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# Probable Associations of BL LAC Objects with Zwicky and Abell Clusters

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**Abstract.** BL Lac's may be found everywhere in space. But they are the dominant members in all systems of which they are part.

The probable associations of 266 BL Lac objects with the Zwicky (Zwicky et al. 1961-1968; Hill 1983) and the complete all-sky sample of 4076 Abell cluster (Abell, Corwin, & Olowin 1989) are discussed.

Almost all of the 266 real BL Lacs (the list of objects used in this work) are giant or supergiant radio-loud galaxies with E,S0 morphology, which usually are the central members of clusters of galaxies. There are many observational results (Xie et al. 1992; Wurtz et al. 1993; Falomo, Pesce, & Treves 1993a,b; Pesce, Falomo, & Treves 1995) to show that BL Lacs really are the central dominant members of clusters of galaxies with Abell richness 1,2. But there are facts also (Stickel, Fried, & Kuhr 1993; Ledlow & Owen 1995) which show that BL Lacs are the dominant members in small groups of galaxies, and are situated at the centers of poor (Abell richness class 0) clusters.

The primary neighborhood was found for each of the BL Lacs with respect to the centers of the clusters. The goal was to ascertain the fraction of BL Lacs in the central parts of Zwicky and Abell clusters.

The observed $(n(Zw.cont.))$ and the expected numbers with standard deviations $(N(Zw.c.)_{\rm exp}\pm\sigma)$ of the projected BL Lac's in the Zwicky cluster contours, the observed $(n(1Ra))$ and the expected numbers of projected BL Lac's in the centers of Abell clusters within one Abell radius $(N(1Ra)_{\rm exp}\pm\sigma)$ as well as in the field are presented in Table 1.

The observed (2 : 5 : 8) and the expected (2.4 : 4.95 : 7.65) distributions of BL Lacs are the same within the 95% confidance level by the $\chi^2$ test, in the regions with respective distances from the centers of Abell clusters : $(R_1 \leq \frac{1}{3}R_a)$, $(R_2{=}\frac{1}{3}R_a{-}\frac{2}{3}R_a)$, $(R_3{=}\frac{2}{3}R_a{-}1R_a)$.

Table 1. The BL Lac's in the Zwicky and Abell clusters

| BL Lac | $n(Zw.cont.)$ | $N(Zw.cont.)\pm\sigma$ | $n(1Ra)$ | $N(1Ra)\pm\sigma$ |
|---|---|---|---|---|
| in the clust. | 11 | $10.07\pm2.42$ | 1 | $0.96\pm0.95$ |
| in the field | 13 | $13.98\pm2.41$ | 22 | $23.04\pm0.95$ |

The maximum observed redshift for BL Lacs is 1.8; about 30% of them have redshifts $Z \geq 0.5$. And it is interesting to examine the distribution of BL Lacs with redshift from the perspective of their large-scale structure in space.

Table 2 presents the results of the known and expected counts of BL Lacs in intervals of redshift ($\Delta Z$) and declination ($\delta$): $N_1$, $N_2$, are the observed and (1), (2), (3) are the expected counts of BL Lacs with their standard deviations in the respective intervals of redshift ($\Delta$ Z) and declination ($\delta$), $N_{Zw}$ is the counts of the Lacertids that were projected in the Zwicky cluster contours (Zwicky et al., 1961-68).

Table 2. The Distribution of BL Lacs by Redshift and Declination

| BL Lac | $\delta \leq -3.0^o$ | | $\delta \geq -3.0^o$ | | in the Zw. cont. | |
|---|---|---|---|---|---|---|
| $\Delta Z$ | $N_1$ | $N_{1\,\mathrm{exp}} \pm \sigma$ | $N_2$ | $N_{2\,\mathrm{exp}} \pm \sigma$ | $N_{zw}$ | $N_{zw\mathrm{exp}} \pm \sigma$ |
| $< 0.3$ | 3 | $9.1 \pm 1.1$ | 87 | $139.5 \pm 6.9$ | 21 | $34.8 \pm 4.4$ |
| $0.3 \div 0.5$ | 6 | $18.3 \pm 1.6$ | 15 | $24.0 \pm 4.3$ | 6 | $9.9 \pm 1.4$ |
| $> 0.5$ | 12 | $36.6 \pm 2.2$ | 24 | $38.5 \pm 5.3$ | 2 | $3.3 \pm 0.8$ |

It may be concluded that the BL Lacs with $Z \leq 0.3$ (the average distances for the Abell and Zwicky clusters): a) may be discovered not only in the centers of clusters as was expected. b) they are the dominant members in all the systems wherever they are found: clusters of galaxies or small groups of galaxies, at different distances from the centers of the clusters, as well as in the field.

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