PROCEEDINGS OF SCIENCE

37 GHz observations of a large sample of BL Lacertae objects

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We present our ongoing BL Lacertae observation project in Metsähovi Radio Observatory at 37 GHz. In 3.5 years we have collected over 3000 data points for almost 400 objects. The results so far have shown that the BL Lacertae population in its entirety can contribute significantly to the radio foreground emission detected by the Planck satellite.

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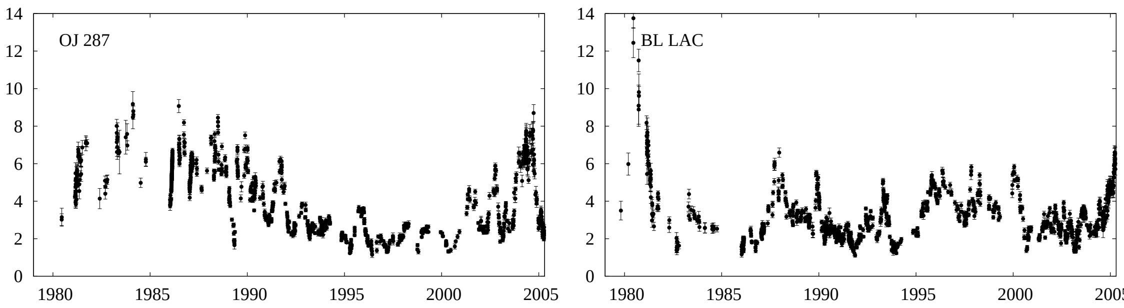

Figure 1: 37 GHz flux curves of two of the best-known LBLs.

1. Motivation

BL Lacertae objects (BLOs) are a group of active galaxies (AGNs) characterized by a flat radio spectrum and a near-featureless emission spectrum [1, 2]. They are divided to low-energy BLOs (LBLs) and high-energy BLOs (HBLs) according to the frequency on which the bulk of their energy is radiated [3, 4]. The intermediate population is termed IBLs.

The first BLOs, discovered almost 40 years ago, exhibited strong and rapid variability (Fig. 1). Since then, the number of known BLOs has increased by two magnitudes. Many of the newcomers are HBLs, which are typically very faint in the radio frequencies, and thus we have no information of their variability behaviour or even of their flux levels. The main purpose of the Metsähovi BLO observation project is to get a full understanding of the BLO population, all the way from the radio-selected BLOs to the X-ray-selected ones, and to put a special emphasis on the intermediate BLOs. We have studied the multifrequency data and the spectral energy distributions of the sample in a previous paper [4]. At present, we are preparing an extensive paper on the 37 GHz variability and timescales of the sample.

2. Sample and observations

The Metsähovi radio telescope is 13.7 metres in diameter and is situated 60 m above sea level in southern Finland. The typical integration times are 1200-1600 s and the detection limit in optimal weather conditions is approximately 0.2 Jy. The observations reported here took place between December 2001 and April 2005. The source sample consists of 398 BLOs taken mostly from the Veron-Cetty and Veron BL Lac catalogue [5] with the selection criterion dec $> -11^{o}$. A few additional sources were found from the literature.

3. Results

During the 3.5 years of observations, we collected over 3000 datapoints and all sources were observed at least once. A third of the sample was detected at $S/N > 4$. For the remaining two thrids, we calculated $S/N > 4$ upper limits from the $S/N < 4$ measurements. The majority of LBLs, 78%, was detected, while the corresponding figure for HBLs was 15% and for IBLs 37%. We calculated

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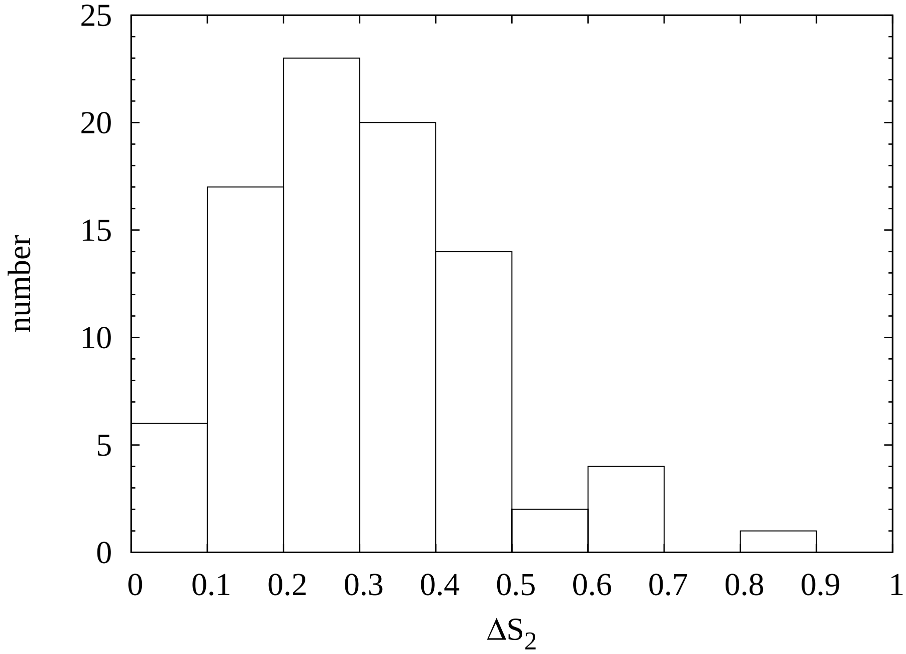

Figure 2: The distribution of the variability index ΔS_2 in the Metsähovi BLO sample.

fractional variability indices for the sample. The distribution of variability is presented in Fig. 2 where

$$\Delta S_2 = (S_{max} - S_{min})/(S_{max} + S_{min}). \quad (3.1)$$

S_{max} and S_{min} are the maximum and minimum fluxes, respectively.

Nearly all sources exhibited variability to some degree. A surprising result was that in the light of our data, there seems to be no correlation between variability and the location of the synchrotron peak of the SED. During the observations we got some serendipitous detections at $S/N > 4$ for IBLs and HBLs which usually are below the detection limit at 37 GHz, furthermore strengthening the view that at least a part of them can be as variable as LBLs.

We also calculated indicative broad band spectral indices between 5-37 GHz and 37-90 GHz using multi-epoch archival data mainly from the CATS database[1] [6]. The mean values were $\alpha_{5-37} = 0.25 \pm 0.57$ and $\alpha_{37-90} = 0.00 \pm 0.54$. Again, there were no statistical differences between the BLO classes. Next we will be performing a more conclusive study on BLO variability and flaring behaviour using only the very brightest sources which have frequent sampling. We will also take a look at characteristic time scales of the sample.

4. Benefits to Planck

The greatest advantages in studying BLOs at Metsähovi are the ample telescope time available for such projects, resulting in frequent sampling, and the large size of the source sample, giving an unbiased view of the BLO population. Because the detection limit of Planck for point sources will

[1] http://cats.sao.ru

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be comparable enough to that of Metsähovi, our results are a preview of what Planck is expected to see.

Based on these results it is very clear that high-energy BLOs cannot be overlooked in the Planck foreground studies. Although usually radio-faint, at least some of them seem to be as variable as low-energy BLOs, and can easily exceed the detection limit of Planck when in an active state.

We continue our Planck-dedicated observing programmes of BLOs, GPS (gigahertz-peaked spectrum) sources and faint AGNs, as well as the theoretical analysis of these data. We will shortly expand our source list to includce new samples of BLOs and other interesting AGNs. We are also continuing the multifrequency observation programme with the RATAN-600 radiotelescope.

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