

# CLBSCat: An online Catalog for Changing-Look (Transition) Blazars (A Preliminary Results for CLBs Catalog)

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## ABSTRACT

An overview of CLBSCat<sup>a)</sup>, a new online interactive catalog for the Changing-Look (transition) blazars (CLBs) is presented. As CLB sources (transitional sources) continues to grow, the usefulness of a one-stop clearing house for information on new rare sources is increasingly evident. CLBSCat is intended to be such a resource. With sky maps, scientific information, visibility plotters, an interface with Google Earth “Sky”, linked references and a review paper section, CLBSCat enables the world-wide astrophysical community to stay up-to-date and informed on this exciting and rapidly developing field (**Copied from the TeVCat** <http://tevcat.uchicago.edu> compiled by Wakely & Horan 2008; Horan & Wakely 2008a,b).

At present, the CLBSCat has not been publicly released, and is only available online at <http://orcid.org/0000-0002-9071-5469> for a web link : <https://github.com/ksj7924/CLBSCat> for the convenience of everyone to view, modify and improve until the application is permanently fixed in a network space. Community groups or individuals are welcome to contribute or provide a suitable network for the joint development.

**Keywords:** Active galactic nuclei (16) — Blazars (164)— BL Lacertae objects (158) — Flat-spectrum radio quasars (2163) — Transitional sources — Changing-Look Blazars

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<sup>a)</sup> <https://github.com/ksj7924/CLBSCat/>

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## 1. INTRODUCTION

The Changing-Look (transition) blazars (CLBs) are extremely rare astronomical objects. This peculiar rare transition phenomenon between FSRQs and BL Lacs (equivalent width, EW, of the spectral line, become larger or smaller) are common addressed by some possible scenarios in the previous literature.

### For instance:

- The broad lines (EW) of some transition sources may be swamped by the strong (beamed) jet continuum variability (e.g., Vermeulen et al. 1995; Giommi et al. 2012; Ruan et al. 2014; Pasham & Wevers 2019), or jet bulk Lorentz factor variability (e.g., Bianchin et al. 2009);
- Some transition sources with weak radiative cooling, the broad lines are overwhelmed by the non-thermal continuum (e.g., Ghisellini et al. 2012).
- Some strong broad lines of the FSRQ type source are missed due to with a high redshift (e.g.,  $z > 0.7$ , D’Elia et al. 2015), the one of the strongest  $H\alpha$  line falls outside the optical window, caused the misclassification.
- Also, several observational effects (e.g., signal-to-noise ratio, and spectral resolution, etc.) may also affected the optical classification (see Peña-Herazo et al. 2021 for the related discussions).

The transitional blazars classification studying will impact studies of the divergent properties of BL Lacs and FSRQs, especially regarding their redshift evolution. Future directions for investigation of these rare transition blazars can focus on understanding the nature of the strong beaming using radio observations, and study of their high-energy inverse-Compton SED peaks to understand why only some of these strongly beamed FSRQs are gamma-ray loud (Copied from Ruan et al. 2014). In-depth research is of great significance to deepen the understanding of the origin of CLB sources, the accretion state transition of supermassive black holes; jet particle acceleration process; and black hole-galaxy co-evolution, etc. (Copied from Mishra 2021)

In the catalog, partial, including but not limited to, the confirmed Changing-Look Blazars (CLBs), the predicted CLBs; and these transitional blazars, or the possible transitional blazars between the standard FSRQs and BL Lac types (EW-based classification); even also including the red or blue (quasars) blazars; and broad line BL Lac types sources, and so on.

Some of the results are described below:

## 2. THE PREDICTIONS

### 2.1. The predictions in Fan & Wu (2019)

The jet power of LBLs shows a very broad distribution, which is somewhat bimodal. The bimodal distribution of LBLs suggests that they may contain two populations, one is actually FSRQs as suggested by Giommi et al. (2012). The other is transitional type BL Lac objects, which show weak emission lines and intermediate jet power. They generally divide LBLs into two groups with the limit  $10^{44.6} \text{ erg s}^{-1}$ . Of the 57 LBLs, 33 with the jet power larger than  $10^{44.6} \text{ erg s}^{-1}$  show similar jet power distribution with FSRQs. (Copied from Fan & Wu 2019). The 33 sources are listed in Table 1

**Table 1.** The predictions in [Fan & Wu \(2019\)](#)

| 4FGL name         | R.A.        | Decl.        | ASSOC name       | Bzcat5 name    | $Class_{sed}$ | $Class_F$ | $Class_p$ |
|-------------------|-------------|--------------|------------------|----------------|---------------|-----------|-----------|
| (1)               | (2)         | (3)          | (4)              | (5)            | (6)           | (7)       | (8)       |
| 3FGL J0049.7+0237 | 00 49 43.23 | +02 37 03.77 | PKS 0047+023     | 5BZBJ0049+0237 | bl            | LSP       | FSRQ      |
| 3FGL J0141.4−0929 | 01 41 25.83 | −09 28 43.67 | PKS 0139−09      | 5BZBJ0141−0928 | bl            | LSP       | FSRQ      |
| 3FGL J0238.6+1636 | 02 38 38.93 | +16 36 59.27 | AO 0235+164      | 5BZBJ0238+1636 | bl            | LSP       | FSRQ      |
| 3FGL J0334.3−4008 | 03 34 13.65 | −40 08 25.39 | PKS 0332−403     | 5BZBJ0334−4008 | bl            | LSP       | FSRQ      |
| 3FGL J0407.5+0740 | 04 07 29.08 | +07 42 07.47 | TXS 0404+075     | 5BZBJ0407+0742 | bl            | LSP       | FSRQ      |
| 3FGL J0428.6−3756 | 04 28 40.42 | −37 56 19.58 | PKS 0426−380     | 5BZBJ0428−3756 | bl            | LSP       | FSRQ      |
| 3FGL J0433.6+2905 | 04 33 37.82 | +29 05 55.47 | MG2 J043337+2905 | 5BZBJ0433+2905 | bl            | LSP       | FSRQ      |
| 3FGL J0434.0−2010 | 04 34 07.91 | −20 15 17.13 | TXS 0431−203     | 5BZBJ0434−2015 | bl            | LSP       | FSRQ      |
| 3FGL J0438.8−4519 | 04 39 00.85 | −45 22 22.56 | PKS 0437−454     | 5BZBJ0439−4522 | bl            | LSP       | FSRQ      |
| 3FGL J0538.8−4405 | 05 38 50.36 | −44 05 08.93 | PKS 0537−441     | 5BZBJ0538−4405 | bl            | LSP       | FSRQ      |
| 3FGL J0629.4−1959 | 06 29 23.76 | −19 59 19.72 | PKS 0627−199     | 5BZBJ0629−1959 | bl            | LSP       | FSRQ      |
| 3FGL J0738.1+1741 | 07 38 07.39 | +17 42 18.99 | PKS 0735+17      | 5BZBJ0738+1742 | bl            | LSP       | FSRQ      |
| 3FGL J0811.3+0146 | 08 11 26.7  | +01 46 52.22 | OJ 014           | 5BZBJ0811+0146 | bl            | LSP       | FSRQ      |
| 3FGL J0818.2+4223 | 08 18 15.99 | +42 22 45.41 | S4 0814+42       | 5BZBJ0818+4222 | bl            | LSP       | FSRQ      |
| 3FGL J0826.0+0307 | 08 25 50.33 | +03 09 24.51 | PKS 0823+033     | 5BZBJ0825+0309 | bl            | LSP       | FSRQ      |
| 3FGL J1058.5+0133 | 10 58 29.6  | +01 33 58.82 | 4C +01.28        | 5BZUJ1058+0133 | bl            | LSP       | FSRQ      |
| 3FGL J1218.0−0029 | 12 17 58.72 | −00 29 46.29 | PKS 1215−002     | 5BZBJ1217−0029 | bl            | LSP       | FSRQ      |
| 3FGL J1250.5+0217 | 12 50 32.58 | +02 16 32.17 | PKS 1247+025     | 5BZBJ1250+0216 | bl            | LSP       | FSRQ      |
| 3FGL J1303.0+2435 | 13 03 03.21 | +24 33 55.72 | MG2 J130304+2434 | 5BZBJ1303+2433 | bl            | LSP       | FSRQ      |
| 3FGL J1522.6−2730 | 15 22 37.67 | −27 30 10.78 | PKS 1519−273     | 5BZBJ1522−2730 | bl            | LSP       | FSRQ      |
| 3FGL J1540.8+1449 | 15 40 49.49 | +14 47 45.88 | 4C +14.60        | 5BZBJ1540+1447 | bl            | LSP       | FSRQ      |
| 3FGL J1748.6+7005 | 17 48 32.84 | +70 05 50.76 | S4 1749+70       | 5BZBJ1748+7005 | bl            | LSP       | FSRQ      |
| 3FGL J1800.5+7827 | 18 00 45.68 | +78 28 04.01 | S5 1803+784      | 5BZBJ1800+7828 | bl            | LSP       | FSRQ      |
| 3FGL J1824.2+5649 | 18 24 07.06 | +56 51 01.49 | 4C +56.27        | 5BZBJ1824+5651 | bl            | LSP       | FSRQ      |
| 3FGL J2031.8+1223 | 20 31 54.99 | +12 19 41.34 | PKS 2029+121     | 5BZUJ2031+1219 | bl            | LSP       | FSRQ      |
| 3FGL J2134.1−0152 | 21 34 10.3  | −01 53 17.23 | PKS 2131−021     | 5BZBJ2134−0153 | bl            | LSP       | FSRQ      |
| 3FGL J2152.4+1735 | 21 52 24.81 | +17 34 37.79 | S3 2150+17       | 5BZBJ2152+1734 | bl            | LSP       | FSRQ      |
| 3FGL J2206.9−0031 | 22 06 43.28 | −00 31 02.49 | PMN J2206−0031   | 5BZBJ2206−0031 | bl            | LSP       | FSRQ      |
| 3FGL J2217.0+2421 | 22 17 00.82 | +24 21 45.95 | B2 2214+24B      | 5BZBJ2217+2421 | bl            | LSP       | FSRQ      |
| 3FGL J2236.3+2829 | 22 36 22.47 | +28 28 57.41 | B2 2234+28A      | 5BZQJ2236+2828 | bl            | LSP       | FSRQ      |
| 3FGL J2243.4−2541 | 22 43 26.4  | −25 44 30.68 | PKS 2240−260     | 5BZBJ2243−2544 | bl            | LSP       | FSRQ      |
| 3FGL J2244.1+4057 | 22 44 12.73 | +40 57 13.62 | TXS 2241+406     | 5BZQJ2244+4057 | bl            | LSP       | FSRQ      |
| 3FGL J2315.7−5018 | 23 15 44.33 | −50 18 39.7  | PKS 2312−505     | 5BZBJ2315−5018 | bl            | LSP       | FSRQ      |

NOTE—The 3FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. The counterpart names and Bzcat5 Counterpart names are listed in Column 4 and 5. Column 6 lists the optical class, column 7 is the spectral energy distribution (SED) class reported in 4FGL catalog. The predictions (optical class) in [Fan & Wu \(2019\)](#) are presented in Columns 8.

2.2. The predictions in *Cheng et al. (2022)*

In *Cheng et al. (2022)*, they found that the distribution of the peak frequency of the synchrotron radiation, gamma-ray photon spectral index, and the X-band (8.4 GHz) flux density showed a similar bimodal **for LSP subclass**; one distribution hump similar to the BL Lacs and another similar to the FSRQs. These observations indicate that some LSP-BL Lacs may belong to BL Lacs and others are essentially FSRQs. They suggest that 47 LSP-BL Lacs that intrinsically FSRQ are misclassified as BL Lacs, and checked the Compton dominance (CD), 37 of 39 sources with CD > 1, which provides some further evidence that FSRQs may be mistaken for LSP BL Lacs. where, some LSP BL Lacs are essentially FSRQs. (Copied from *Cheng et al. 2022*). The 47 sources are listed in Table 2

**Table 2.** The predictions in *Cheng et al. (2022)*

| 4FGL name         | R.A.     | Decl.    | ASSOC name      | RFC name   | SED class | 4FGL Class | From class | To class |
|-------------------|----------|----------|-----------------|------------|-----------|------------|------------|----------|
| (1)               | (2)      | (3)      | (4)             | (5)        | (6)       | (7)        | (8)        | (9)      |
| 4FGL J1302.8+5748 | 195.7209 | 57.8146  | TXS 1300+580    | J1302+5748 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2346.7+8008 | 356.6867 | 80.1366  | WN B2344.2+7951 | J2346+8007 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2357.4-0152 | 359.3674 | -1.8703  | PKS 2354-021    | J2357-0152 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2200.3+1029 | 330.0887 | 10.4956  | TXS 2157+102    | J2200+1030 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2241.2+4120 | 340.3087 | 41.3396  | B3 2238+410     | J2241+4120 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1224.9+4334 | 186.2371 | 43.5691  | B3 1222+438     | J1224+4335 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0359.4-2616 | 59.8713  | -26.2734 | PKS 0357-264    | J0359-2615 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0403.5-2437 | 60.8989  | -24.6168 | TXS 0401-248    | J0403-2444 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0208.5-0046 | 32.135   | -0.7768  | PKS 0205-010    | J0208-0047 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0610.1-1848 | 92.5455  | -18.8076 | PMN J0610-1847  | J0610-1847 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1439.7+4958 | 219.9411 | 49.9775  | GB6 J1439+4958  | J1439+4958 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1445.9-1626 | 221.4978 | -16.4498 | PKS B1443-162   | J1445-1629 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1148.6+1841 | 177.1542 | 18.6861  | TXS 1146+189    | J1148+1840 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1954.6-1122 | 298.6693 | -11.3815 | TXS 1951-115    | J1954-1123 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1201.7+1429 | 180.4471 | 14.4852  | OM 198          | J1201+1431 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2315.6-5018 | 348.914  | -50.3127 | PKS 2312-505    | J2315-5018 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0209.9+7229 | 32.4979  | 72.4877  | S5 0205+722     | J0209+7229 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0832.4+4912 | 128.1078 | 49.2127  | OJ 448          | J0832+4913 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1427.6-3305 | 216.913  | -33.094  | PKS 1424-328    | J1427-3305 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1329.0-5607 | 202.2672 | -56.1186 | PMN J1329-5608  | J1329-5608 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1500.7+4752 | 225.1837 | 47.8716  | TXS 1459+480    | J1500+4751 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1410.1+0202 | 212.5287 | 2.0354   | PKS 1407+022    | J1410+0203 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2257.5+0748 | 344.3874 | 7.8014   | OY 91           | J2257+0743 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1315.1-5333 | 198.7978 | -53.5649 | PMN J1315-5334  | J1315-5334 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0113.7+0225 | 18.4279  | 2.4196   | UGC 773         | J0113+0222 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0710.9+4733 | 107.7323 | 47.553   | S4 0707+47      | J0710+4732 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2152.5+1737 | 328.137  | 17.6173  | S3 2150+17      | J2152+1734 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0407.5+0741 | 61.8921  | 7.6998   | TXS 0404+075    | J0407+0742 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2056.7-3209 | 314.178  | -32.1612 | PKS 2053-323    | J2056-3208 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2050.0+0408 | 312.5181 | 4.1401   | PKS 2047+039    | J2050+0407 | LSP       | bl         | bl         | FSRQ     |

**Table 2** continued on next page

**Table 2** (*continued*)

| 4FGL name         | R.A.     | Decl.    | ASSOC name       | RFC name   | SED class | 4FGL Class | From class | To class |
|-------------------|----------|----------|------------------|------------|-----------|------------|------------|----------|
| (1)               | (2)      | (3)      | (4)              | (5)        | (6)       | (7)        | (8)        | (9)      |
| 4FGL J2049.9+1002 | 312.4782 | 10.0407  | PKS 2047+098     | J2049+1003 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1516.9+1934 | 229.2442 | 19.5805  | PKS 1514+197     | J1516+1932 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1717.5−3342 | 259.3985 | −33.7003 | TXS 1714−336     | J1717−3342 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1941.3−6210 | 295.3468 | −62.1753 | PKS 1936−623     | J1941−6211 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2216.9+2421 | 334.238  | 24.3575  | B2 2214+24B      | J2217+2421 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0438.9−4521 | 69.7447  | −45.3584 | PKS 0437−454     | J0439−4522 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2010.0+7229 | 302.5159 | 72.4874  | 4C +72.28.       | J2009+7229 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1330.4+3157 | 202.6002 | 31.963   | MG2 J132953+3153 | J1329+3154 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0747.3−3310 | 116.8328 | −33.1778 | PKS 0745−330     | J0747−3310 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1326.8−5256 | 201.7201 | −52.9376 | PMN J1326−5256   | J1326−5256 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2032.0+1219 | 308.004  | 12.3279  | PKS 2029+121     | J2031+1219 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1604.5−4441 | 241.1277 | −44.6903 | PMN J1604−4441   | J1604−4441 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1824.1+5651 | 276.0393 | 56.8585  | 4C +56.27        | J1824+5651 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1641.9−0621 | 250.4892 | −6.3529  | TXS 1639−062     | J1642−0621 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1650.3−5045 | 252.5894 | −50.7515 | PMN J1650−5044   | J1650−5044 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2134.2−0154 | 323.5699 | −1.9042  | PKS 2131−021     | J2134−0153 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2025.3+3341 | 306.3412 | 33.6891  | B2 2023+33       | J2025+3343 | LSP       | bl         | bl         | FSRQ     |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. The counterpart names and VLBI Counterpart names are listed in Column 4 and 5. Column 6 lists the optical class, column 7 is the spectral energy distribution (SED) class reported in 4FGL catalog. The based optical class (From class) in [Cheng et al. \(2022\)](#) listed in Columns 8. The predictions (optical class) in [Cheng et al. \(2022\)](#) are presented in Columns 9.

## 2.3. The predictions in Kang et al. 2022

Based on the 4LAC, 4FGL and RCF catalog, we constructed a sample containing 1680 Fermi sources with known EW-based (optical) classifications (FSRQs and BL Lacs) and SED-based classifications (LSP, ISP, and HSP). Using the random forests supervised machine learning algorithm, 113 actually BL Lac type sources and 157 possible Changing-Look Blazar Candidates that possible intrinsically FSRQs misclassified as BL Lacs are predicted, and 58 remain without a clear prediction; for 328 LSP BL Lacs reported in the high Galactic latitudes ( $|b| > 10^\circ$ ) 4LAC-DR2 catalog (Copied from Kang et al. 2022). The 157 possible Changing-Look Blazar Candidates and 58 sources without a clear prediction (UNK) are listed in Table 3

**Table 3.** The predictions in Kang et al. 2022

| 4FGL name         | R.A.    | Decl.    | ASSOC name          | SED class | 4FGL Class | From class | To class |
|-------------------|---------|----------|---------------------|-----------|------------|------------|----------|
| (1)               | (2)     | (3)      | (4)                 | (5)       | (6)        | (7)        | (8)      |
| 4FGL J0003.9–1149 | 0.9986  | -11.8251 | PMN J0004–1148      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0006.3–0620 | 1.5992  | -6.3493  | PKS 0003–066        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0013.1–3955 | 3.2802  | -39.9272 | PKS 0010–401        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0014.1+1910 | 3.5368  | 19.1713  | MG3 J001356+1910    | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0019.6+2022 | 4.9070  | 20.3755  | PKS 0017+200        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0049.7+0237 | 12.4377 | 2.6273   | PKS 0047+023        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0056.8+1626 | 14.2020 | 16.4360  | TXS 0054+161        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0105.1+3929 | 16.2913 | 39.4963  | GB6 J0105+3928      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0107.4+0334 | 16.8508 | 3.5691   | PMN J0107+0333      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0113.7+0225 | 18.4279 | 2.4196   | UGC 773             | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0125.3–2548 | 21.3474 | -25.8074 | PKS 0122–260        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0141.4–0928 | 25.3626 | -9.4825  | PKS 0139–09         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0144.6+2705 | 26.1502 | 27.0899  | TXS 0141+268        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0202.7+4204 | 30.6862 | 42.0714  | B3 0159+418         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0203.6+7233 | 30.9114 | 72.5530  | S5 0159+723         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0203.7+3042 | 30.9327 | 30.7139  | NVSS J020344+304238 | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0208.5–0046 | 32.1350 | -0.7768  | PKS 0205–010        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0209.9+7229 | 32.4979 | 72.4877  | S5 0205+722         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0217.2+0837 | 34.3163 | 8.6234   | ZS 0214+083         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0238.6+1637 | 39.6680 | 16.6179  | PKS 0235+164        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0301.0–1652 | 45.2714 | -16.8688 | PMN J0301–1652      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0334.2–4008 | 53.5566 | -40.1450 | PKS 0332–403        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0340.5–2118 | 55.1477 | -21.3158 | PKS 0338–214        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0348.6–1609 | 57.1532 | -16.1654 | PKS 0346–163        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0354.7+8009 | 58.6919 | 80.1647  | S5 0346+80          | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0359.4–2616 | 59.8713 | -26.2734 | PKS 0357–264        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0403.5–2437 | 60.8989 | -24.6168 | TXS 0401–248        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0407.5+0741 | 61.8921 | 7.6998   | TXS 0404+075        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0424.7+0036 | 66.1945 | 0.6028   | PKS 0422+00         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0424.9–5331 | 66.2498 | -53.5257 | PMN J0425–5331      | LSP       | bll        | bll        | FSRQ     |

Table 3 continued on next page

**Table 3** (*continued*)

| 4FGL name         | R.A.     | Decl.    | ASSOC name          | SED class | 4FGL Class | From class | To class |
|-------------------|----------|----------|---------------------|-----------|------------|------------|----------|
| (1)               | (2)      | (3)      | (4)                 | (5)       | (6)        | (7)        | (8)      |
| 4FGL J0438.9–4521 | 69.7447  | -45.3584 | PKS 0437–454        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0502.5+1340 | 75.6341  | 13.6685  | PKS 0459+135        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0513.9–3746 | 78.4961  | -37.7774 | NVSS J051404–374607 | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0516.7–6207 | 79.1798  | -62.1248 | PKS 0516–621        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0538.8–4405 | 84.7089  | -44.0862 | PKS 0537–441        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0610.1–1848 | 92.5455  | -18.8076 | PMN J0610–1847      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0625.3+4439 | 96.3288  | 44.6648  | GB6 J0625+4440      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0628.8–6250 | 97.2174  | -62.8405 | PKS 0628–627        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0629.3–1959 | 97.3478  | -19.9999 | PKS 0627–199        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0647.7–6058 | 101.9314 | -60.9781 | PMN J0647–6058      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0706.9+6109 | 106.7319 | 61.1595  | TXS 0702+612        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0710.9+4733 | 107.7323 | 47.5530  | S4 0707+47          | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0712.7+5033 | 108.1876 | 50.5506  | GB6 J0712+5033      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0743.1+1713 | 115.7753 | 17.2198  | TXS 0740+173        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0753.0+5353 | 118.2530 | 53.8891  | 4C +54.15           | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0754.7+4823 | 118.6929 | 48.3932  | GB1 0751+485        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0757.1+0956 | 119.2856 | 9.9491   | PKS 0754+100        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0800.9+4401 | 120.2457 | 44.0181  | B3 0757+441         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0814.6+6430 | 123.6654 | 64.5050  | GB6 J0814+6431      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0819.0+2746 | 124.7636 | 27.7772  | 5C 07.119           | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0825.8+0309 | 126.4567 | 3.1656   | PKS 0823+033        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0831.8+0429 | 127.9732 | 4.4941   | PKS 0829+046        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0832.4+4912 | 128.1078 | 49.2127  | OJ 448              | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0839.4+1803 | 129.8695 | 18.0606  | TXS 0836+182        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0847.9–0702 | 131.9945 | -7.0434  | TXS 0845–068        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0848.9+0205 | 132.2375 | 2.0870   | PMN J0849+0206      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0854.8+2006 | 133.7071 | 20.1159  | OJ 287              | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0901.2+6742 | 135.3164 | 67.7129  | TXS 0856+679        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0925.7+3126 | 141.4454 | 31.4470  | B2 0922+31B         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0929.3+5014 | 142.3265 | 50.2352  | GB6 J0929+5013      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0930.3+8612 | 142.5994 | 86.2021  | S5 0916+864         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0930.7+3502 | 142.6813 | 35.0334  | B2 0927+35          | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0942.3–0800 | 145.5856 | -8.0076  | PMN J0942–0800      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J0958.7+6534 | 149.6897 | 65.5678  | S4 0954+65          | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1001.1+2911 | 150.2938 | 29.1880  | GB6 J1001+2911      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1008.0+0620 | 152.0136 | 6.3475   | MG1 J100800+0621    | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1019.7+6321 | 154.9263 | 63.3527  | GB6 J1019+6319      | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1024.8+2332 | 156.2101 | 23.5462  | MG2 J102456+2332    | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1058.0+4305 | 164.5181 | 43.0938  | B3 1055+433         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1058.4+0133 | 164.6240 | 1.5641   | 4C +01.28           | LSP       | bll        | bll        | FSRQ     |

**Table 3** *continued on next page*

**Table 3** (*continued*)

| 4FGL name         | R.A.     | Decl.    | ASSOC name           | SED class | 4FGL Class | From class | To class |
|-------------------|----------|----------|----------------------|-----------|------------|------------|----------|
| (1)               | (2)      | (3)      | (4)                  | (5)       | (6)        | (7)        | (8)      |
| 4FGL J1058.6−8003 | 164.6600 | −80.0640 | PKS 1057−79          | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1105.8+3944 | 166.4589 | 39.7426  | GB6 J1105+3946       | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1128.8+3757 | 172.2042 | 37.9657  | NVSS J112903+375655  | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1138.2+4115 | 174.5711 | 41.2562  | NVSS J113812+411353  | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1147.0−3812 | 176.7600 | −38.2006 | PKS 1144−379         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1148.6+1841 | 177.1542 | 18.6861  | TXS 1146+189         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1154.1−3243 | 178.5423 | −32.7189 | PKS 1151−324         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1201.7+1429 | 180.4471 | 14.4852  | OM 198               | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1218.0−0028 | 184.5136 | −0.4832  | PKS 1215−002         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1218.5−0119 | 184.6388 | −1.3270  | PKS 1216−010         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1223.8+8039 | 185.9707 | 80.6598  | S5 1221+80           | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1224.9+4334 | 186.2371 | 43.5691  | B3 1222+438          | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1227.1−4437 | 186.7859 | −44.6274 | PKS 1224−443         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1239.4+0728 | 189.8620 | 7.4709   | PKS 1236+077         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1250.6+0217 | 192.6513 | 2.2876   | PKS 1247+025         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1254.9−4426 | 193.7280 | −44.4441 | PKS 1252−441         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1259.7−3223 | 194.9449 | −32.3898 | LEDA 4075145         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1302.8+5748 | 195.7209 | 57.8146  | TXS 1300+580         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1303.0+2434 | 195.7571 | 24.5821  | MG2 J130304+2434     | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1305.6+7853 | 196.4126 | 78.8923  | S5 1304+79           | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1309.7+1153 | 197.4377 | 11.8969  | 4C +12.46            | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1330.4+3157 | 202.6002 | 31.9630  | MG2 J132953+3153     | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1353.0−4413 | 208.2566 | −44.2260 | PKS 1349−439         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1353.3+1434 | 208.3355 | 14.5755  | OP 186               | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1407.6−4301 | 211.9194 | −43.0234 | SUMSS J140739−430231 | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1410.1+0202 | 212.5287 | 2.0354   | PKS 1407+022         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1419.8+5423 | 214.9550 | 54.3937  | OQ 530               | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1427.6−3305 | 216.9130 | −33.0940 | PKS 1424−328         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1439.7+4958 | 219.9411 | 49.9775  | GB6 J1439+4958       | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1440.0−1530 | 220.0072 | −15.5154 | PKS 1437−153         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1445.9−1626 | 221.4978 | −16.4498 | PKS B1443−162        | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1458.6+3722 | 224.6733 | 37.3726  | B3 1456+375          | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1500.7+4752 | 225.1837 | 47.8716  | TXS 1459+480         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1505.0−3433 | 226.2581 | −34.5546 | PMN J1505−3432       | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1516.9+1934 | 229.2442 | 19.5805  | PKS 1514+197         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1522.6−2730 | 230.6642 | −27.5059 | PKS 1519−273         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1536.8−3155 | 234.2127 | −31.9224 | PKS 1533−317         | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1540.7+1449 | 235.1903 | 14.8220  | 4C +14.60            | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1546.5+1816 | 236.6338 | 18.2826  | MG1 J154628+1817     | LSP       | bll        | bll        | FSRQ     |
| 4FGL J1549.6+1710 | 237.4120 | 17.1784  | MG1 J154930+1708     | LSP       | bll        | bll        | FSRQ     |

**Table 3** *continued on next page*



**Table 3** (*continued*)

| 4FGL name         | R.A.     | Decl.    | ASSOC name           | SED class | 4FGL Class | From class | To class |
|-------------------|----------|----------|----------------------|-----------|------------|------------|----------|
| (1)               | (2)      | (3)      | (4)                  | (5)       | (6)        | (7)        | (8)      |
| 4FGL J1553.3+0600 | 238.3284 | 6.0127   | NVSS J155331+060143  | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1603.8+1104 | 240.9601 | 11.0701  | MG1 J160340+1106     | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1604.7+1734 | 241.1857 | 17.5717  | NVSS J160436+173324  | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1607.0+1550 | 241.7745 | 15.8447  | 4C +15.54            | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1624.6+5651 | 246.1715 | 56.8504  | SBS 1623+569         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1641.9-0621 | 250.4892 | -6.3529  | TXS 1639-062         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1642.3-8108 | 250.5855 | -81.1375 | PKS 1633-810         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1701.3+3956 | 255.3340 | 39.9406  | B3 1659+399          | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1751.5+0938 | 267.8776 | 9.6456   | OT 081               | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1800.6+7828 | 270.1730 | 78.4674  | S5 1803+784          | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1806.8+6949 | 271.7108 | 69.8270  | 3C 371               | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1824.1+5651 | 276.0393 | 56.8585  | 4C +56.27            | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1830.0-5225 | 277.5117 | -52.4188 | SUMSS J183004-522618 | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1834.7-5858 | 278.6874 | -58.9818 | PKS 1830-589         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1849.4+2745 | 282.3543 | 27.7542  | MG2 J184929+2748     | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1925.8-2220 | 291.4665 | -22.3410 | TXS 1922-224         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1927.5+6117 | 291.8822 | 61.2940  | S4 1926+61           | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1941.3-6210 | 295.3468 | -62.1753 | PKS 1936-623         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J1954.6-1122 | 298.6693 | -11.3815 | TXS 1951-115         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2005.5+7752 | 301.3930 | 77.8829  | S5 2007+77           | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2010.0+7229 | 302.5159 | 72.4874  | 4C +72.28            | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2012.2-1646 | 303.0719 | -16.7729 | PMN J2012-1646       | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2015.2-0137 | 303.8074 | -1.6254  | PKS 2012-017         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2022.5+7612 | 305.6459 | 76.2007  | S5 2023+760          | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2032.0+1219 | 308.0040 | 12.3279  | PKS 2029+121         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2049.9+1002 | 312.4782 | 10.0407  | PKS 2047+098         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2050.0+0408 | 312.5181 | 4.1401   | PKS 2047+039         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2056.7-3209 | 314.1780 | -32.1612 | PKS 2053-323         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2134.2-0154 | 323.5699 | -1.9042  | PKS 2131-021         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2152.5+1737 | 328.1370 | 17.6173  | S3 2150+17           | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2200.3+1029 | 330.0887 | 10.4956  | TXS 2157+102         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2202.7+4216 | 330.6946 | 42.2821  | BL Lac               | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2206.8-0032 | 331.7087 | -0.5461  | PMN J2206-0031       | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2216.9+2421 | 334.2380 | 24.3575  | B2 2214+24B          | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2224.0-1127 | 336.0241 | -11.4658 | PKS 2221-116         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2236.2-1706 | 339.0648 | -17.1066 | PKS 2233-173         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2236.5-1433 | 339.1444 | -14.5557 | PKS 2233-148         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2243.4-2544 | 340.8654 | -25.7363 | PKS 2240-260         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2247.4-0001 | 341.8670 | -0.0263  | PKS 2244-002         | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2250.7-2806 | 342.6903 | -28.1114 | PMN J2250-2806       | LSP       | bl         | bl         | FSRQ     |

**Table 3** *continued on next page*

**Table 3** (*continued*)

| 4FGL name         | R.A.     | Decl.    | ASSOC name               | SED class | 4FGL Class | From class | To class |
|-------------------|----------|----------|--------------------------|-----------|------------|------------|----------|
| (1)               | (2)      | (3)      | (4)                      | (5)       | (6)        | (7)        | (8)      |
| 4FGL J2256.6–2011 | 344.1728 | -20.1986 | PKS 2254–204             | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2257.5+0748 | 344.3874 | 7.8014   | OY 91                    | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2315.6–5018 | 348.9140 | -50.3127 | PKS 2312–505             | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2330.6–3726 | 352.6603 | -37.4346 | PKS 2327–376             | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2346.7+8008 | 356.6867 | 80.1366  | WN B2344.2+7951          | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2353.7–3037 | 358.4321 | -30.6219 | PKS 2351–309             | LSP       | bl         | bl         | FSRQ     |
| 4FGL J2357.4–0152 | 359.3674 | -1.8703  | PKS 2354–021             | LSP       | bl         | bl         | FSRQ     |
| 4FGL J0001.2–0747 | 0.3151   | -7.7971  | PMN J0001–0746           | LSP       | bl         | bl         | UNK      |
| 4FGL J0003.2+2207 | 0.8058   | 22.1302  | 2MASX J00032450+2204559  | LSP       | bl         | bl         | UNK      |
| 4FGL J0022.5+0608 | 5.6376   | 6.1343   | PKS 0019+058             | LSP       | bl         | bl         | UNK      |
| 4FGL J0029.0–7044 | 7.2509   | -70.7414 | PKS 0026–710             | LSP       | bl         | bl         | UNK      |
| 4FGL J0032.4–2849 | 8.1076   | -28.8224 | PMN J0032–2849           | LSP       | bl         | bl         | UNK      |
| 4FGL J0124.8–0625 | 21.2178  | -6.4328  | PMN J0124–0624           | LSP       | bl         | bl         | UNK      |
| 4FGL J0142.7–0543 | 25.6754  | -5.7332  | PKS 0140–059             | LSP       | bl         | bl         | UNK      |
| 4FGL J0224.0–7941 | 36.0056  | -79.6934 | PMN J0223–7940           | LSP       | bl         | bl         | UNK      |
| 4FGL J0241.0–0505 | 40.2509  | -5.0943  | PKS 0238–052             | LSP       | bl         | bl         | UNK      |
| 4FGL J0314.3–5103 | 48.5929  | -51.0550 | PMN J0314–5104           | LSP       | bl         | bl         | UNK      |
| 4FGL J0422.3+1951 | 65.5868  | 19.8618  | MS 0419.3+1943           | LSP       | bl         | bl         | UNK      |
| 4FGL J0428.6–3756 | 67.1730  | -37.9403 | PKS 0426–380             | LSP       | bl         | bl         | UNK      |
| 4FGL J0617.2+5701 | 94.3162  | 57.0249  | 87GB 061258.1+570222     | LSP       | bl         | bl         | UNK      |
| 4FGL J0811.4+0146 | 122.8610 | 1.7756   | OJ 014                   | LSP       | bl         | bl         | UNK      |
| 4FGL J0817.8–0934 | 124.4734 | -9.5777  | TXS 0815–094             | LSP       | bl         | bl         | UNK      |
| 4FGL J0818.2+4222 | 124.5572 | 42.3819  | S4 0814+42               | LSP       | bl         | bl         | UNK      |
| 4FGL J0850.0+4855 | 132.5083 | 48.9217  | GB6 J0850+4855           | LSP       | bl         | bl         | UNK      |
| 4FGL J0909.6+0159 | 137.4222 | 1.9917   | PKS 0907+022             | LSP       | bl         | bl         | UNK      |
| 4FGL J0934.3+3926 | 143.5861 | 39.4365  | GB6 J0934+3926           | LSP       | bl         | bl         | UNK      |
| 4FGL J0941.9+2724 | 145.4936 | 27.4136  | GB6 J0941+2721           | LSP       | bl         | bl         | UNK      |
| 4FGL J1018.1+1905 | 154.5480 | 19.0963  | NVSS J101808+190614      | LSP       | bl         | bl         | UNK      |
| 4FGL J1129.1+3703 | 172.2959 | 37.0644  | CRATES J112916+370317    | LSP       | bl         | bl         | UNK      |
| 4FGL J1143.1+6122 | 175.7881 | 61.3801  | GB6 J1143+6122           | LSP       | bl         | bl         | UNK      |
| 4FGL J1153.7+3822 | 178.4464 | 38.3684  | B3 1151+386              | LSP       | bl         | bl         | UNK      |
| 4FGL J1223.3+1213 | 185.8415 | 12.2312  | MG1 J122332+1208         | LSP       | bl         | bl         | UNK      |
| 4FGL J1226.8–1329 | 186.7188 | -13.4940 | PMN J1226–1328           | LSP       | bl         | bl         | UNK      |
| 4FGL J1238.3–1959 | 189.5936 | -19.9945 | PMN J1238–1959           | LSP       | bl         | bl         | UNK      |
| 4FGL J1259.1–2311 | 194.7798 | -23.1925 | PKS B1256–229            | LSP       | bl         | bl         | UNK      |
| 4FGL J1304.0+3704 | 196.0075 | 37.0710  | WISE J130407.31+370908.1 | LSP       | bl         | bl         | UNK      |
| 4FGL J1311.8+3954 | 197.9598 | 39.9010  | FIRST J131146.0+395317   | LSP       | bl         | bl         | UNK      |
| 4FGL J1331.2–1325 | 202.8192 | -13.4282 | PMN J1331–1326           | LSP       | bl         | bl         | UNK      |
| 4FGL J1424.2+0433 | 216.0508 | 4.5628   | TXS 1421+048             | LSP       | bl         | bl         | UNK      |
| 4FGL J1431.1–3120 | 217.7962 | -31.3468 | PKS 1428–311             | LSP       | bl         | bl         | UNK      |

**Table 3** *continued on next page*

**Table 3** (*continued*)

| 4FGL name         | R.A.     | Decl.    | ASSOC name           | SED class | 4FGL Class | From class | To class |
|-------------------|----------|----------|----------------------|-----------|------------|------------|----------|
| (1)               | (2)      | (3)      | (4)                  | (5)       | (6)        | (7)        | (8)      |
| 4FGL J1451.4+6355 | 222.8554 | 63.9172  | RX J1451.4+6354      | LSP       | bll        | bll        | UNK      |
| 4FGL J1455.0+0247 | 223.7616 | 2.7958   | 87GB 145233.9+030210 | LSP       | bll        | bll        | UNK      |
| 4FGL J1456.0+5051 | 224.0181 | 50.8500  | RGB J1456+508        | LSP       | bll        | bll        | UNK      |
| 4FGL J1516.8+3651 | 229.2217 | 36.8505  | MG2 J151646+3650     | LSP       | bll        | bll        | UNK      |
| 4FGL J1539.9+4220 | 234.9771 | 42.3381  | 87GB 153741.6+422719 | LSP       | bll        | bll        | UNK      |
| 4FGL J1549.3+6310 | 237.3324 | 63.1780  | WN B1549+6319        | LSP       | bll        | bll        | UNK      |
| 4FGL J1558.8+5625 | 239.7179 | 56.4268  | TXS 1557+565         | LSP       | bll        | bll        | UNK      |
| 4FGL J1616.7+4107 | 244.1821 | 41.1234  | B3 1615+412          | LSP       | bll        | bll        | UNK      |
| 4FGL J1643.0−7714 | 250.7719 | −77.2488 | PKS 1636−77          | LSP       | bll        | bll        | UNK      |
| 4FGL J1643.0+3223 | 250.7585 | 32.3982  | NVSS J164301+322104  | LSP       | bll        | bll        | UNK      |
| 4FGL J1647.5+4950 | 251.8923 | 49.8336  | SBS 1646+499         | LSP       | bll        | bll        | UNK      |
| 4FGL J1704.2+1234 | 256.0599 | 12.5752  | NVSS J170409+123421  | LSP       | bll        | bll        | UNK      |
| 4FGL J1719.2+1745 | 259.8062 | 17.7533  | PKS 1717+177         | LSP       | bll        | bll        | UNK      |
| 4FGL J1745.4−0753 | 266.3636 | −7.8894  | TXS 1742−078         | LSP       | bll        | bll        | UNK      |
| 4FGL J1749.0+4321 | 267.2554 | 43.3616  | B3 1747+433          | LSP       | bll        | bll        | UNK      |
| 4FGL J1813.6+0614 | 273.4084 | 6.2408   | TXS 1811+062         | LSP       | bll        | bll        | UNK      |
| 4FGL J1849.4−4313 | 282.3623 | −43.2214 | PMN J1849−4314       | LSP       | bll        | bll        | UNK      |
| 4FGL J1858.3+4321 | 284.5967 | 43.3590  | NVSS J185813+432452  | LSP       | bll        | bll        | UNK      |
| 4FGL J2017.5−3753 | 304.3957 | −37.8970 | PKS 2014−380         | LSP       | bll        | bll        | UNK      |
| 4FGL J2039.0−1046 | 309.7581 | −10.7731 | TXS 2036−109         | LSP       | bll        | bll        | UNK      |
| 4FGL J2115.9−0113 | 318.9959 | −1.2306  | NVSS J211603−010828  | LSP       | bll        | bll        | UNK      |
| 4FGL J2225.5−1114 | 336.3957 | −11.2422 | PKS 2223−114         | LSP       | bll        | bll        | UNK      |
| 4FGL J2241.2+4120 | 340.3087 | 41.3396  | B3 2238+410          | LSP       | bll        | bll        | UNK      |
| 4FGL J2307.6+1451 | 346.9222 | 14.8644  | MG1 J230734+1449     | LSP       | bll        | bll        | UNK      |
| 4FGL J2311.0+0205 | 347.7661 | 2.0995   | NVSS J231101+020504  | LSP       | bll        | bll        | UNK      |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. The counterpart names are listed in Column 4. Column 5 and 6 lists the spectral energy distribution (SED) class and the optical class reported in 4FGL catalog, respectively. The based optical class (From class) in [Kang et al. 2022](#) listed in Columns 7. The predictions (optical class) in Kang et al. 2022 are presented in Columns 8. Where, UNK indicate the sources without a clear prediction.

#### 2.4. The predictions in *Pei et al. (2022)*.

Based on the values of  $L_{Disk}/L_{Edd} = 0.055$  and  $0.024$  for the two LSP BL Lacs : 4FGL J0238.6+1637 (PKS 0235+164) and 4FGL J0538.8-4405 (PKS 0537-441) labeled as LSP BL Lacs in 4FGL catalog, which are located in the “appareling zone” that perhaps Changing-Look blazars and the transition of BL Lacs-FSRQs would occur, They consider these two sources to be potential changing-look blazars. Which are listed in Table 4 (**Copied from Pei et al. 2022**).

**Table 4.** The predictions in *Pei et al. (2022)*

| 4FGL name         | R.A.    | Decl.    | ASSOC name    | SED class | 4FGL Class | From class | To class |
|-------------------|---------|----------|---------------|-----------|------------|------------|----------|
| (1)               | (2)     | (3)      | (4)           | (5)       | (6)        | (7)        | (8)      |
| 4FGL J0238.6+1637 | 39.6680 | 16.6179  | PKS 0235 +164 | LSP       | bll        | BL Lacs    | FRSQs    |
| 4FGL J0538.8-4405 | 84.7089 | -44.0862 | PKS 0537-441  | LSP       | bll        | BL Lacs    | FRSQs    |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. The counterpart names are listed in Column 4. Column 5 lists the optical class, column 4 is the spectral energy distribution (SED) class reported in 4FGL catalog, respectively. The optical class before and after the predictions (transition) in *Pei et al. (2022)* are presented in Columns 7 and 8.

## 3. THE CONFIRMED CHANGING-LOOK BLAZARS (CLBS)

The confirmed changing-look blazars (CLBs), which are the source that there are optical spectra at different epochs showing radical changes. Clearly these sources are transitional between the standard FSRQs and BL Lac types.

3.1. *The confirmed CLBs in Foschini et al. (2021)*

Foschini et al. (2021) compiled a gamma-ray jetted AGN sample based on the 4FGL catalog. They reported 11 changing-look AGNs, when there are optical spectra at different epochs showing radical changes, such as from a featureless continuum to strong emission lines, thus indicating a change in the accretion history. 9 of them are blazars labeled as FSRQ in 4FGL catalog, one of them is non-blazar active galaxy labeled as “agn” in 4FGL catalog, and one of them is compact steep spectrum radio source labeled as “css” in 4FGL catalog, based on a featureless spectrum reported in the previous literature (see Foschini et al. 2021 for more details and references therein). The 11 sources are listed in Table 5 (Copied from Foschini et al. 2021).

**Table 5.** The confirmed CLBs in Foschini et al. (2021)

| 4FGL name         | R.A.     | Decl.      | ASSOC name      | SED class | 4FGL Class | From class  | To class |
|-------------------|----------|------------|-----------------|-----------|------------|-------------|----------|
| (1)               | (2)      | (3)        | (4)             | (5)       | (6)        | (7)         | (8)      |
| 4FGL J0134.5+2637 | 23.6272  | 26.6294    | RX J0134.4+2638 | HSP       | fsrq       | featureless | fsrq     |
| 4FGL J0217.8+0144 | 34.4621  | 1.7346     | PKS 0215+015    | LSP       | fsrq       | featureless | fsrq     |
| 4FGL J0449.1+1121 | 72.2823  | 11.3569    | PKS 0446+11     | LSP       | fsrq       | featureless | fsrq     |
| 4FGL J0509.4+1012 | 77.3510  | 10.2008    | PKS 0506+101    | LSP       | fsrq       | featureless | fsrq     |
| 4FGL J0510.0+1800 | 77.5181  | 18.0135    | PKS 0507+17     | LSP       | fsrq       | featureless | fsrq     |
| 4FGL J0522.9−3628 | 80.7370  | −1636.4686 | PKS 0521−36     | LSP       | agn        | featureless | agn      |
| 4FGL J0719.3+3307 | 109.8400 | 33.1232    | B2 0716+33      | LSP       | fsrq       | featureless | fsrq     |
| 4FGL J0833.9+4223 | 128.4759 | 42.3989    | OJ 451          | LSP       | fsrq       | featureless | fsrq     |
| 4FGL J0910.0+4257 | 137.5058 | 42.9623    | 3C 216          | ...       | css        | featureless | css      |
| 4FGL J1037.4−2933 | 159.3564 | −29.5568   | PKS 1034−293    | LSP       | fsrq       | featureless | fsrq     |
| 4FGL J1124.0+2336 | 171.0045 | 23.6159    | OM 235          | LSP       | fsrq       | featureless | fsrq     |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. The counterpart names are listed in Column 4. Column 5 and 6 lists the spectral energy distribution (SED) class and the optical class reported in 4FGL catalog, respectively. The optical class before and after the transition in Foschini et al. (2021) are presented in Columns 7 and 8, respectively.

### 3.2. The confirmed CLBs in *Peña-Herazo et al. (2021)*

In *Peña-Herazo et al. (2021)*, they reported 26 Changing-Look (transitional) blazars (CLBs). They discover 26 transitional (i.e., changing-look) blazars that changed their classification. Finally, we are able to confirm the blazar-like nature of six BL Lac candidates. All remaining sources analyzed agree with previous classifications (*Copied from Peña-Herazo et al. 2021*). Which are listed in Table 6.

**Table 6.** The confirmed CLBs in *Peña-Herazo et al. (2021)*

| 4FGL name         | R.A.     | Decl.   | SED class | 4FGL Class | ASSOC name               | From class | To class |
|-------------------|----------|---------|-----------|------------|--------------------------|------------|----------|
| (1)               | (2)      | (3)     | (4)       | (5)        | (6)                      | (7)        | (8)      |
| 4FGL J1410.3+1438 | 212.5908 | 14.6434 | ...       | bll        | 4FGL J1410.3+1438        | bll        | bzq      |
| 4FGL J1503.5+4759 | 225.8955 | 47.9959 | LSP       | bll        | 4FGL J1503.5+4759        | bll        | bzq      |
| ...               | ...      | ...     | ...       | ...        | SDSS J134240.02+094752.4 | bzq        | bzb      |
| ...               | ...      | ...     | ...       | ...        | 5BZG J0006+1051          | bzg        | bzb      |
| 4FGL J0022.0+0006 | 5.5154   | 0.1134  | HSP       | bll        | 5BZG J0022+0006          | bzg        | bzb      |
| 4FGL J0303.3+0555 | 45.8465  | 5.9249  | HSP       | bll        | 5BZG J0303+0554          | bzg        | bzb      |
| ...               | ...      | ...     | ...       | ...        | 5BZG J0751+1730          | bzg        | bzq      |
| ...               | ...      | ...     | ...       | ...        | 5BZG J0756+3834          | bzg        | bzq      |
| 4FGL J0916.7+5238 | 139.1906 | 52.6454 | HSP       | bll        | 5BZG J0916+5238          | bzg        | bzb      |
| 4FGL J1001.1+2911 | 150.2938 | 29.1880 | LSP       | bll        | 5BZB J1001+2911          | bzb        | bzq      |
| 4FGL J1043.2+2408 | 160.8053 | 24.1460 | LSP       | fsrq       | 5BZQ J1043+2408          | bzq        | bzb      |
| ...               | ...      | ...     | ...       | ...        | 5BZQ J1054+3855          | bzq        | bzb      |
| 4FGL J1056.0+0253 | 164.0027 | 2.8935  | ...       | bll        | 5BZG J1056+0252          | bzg        | bzb      |
| ...               | ...      | ...     | ...       | ...        | 5BZG J1103+0022          | bzg        | bzb      |
| 4FGL J1106.0+2813 | 166.5020 | 28.2254 | LSP       | fsrq       | 5BZQ J1106+2812          | bzq        | bzb      |
| ...               | ...      | ...     | ...       | ...        | 5BZQ J1243+4043          | bzq        | bzb      |
| 4FGL J1321.1+2216 | 200.2958 | 22.2808 | LSP       | fsrq       | 5BZQ J1321+2216          | bzq        | bzb      |
| 4FGL J1326.1+1232 | 201.5493 | 12.5348 | HSP       | bll        | 5BZG J1326+1229          | bzg        | bzb      |
| ...               | ...      | ...     | ...       | ...        | 5BZQ J1343+2844          | bzq        | bzb      |
| 4FGL J1402.6+1600 | 210.6584 | 16.0016 | ISP       | bll        | 5BZB J1402+1559          | bzb        | bzq      |
| 4FGL J1449.5+2746 | 222.3956 | 27.7686 | ISP       | rdg        | 5BZG J1449+2746          | bzg        | bzb      |
| ...               | ...      | ...     | ...       | ...        | 5BZG J1504−0248          | bzg        | bzq      |
| 4FGL J1512.2+0202 | 228.0702 | 2.0403  | LSP       | fsrq       | 5BZG J1512+0203          | bzg        | bzq      |
| 4FGL J1730.8+3715 | 262.7026 | 37.2641 | ISP       | bll        | 5BZG J1730+3714          | bzg        | bzb      |
| ...               | ...      | ...     | ...       | ...        | 5BZG J1733+4519          | bzg        | bzb      |
| ...               | ...      | ...     | ...       | ...        | 5BZG J2346+4024          | bzg        | bzq      |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. Column 4 is the spectral energy distribution (SED) class and Column 5 lists the optical class reported in 4FGL catalog, respectively. The counterpart names are listed in Column 6. The optical class before and after the transition in *Peña-Herazo et al. (2021)* are presented in Columns 7 and 8, respectively. Where, BL lacs labeled as BZB and FSRQs labeled as BZQ (or BZG) in the Roma-BZCAT.

3.3. *The confirmed CLBs in Ruan et al. (2014)*

Blazars are classically divided into the BL Lacertae (BLL) and flat-spectrum radio quasar (FSRQ) subclasses, based on the equivalent width (EW) of their optical broad emission lines (BELs). However, EW-based classification criteria are not physically motivated, and a few blazars have previously “transitioned” from one subclass to the other. They present the first systematic search for these transition blazars in a sample of 602 unique pairs of repeat spectra of 354 blazars in the Sloan Digital Sky Survey, finding six clear cases (transition blazars) (Copied from Ruan et al. 2014). Which are listed in Table 7.

**Table 7.** The confirmed CLBs in Ruan et al. (2014)

| 4FGL name         | R.A.     | Decl.   | SED class | 4FGL Class | ASSOC name               | From class | To class  |
|-------------------|----------|---------|-----------|------------|--------------------------|------------|-----------|
| (1)               | (2)      | (3)     | (4)       | (5)        | (6)                      | (7)        | (8)       |
| 4FGL J0833.9+4223 | 128.4759 | 42.3989 | LSP       | fsrq       | SDSS J083353.88+422401.8 | P–BLL      | FSRQ–like |
| 4FGL J1016.0+0512 | 154.0093 | 5.2089  | LSP       | fsrq       | SDSS J101603.13+051302.3 | P–BLL      | FSRQ–like |
| 4FGL J1308.5+3547 | 197.1286 | 35.7918 | LSP       | fsrq       | SDSS J130823.70+354637.0 | P–BLL      | FSRQ–like |
| 4FGL J2206.8–0032 | 331.7087 | –0.5461 | LSP       | bll        | SDSS J220643.28–003102.5 | P–BLL      | FSRQ–like |
| 4FGL J1250.6+0217 | 192.6513 | 2.2876  | LSP       | bll        | SDSS J125032.57+021632.1 | P–BLL      | FSRQ–like |
| ...               | ...      | ...     | ...       | ...        | SDSS J143758.67+300207.1 | P–BLL      | FSRQ–like |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. Column 4 lists the spectral energy distribution (SED) class and column 5 lists the optical class reported in 4FGL catalog, respectively. The counterpart names are listed in Column 6. The optical class before and after the transition in Ruan et al. (2014) are presented in Columns 7 and 8.

### 3.4. The transition sources in *Shaw et al. (2012)*

Several blazars were classified as BL Lac objects in initial epoch observations. At the “primary” spectrum epoch, with low continuum, each was a nominal FSRQ. The objects which changed (and continuum decrease) were: J0058+3311 (8 $\times$ ), J0923+4125 (4 $\times$ ), J1001+2911 (6 $\times$ ), J1607+1551 (5 $\times$ ), J2031+1219 (4 $\times$ ), and J2244+4057 (10 $\times$ ).

With very high S/N observations, we were able to detect broad lines at high significance at EW levels  $< 5\text{\AA}$  in several objects. These were thus “BL Lac objects” at all of our epochs, but can be analyzed along with the FSRQ. The BL Lac objects (and strongest broad-line EWs) were: J0430-2507 (Mgii at EW =  $0.9\text{\AA}$ ), J0516-6207 (Civ at EW =  $1.6\text{\AA}$ ; Ciii, Mgii also present), J1058+0133 (Mg ii at EW =  $2.2\text{\AA}$ ), J2236+2828 (Mgii at EW =  $4.9\text{\AA}$ ), and J2315-5018 (Mgii at EW =  $3.8\text{\AA}$ ). These EW measurements are in observed frame. Clearly these sources are transitional between our standard FSRQs and BL Lac types (*copied from Shaw et al. 2012*). Which are listed in Table 8

**Table 8.** The 11 transition sources in *Shaw et al. (2012)*

| 4FGL name         | R.A.     | Decl.    | SED class | 4FGL Class | ASSOC name        | From class | To class        |
|-------------------|----------|----------|-----------|------------|-------------------|------------|-----------------|
| (1)               | (2)      | (3)      | (4)       | (5)        | (6)               | (7)        | (8)             |
| 4FGL J0058.4+3315 | 14.6101  | 33.2505  | LSP       | fsrq       | 1FGL J0058.0+3314 | BL Lac     | nominal_FSRQ    |
| 4FGL J0923.5+4125 | 140.8949 | 41.4283  | LSP       | fsrq       | 1FGL J0923.2+4121 | BL Lac     | nominal_FSRQ    |
| 4FGL J1001.1+2911 | 150.2938 | 29.1880  | LSP       | bll        | 1FGL J1000.9+2915 | BL Lac     | nominal_FSRQ    |
| 4FGL J1607.0+1550 | 241.7745 | 15.8447  | LSP       | bll        | 1FGL J1607.1+1552 | BL Lac     | nominal_FSRQ    |
| 4FGL J2032.0+1219 | 308.0040 | 12.3279  | LSP       | bll        | 1FGL J2031.5+1219 | BL Lac     | nominal_FSRQ    |
| 4FGL J2244.2+4057 | 341.0614 | 40.9597  | LSP       | fsrq       | 1FGL J2243.4+4104 | BL Lac     | nominal_FSRQ    |
| 4FGL J0430.3-2507 | 67.5751  | -25.1283 | ISP       | bll        | 1FGL J0430.4-2509 | BL Lac     | broad_lines_BLL |
| 4FGL J0516.7-6207 | 79.1798  | -62.1248 | LSP       | bll        | 1FGL J0516.7-6207 | BL Lac     | broad_lines_BLL |
| 4FGL J1058.4+0133 | 164.6240 | 1.5641   | LSP       | bll        | 1FGL J1058.4+0134 | BL Lac     | broad_lines_BLL |
| 4FGL J2236.3+2828 | 339.0962 | 28.4832  | LSP       | fsrq       | 1FGL J2236.2+2828 | BL Lac     | broad_lines_BLL |
| 4FGL J2315.6-5018 | 348.9140 | -50.3127 | LSP       | bll        | 1FGL J2315.9-5014 | BL Lac     | broad_lines_BLL |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. Column 4 is the spectral energy distribution (SED) class and Column 5 lists the optical class reported in 4FGL catalog, respectively. The 1FGL counterpart names are listed in Column 6. The optical class before and after the transition in *Shaw et al. (2012)* are presented in Columns 7 and 8, respectively.



3.5. *The considered as transition sources in Ghisellini et al. (2011)*

Sources classified as BL Lacs with an SED appearing as intermediate between BL Lacs and FSRQs also have relatively weak broad emission lines and small EW, and can be considered as transition sources (**copied from Ghisellini et al. 2011**). Which are listed in Table 10.

**Table 9.** The considered as transition sources in Ghisellini et al. (2011)

| 4FGL name<br>(1)  | R.A.<br>(2) | Decl.<br>(3) | ASSOC name<br>(4) | SED class<br>(5) | 4FGL Class<br>(6) | From class<br>(7) | To class<br>(8) |
|-------------------|-------------|--------------|-------------------|------------------|-------------------|-------------------|-----------------|
| 4FGL J0058.4+3315 | 14.6101     | 33.2505      | MG3 J005830+3311  | LSP              | fsrq              | BL Lacs           | FS              |
| 4FGL J0210.7−5101 | 32.6946     | −51.0218     | PKS 0208−512      | LSP              | fsrq              | BL Lacs           | FS              |
| 4FGL J0538.8−4405 | 84.7089     | −44.0862     | PKS 0537−441      | LSP              | bll               | BL Lacs           | FS              |
| 4FGL J0811.4+0146 | 122.8610    | 1.7756       | OJ 014.           | LSP              | bll               | BL Lacs           | FS              |
| 4FGL J0238.6+1637 | 39.6680     | 16.6179      | PKS 0235+164      | LSP              | bll               | BL Lacs           | FS              |
| 4FGL J0428.6−3756 | 67.1730     | −37.9403     | PKS 0426−380      | LSP              | bll               | BL Lacs           | FS              |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. The counterpart names are listed in Column 4. Column 5 is the spectral energy distribution (SED) class and column 6 lists the optical class reported in 4FGL catalog, respectively. The optical class before and after the transition in Ghisellini et al. (2011) are presented in Columns 7 and 8.

3.6. *The CLB (transition) sources in other literatures***Table 10.** The CLB (transition) sources in other literatures

| 4FGL name         | R.A.     | Decl.    | SED class | 4FGL Class | ASSOC name            | From class | To class | ref.         |
|-------------------|----------|----------|-----------|------------|-----------------------|------------|----------|--------------|
| (1)               | (2)      | (3)      | (4)       | (5)        | (6)                   | (7)        | (8)      | (9)          |
| 4FGL J2202.7+4216 | 330.6946 | 42.2821  | LSP       | bll        | BL Lac (prototype)    | BL Lac     | FSRQ     | <sup>a</sup> |
| 4FGL J1422.3+3223 | 215.5772 | 32.3911  | LSP       | fsrq       | B2 1420+32            | FSRQ       | BL Lac   | <sup>b</sup> |
| ...               | ...      | ...      | ...       | ...        | 5BZB J0724+2621       | BL Lac     | FSRQ.    | <sup>c</sup> |
| ...               | ...      | ...      | ...       | ...        | J211354.71+112125.3.  | FSRQ       | no BELs. | <sup>d</sup> |
| ...               | ...      | ...      | ...       | ...        | AT2019evq             | FSRQ       | no BELs. | <sup>d</sup> |
| 4FGL J1153.4+4931 | 178.3505 | 49.5169  | LSP       | fsrq       | 4C+29.22 (S4 1150+49) | FSRQ       | BL Lacs  | <sup>e</sup> |
| 4FGL J0509.4+0542 | 77.3593  | 5.7014   | ISP       | bll        | TXS 0506+056          | bll        | FSRQ     | <sup>f</sup> |
| 4FGL J2151.8−3027 | 327.9655 | −30.4600 | LSP       | fsrq       | PKS 2149−306          |            |          | <sup>g</sup> |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. Column 4 is the spectral energy distribution (SED) class and column 5 lists the optical class reported in 4FGL catalog, respectively. The counterpart names are listed in Column 6. The optical class before and after the transition in Ghisellini et al. (2011) are presented in Columns 7 and 8, respectively. Where,

<sup>a</sup>Vermeulen et al. (1995); based on optical line.

<sup>b</sup>Mishra et al. (2021); based on optical line.

<sup>c</sup>Álvarez Crespo et al. (2016); based on optical line.

<sup>d</sup>Pasham & Wevers (2019); based on optical line.

<sup>e</sup>Cutini et al. (2014); based on SED.

<sup>f</sup>Padovani et al. (2019); based on Eddington ratio.

<sup>g</sup>Bianchin et al. (2009). based on SED.

## 4. THE BLUE QUASARS

4.1. *The Blue Fermi flat spectrum radio quasars in Ghisellini et al. (2012)*

Many blazars detected by the Fermi satellite, observed spectroscopically in the optical, are line-less, and have been classified as BL Lac objects. Optical-ultraviolet (UV) photometry of nearly 100 of them allowed us to determine the redshift for a handful of objects and redshift upper limits in the great majority. A few of these are candidates to be ‘blue quasars’, namely flat spectrum radio quasars whose broad emission lines are hidden by an overwhelming synchrotron emission peaking in the UV. This implies that the emitting electrons have high energies. In turn, this requires relatively weak radiative cooling, a condition that can be met if the main radiative dissipation of the jet power occurs outside the broad-line region. We confirm this hypothesis by studying and modelling the spectral energy distributions of the four ‘blue quasars’ recently discovered. Furthermore, we discuss the distribution of Fermi blazars in the gamma-ray spectral index-gamma-ray luminosity plane, and argue that ‘blue quasars’ objects are a minority within the blazar populations (Copied from Ghisellini et al. 2012). Which are listed in Table 11.

**Table 11.** The becomes blue sources in Ghisellini et al. (2012, 2013)

| 4FGL name         | R.A.     | Decl.    | SED class | 4FGL Class | ASSOC name           | From class | To class     |
|-------------------|----------|----------|-----------|------------|----------------------|------------|--------------|
| (1)               | (2)      | (3)      | (4)       | (5)        | (6)                  | (7)        | (8)          |
| 4FGL J2345.2–1555 | 356.3030 | -15.9182 | LSP       | fsrq       | PMN J2345–1555.      | FSRQ(red)  | BL Lac(blue) |
| 4FGL J0035.2+1514 | 8.8123   | 15.2405  | ISP       | bll        | RX J0035.2+1515      | bll        | FSRQ(blue)   |
| 4FGL J0537.7–5717 | 84.4251  | -57.2909 | HSP       | bll        | SUMMS J053748–571828 | bll        | FSRQ(blue)   |
| 4FGL J0630.9–2406 | 97.7414  | -24.1110 | HSP       | bll        | CRATES J0630–2406    | bll        | FSRQ(blue)   |
| 4FGL J1312.4–2156 | 198.1108 | -21.9380 | HSP       | bll        | CRATES 1312–2156     | bll        | FSRQ(blue)   |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. Column 4 is the spectral energy distribution (SED) class and Column 5 lists the optical class reported in 4FGL catalog, respectively. The counterpart names are listed in Column 6. The optical class before and after becoming blue in Ghisellini et al. (2012, 2013) are presented in Columns 7 and 8.

In addition, the flat spectrum radio quasar PMN J2345-1555 (see, Table 11) is a bright gamma-ray source, that recently underwent a flaring episode in the infrared (IR), ultraviolet (UV) and gamma-ray bands. The flux changed quasi-simultaneously at different frequencies, suggesting that it was produced by a single population of emitting particles, hence by a single and well-localized region of the jet. While the overall spectral energy distribution (SED) before the flare was typical of powerful blazars (namely two broad humps peaking in the far-IR and below 100 MeV bands, respectively), during the flare the peaks moved to the optical-UV and to energies larger than 1 GeV, to resemble low power BL Lac objects, even if the observed bolometric luminosity increased by more than one order of magnitude. We interpret this behaviour as due to a change of the location of the emission region in the jet, from within the broad-line region, to just outside. The corresponding decrease of the radiation energy density as seen in the comoving frame of the jet allowed the relativistic electrons to be accelerated to higher energies, and thus produce a ‘bluer’ SED (Copied from Ghisellini et al. 2013).

## 5. THE PREDICTIONS (CHECK) CLBCS IN 2022

5.1. *The predictions (check) in Zhang et al. (2022)***Table 12.** The predictions in Zhang et al. (2022)

| 4FGL name<br>(1)  | R.A.<br>(2) | Decl.<br>(3) | ASSOC name<br>(4)   | SED class<br>(5) | 4FGL Class<br>(6) | From class<br>(7)  | To class<br>(8) |
|-------------------|-------------|--------------|---------------------|------------------|-------------------|--------------------|-----------------|
| 4FGL J0114.8+1326 | 18.7119     | 13.4342      | GB6 J0114+1325      | ISP              | bll               | 1bzb/2bzq/3CB/4CB  |                 |
| 4FGL J0203.7+3042 | 30.9327     | 30.7139      | NVSS J020344+304238 | LSP              | bll               | 1agu/ 2bzq/3CB/4CB |                 |
| 4FGL J0407.5+0741 | 61.8921     | 7.6998       | TXS 0404+075        | LSP              | bll               | 1bzq/2bzq/3CB/ 4CB |                 |
| 4FGL J0433.1+3227 | 68.2897     | 32.4614      | NVSS J043307+322840 | HSP              | bll               | 1bzq/2bzq/3BCU/4CB |                 |
| 4FGL J1058.4+0133 | 164.6240    | 1.5641       | 4C +01.28           | LSP              | bll               | 1bzq/2bzb/3CB/4CB  |                 |

NOTE—The 4FGL name are presented in Column 1. Columns 2 and 3 are the J2000 coordinates. The counterpart names are listed in Column 4. Column 5 lists the optical class, column 4 is the spectral energy distribution (SED) class reported in 4FGL catalog, respectively. The optical class before and after the predictions (transition) in Zhang et al. (2022) are presented in Columns 7 and 8.

## 6. SUMMARY

In this work, the CLBsCat: An online Catalog for Changing-Look (Transition) Blazars is compiled. In the catalog, a total of 297 (33+47+2+157+58) forecast records were collected in Section 2, (also see Table 1, 2, 3, and 4). where, 33 LSP BL Lacs predicted as possible FSRQs in Fan & Wu (2019); 47 LSP BL Lacs predicted as possible FSRQs in Cheng et al. (2022); 2 LSP BL Lacs predicted as possible FSRQs in Pei et al. (2022); and 215 LSP BL Lacs predicted as potential FSRQs in Kang et al. 2022, including 157 possible FSRQs and 58 unknown sources without a clear prediction (see, Table ??).

In Section 3, based on the transition between the standard FSRQs and BL Lac types (EW-based classification), a total of 60 (26+11+6+11+6) records for the CLBs confirmed by EW changes of spectral emission lines are collected. Where, 26 CLBs reported in Peña-Herazo et al. (2021), 9 of 11 changing-look AGNs are CLBs reported in Foschini et al. (2021), and 6 transition sources (CLB type) reported in Ruan et al. (2014), 11 transition sources (CLB type) reported in Shaw et al. (2012), 6 transition sources (CLB type) reported in Ghisellini et al. (2011).

Other CLBs (transition sources)

Furthermore, the ‘blue quasars’ (e.g., Blue Fermi flat spectrum radio quasars) are also shown in the catalog (see Section 4).

**Note:**

In addition, in order to describe as accurately as possible, some sentences are directly copied from the original text.

During the collection and sorting process, we try to check every detail, however, errors, omissions, errata, etc. are inevitable, please do not hesitate to enlighten me, thank you, thank you.

Finally, we hope that our manuscript will be helpful and beneficial to you.

Research on CLBs is ongoing. A detailed in-depth discussion of it is in progress.

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*Facilities:* Fermi(LAT), Swift(XRT and UVOT), AAVSO, CTIO:1.3m, CTIO:1.5m,CXO

*Software:* R (R Core Team 2022), FITSio package (Harris 2021), astrolibR package (Chakraborty et al. 2014), reshape package (Wickham 2007)

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