CSS objects as a probe of fuelling the AGN

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Abstract. The compact steep-spectrum (CSS) and Gigahertz peaked-spectrum (GPS) objects are widely believed to be young radio sources, with ages of $\lesssim 10^6$ yr. If the nuclear activity is fuelled by the supply of gas, one might find evidence of this gas by examining the structural and polarization properties of CSS objects as they advance outwards through this gas. This paper summarises some of the ‘smoking-gun’ evidence of this gas which may have triggered and fuelled the radio source.

1. Introduction

There is a consensus of opinion that the CSS and GPS objects are young sources with ages $\lesssim 10^6$ yr. These objects are possibly fuelled by the supply of gas to the central regions due to interactions with companions and mergers. Evidence of this infalling material could be probed via the radio components which interact with this material. For example, in an initially symmetric double-lobed radio source, the component advancing outwards in the direction of more infalling material will encounter a denser medium, and will appear brighter and closer to the nucleus. Thus the CSS and GPS objects, which have a greater chance of interacting with this material, should statistically appear more asymmetric in both brightness and location of the outer lobes compared with the larger sources. Also, the lobe interacting with the denser gas, could have its field lines sheared and compressed and also more strongly depolarized by the external gas. This would lead to a greater polarization asymmetry of the outer lobes.

2. Location, flux-density and polarization asymmetry

The distributions of the arm-length or separation ratio, $r_D$, defined to be $>1$, for a sample of 109 FRII sources from the 3CR and S4 samples of radio sources with a radio luminosity at 178 MHz $\gtrsim 10^{26}$ W Hz$^{-1}$ sr$^{-1}$ ($H_0=100$ km s$^{-1}$ Mpc$^{-1}$ and $q_0=0$) and a detected radio core are shown in Fig. 1. The CSSs (<20 kpc in size) associated with both radio galaxies and quasars have flatter distributions with higher median values, indicating their evolution in an asymmetric environment. In the $r_D$-$r_L$ diagram for this sample (Fig. 1, right panel), where $r_L$ is the flux density ratio, the nearer component is brighter for sources with $r_L<1$. Considering only those with $r_L<1$, the median value of $r_L$ is $\sim 0.4$ for CSSs and close to $\sim 0.6$ for the larger objects, suggesting again that the CSSs are evolving in a more asymmetric environment.
Figure 1. The distributions of $r_D$ for the sample of high-luminosity FRII radio galaxies and quasars. The CSS sources are shown in black. The $r_D$-$r_L$ diagram, where the filled and open symbols represent quasars and galaxies, respectively. The CSS sources are shown as triangles.

Figure 2. The distribution of $r_L$ for the samples of high-luminosity 3CRR large, 3CRR CSS and B3-VLA CSS sources. All the sources with $r_L > 5$ have been placed in the last bin.

The flux density asymmetry alone for a larger sample shows that the distributions for the CSS and larger sources are different at a confidence level of greater than 99%. The fraction of very asymmetric objects, i.e., those with $r_L > 5$, is 25% for the CSSs and 6% for the larger sources (Fig. 2).

The median value of the ratio of the degree of polarization of the oppositely-directed lobes at $\lambda 6$ or 3.6 cm is $\sim 6$ for the CSS objects compared with $\sim 1.5$ for the larger sources. A Kolmogorov-Smirnov test shows the CSSs and larger sources to be different at a significance level of $> 99.9%$. The degree of polarization asymmetry is much higher than expected due to the Laing-Garrington effect. Also, in a number of cases, it is the jet side which is either more strongly depolarized (e.g. 3C459) or has a much higher RM (e.g. 3C147).

3. Conclusions

The structural and polarization asymmetries support the hypothesis that CSSs show greater asymmetries than do FR IIIs predominantly because ambient gas asymmetries (the AGN fuel?) are concentrated in their central regions.

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