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# Arcsecond-Scale Radio Jets of Ultra-High-Energy Synchrotron Peak BL Lacs (UHBLs)

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**Abstract.** We present the arcsecond-scale jet structure and related radio properties for a sample of 9 UHBLs selected from Nieppola *et al.* (2006) with $\log(\nu_{\rm peak}/{\rm Hz}) > 20$. Our preliminary results show that most of the UHBLs have compact structures, and their core dominance parameters are much larger than FR-I radio galaxies, suggesting that beaming may be prevalent in the jets of these sources.

*Key words.* Galaxies: active—galaxies: nuclei—BL Lacertae objects: general—galaxies: galaxies.

## 1. Introduction

BL Lac objects can be classified as different subclasses based on their Spectral Energy Distribution (SED), viz. low frequency peaked BL Lac objects (LBL), intermediate objects (IBL) and high frequency peaked BL Lac objects (HBL) (Padovani & Giommi 1995). Ghisellini (1999) suggested that there is a class of BL Lacs with the synchrotron peak at higher frequencies than that of conventional HBLs, i.e., $\log(\nu_{\rm peak}/{\rm Hz}) > 19$, and these sources can be called ultra-high-energy synchrotron peak BL Lacs (UHBLs) (Giommi *et al.* 2001). UHBLs are at the extreme end of $\nu_{\rm peak}$ that distribution. Wu *et al.* (2007) suggested that UHBLs may have smaller Doppler factor, larger viewing angle, and lower radio luminosity. In general, the multi-resolution radio jet observational data will help in understanding their jet properties. In this paper, we present preliminary results for the arcsecond scale jet properties from VLA archive data.

## 2. Sample selection and data collection

Nieppola *et al.* (2006) have constructed SEDs for a large, heterogeneous sample of BL Lacs. In the sample, 22 BL Lacs with $\nu_{\rm peak} > 10^{19}$ Hz were classified as UHBLs candidates. From these sources, we selected all nine sources with $\log(\nu_{\rm peak}/{\rm Hz}) > 20$, which represent the extreme population of BL Lac objects. From VLBI observations for the 9 sources, Wu *et al.* (2012) suggested that beaming effect might be

**Table 1.** The model fit results.

| Object | $z$ | Epoch | Freq. (GHz) | $F_{\rm t}$ (mJy) | $F_{\rm core}$ (mJy) | $R_{\rm CE}$ |
|---|---|---|---|---|---|---|
| 2E 0414 + 0057 | 0.287 | 1986 Feb. 26 | 1.5 | 79.9 | 67.9 | 5.7 |
| | | 1995 Nov. 04 | 4.7 | 77.1 | 74.7 | 31.1 |
| EXO 0706.1 + 5913 | 0.125 | 1993 Feb. 23 | 4.9 | 65.8 | 53.3 | 4.3 |
| | | 2002 Feb. 22 | 1.4 | 70.1 | 64.7 | 12.0 |
| 1ES 0927 + 500 | 0.14 | 2002 Feb. 22 | 1.4 | 22.5 | 21.1 | 15.1 |
| | | 1994 May 08 | 4.8 | 17.4 | 17.1 | 57.0 |
| RXS J1012.7 + 4229 | 0.364 | 1998 Apr. 05 | 8.5 | 40.8 | 40.3 | 80.6 |
| | | 1992 Oct. 20 | 4.9 | 43.3 | 42.1 | 35.1 |
| RGB 1319 + 140 | 0.573 | 1992 Oct. 03 | 4.9 | 43.6 | 43.0 | 71.7 |
| | | 1998 Mar. 16 | 8.4 | 31.9 | 30.1 | 16.7 |
| RXS J1341 + 3959 | 0.163 | 1992 Oct. 03 | 4.9 | 17.8 | 17.0 | 21.2 |
| RXS J1410 + 6100 | 0.384 | 1994 May 07 | 4.9 | 4.46 | 4.58 | – |
| RXS J2304.6 + 3705 | 0.57 | 2009 Nov. 14 | 8.5 | 19.5 | 18.4 | 16.7 |

Col. 5: The total flux is the combined flux in cleaned models; Col. 6: The core flux is the one circular-Gaussian model fit of the core area.

present in the jets of UHBLs. In order to understand the jet properties of these particular type of sources better, we searched VLA archive data for the 9 UHBLs in Wu *et al.* (2012), but there were only 8 sources available. In this paper, we present the preliminary results of arcsecond scale radio properties and structures for the 8 UHBLs (see Table 1). The data reduction were performed using the NRAO Astronomical Image Processing System (AIPS). The imaging and model fitting were carried out with DIFMAP package (Shepherd *et al.* 1994).

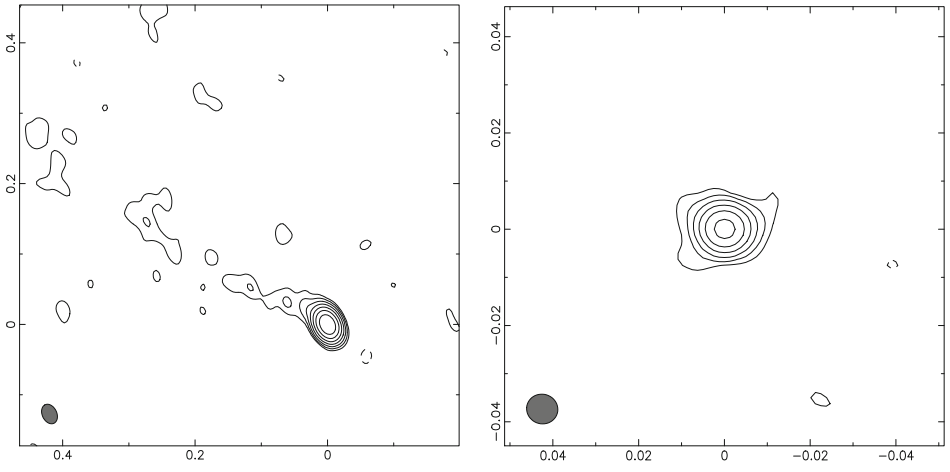


**Figure 1.** *Left*: The 1.5 GHz VLA image of 2E J0414 + 0057, for epoch 1986 Feb. 26; *Right*: The 4.9 GHz VLA image of RXS J1012.7 + 4229 for epoch 1992OCT20. The axes of the two images are labelled in arcseconds.

## 3. Results and discussions

(1) The core-jet structure is detected in 2 sources, all the other sources posses 28 compact core on kpc scale. The two examples are shown in Fig. 1: 2E J0414 + 0057 shows a core-jet structure, while RXS J1012.7 + 4229 shows a compact core. In order to understand the arcsecond scale jet properties of these sources better, high sensitivity observations will be needed.

(2) The jet structures of these UHBLs at arcsecond scale seem to be core dominated, the core dominance parameter $R_{\rm CE}$ is much larger than that for FR-I radio galaxies (mostly $<1$) in Zirbel & Baum (1995). Our results indicate that beaming possibly exists in these sources; this is consistent with our results reported in Wu *et al.* (2012) that beaming effects might be present in the jets of UHBLs.

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