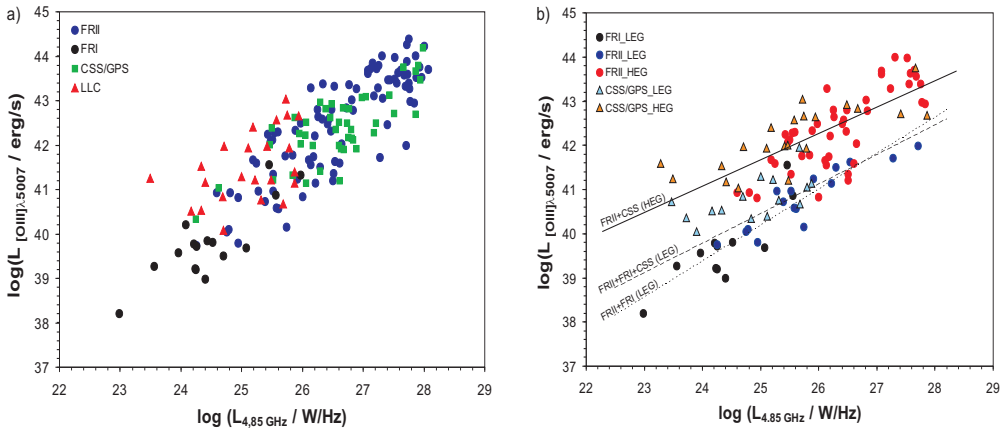

Figure 2: (a) [OIII] luminosity - radio luminosity diagram for AGNs, (b) [OIII] luminosity - radio luminosity diagram for AGNs classified as HEG and LEG. Squares indicate CSS sources from samples of Labiano et al.(2007), Laing et al.(1983), Willott et al.(1999), Fanti et al.(2001) and Marecki et al.(2003). The diamonds indicate GPS and HFP objects from sample Labiano et al.(2007). The circles indicate FRI and FRII objects from samples of Laing et al.(1983), Buttiglione et al.(2009a,b, 2010) and Willot et al.(1999). The triangles indicate the current sample of LLC sources.

objects and large scale FR IIs and FR Is (Kunert-Bajraszewska et al.,2010a). The Luminosity-Size diagram (Fig.1a) shows an evolutionary scheme of radio-loud AGNs.The selection criteria used for the new sample resulted in approximately one third of the LLC sources having a value of the 1.4 GHz radio luminosity comparable to FR Is. Their luminosities are definitely lower than CSS sources from last existing samples (Fanti et al.2001 and Marecki et al.2003). We conclude that many of them can be short-lived objects, at least in the current phase of evolution and undergo disrupted evolution many times as they will be able to get out of the host galaxy and evolve to FR IIs (two-sided arrows in Fig.1b). The observed parameters of LLC sources (radio luminosity and size), their radio morphology and spectroscopic features indicate that most of them will evolve finally to FR II. However, we suggest that there exists a much larger population of short-lived low luminosity compact objects unexplored so far and among them we can find precursors of large scale FR Is. The proposed evolutionary scheme is drawn in Fig.1b.

3. Results of optical analysis

Optical data are available for most of the LLC sources and based on them we have classified the sources as high and low excitation galaxies (HEG and LEG, respectively). We have compared the [O III] luminosity with the radio properties for LLC sources, and expanded the sample with other CSS, GPS sources and FR I and FR II objects (Kunert-Bajraszewska et al., 2010b). The whole sample shows that, for a given size or radio luminosity, HEG sources are brighter than LEG in the [O III] line by a factor of 10 (Fig.2b). The LLC objects follow the same correlation between [O III] luminosity and radio power, as the rest of the sample, although the LLC objects have lower values of [O III] luminosity than the more powerful CSS sources (Fig.2a). Based on the analysis above, we propose a scenario where the differences in the nature of LEG and HEG (accretion

mode or black hole spin) are already visible in the CSS phase of AGN evolution and determine the evolution of the source: i.e. CSS_{LEG} evolve to FR_{LEG}, CSS_{HEG} evolve to FR_{HEG}. The main evolution scenario (GPS-CSS-FR II) for radio-loud AGNs was proposed years ago. However, once the HEG/LEG division is included, these sources seem to evolve in parallel: GPS_{LEG}-CSS_{LEG}-FR_{LEG} and GPS_{HEG}-CSS_{HEG}-FR_{HEG}. Concerning LEG, it is still not clear if CSS_{LEG} would evolve directly to $FR\,I_{LEG}$ or go through a $FR\,II_{LEG}$ phase before the $FR\,I_{LEG}$. As discussed in Kunert-Bajraszewska et al., 2010a, there should also exist a group of short-lived CSS objects with lower radio luminosities. These short-lived CSSs could probably show the low [O III] luminosities seen in FR Is.

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