

Investigation of Extragalactic Radio Sources by Cross-Matching of Radio Catalogs

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Abstract. To search for variable radio sources, we used two well-known radio catalogs NVSS and FIRST, both providing fluxes at 1400 MHz. Cross-correlation enabled us to find 556,282 radio sources present in both catalogs. Using the 3σ criteria we distinguished 6,301 variable radio sources, and with certain limitations specified the 260 strongest radio variables. We cross-correlated these 260 sources with other catalogs at different wavelengths (APM, SDSS DR10, VCV-13, BZCAT, 2MASS, and WISE). As a result we obtained photometric data for optical, NIR, MIR and radio ranges for these 260 variable radio sources to study them in details.

Keywords. radio catalogs, cross-matching, variable radio sources, AGN, blazars

NVSS catalog (Condon *et al.* 1998) contains 1,773,484 sources down to sensitivity 2.5 mJy over a surface $\sim 34,000$ deg² with accuracy of 15 arcsec rms. FIRST (online version 2012Feb16, Becker *et al.* 2012) contains 946,464 sources down to sensitivity 1 mJy over a surface $\sim 10,000$ deg² with accuracy of 5 arcsec rms. We cross-correlated these 2 catalogs using new software (<http://arvo.sci.am/crosscorrelation/crosscor.html>), where accuracies of each source are taken into account. As a result, we obtained 556,282 identifications present in both catalogs. We divided them into 2 parts. We included in the first group those, which have only one identification and which was within 1 sigma. In the second group, we included all another identifications. In the second group we can distinguish sources having several identifications (1 source in NVSS and a few sources in FIRST). In future these data will be used to understand the radio structure of many sources and some physical parameters of these structures.

For further investigations we have taken the first part of identified sources. In NVSS and FIRST catalogs we have fluxes and errors of fluxes at 1400 MHz for each source. Using these data we distinguish identifications that have statistically different fluxes. We separate identifications using the following formula:

$$3\sigma(\text{NVSS}/\text{FIRST}) = 3*\text{rms}(\text{NVSS}) + 3*\text{rms}(\text{FIRST})$$

As variables, we take those identifications having differences of fluxes more than 3σ . From the distribution of sources by the differences of NVSS/FIRST fluxes (Fig. 1), one could conclude that the source is variable in radio wavalengths if the flux difference is more than 15 mJy. We have 6,301 such radio variable sources. As a pilot survey, for a strong selection we take sources with difference more than 200 mJy. There are 260 such strongly variable radio sources.

To match the radio variability with the nature of sources, we cross-corellated our list of 260 sources with the following catalogs: APM (McMahon *et al.* 2000), SDSS DR10 (Ahn *et al.* 2013), Catalogue of QSOs and Active Galaxies (VCV-13, Veron-Cetty & Veron 2010), Rome Blazar Catalogue (BZCAT, Massaro *et al.* 2009), NED, and WISE (Cutri *et al.* 2012) and found 125 known objects having classification (however, only

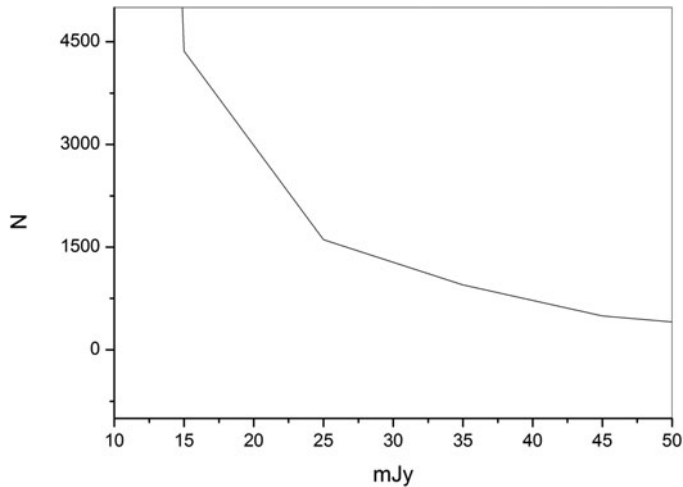


Figure 1. Distribution of radio sources by flux differences between FIRST and NVSS

20 sources have BZCAT identifications). Data on other 135 variable radio sources are absent. Now we are able to carry out investigations of these known sources according to their classifications as follows:

- S3+S2+S1.9 – 16
- S1+S1.2+S1.5 – 20
- QSO – 36
- Blazar (HP, BL) – 19
- Other objects – 34
- All known objects – 125

We assumed that blazars should have higher average flux differences than other sources, however it appeared that the picture is opposite, which was rather strange: blazars and quasars have lower variability than Seyfert galaxies, and among the latter ones less luminous Seyferts (Sy 1.8, Sy 1.9 and Sy 2) and LINERs have higher radio variability.

For the 260 sources we also retrieved data from WISE (Cutri *et al.* 2012) having data in 4 wavelength (3.35, 4.6, 11.6 and 22.1 μm), as well as 2MASS data are included (fluxes at 1.25, 1.65 and 2.17 μm). We built SED for each variable radio source having 16 photometric points from optical wavelengths to radio. The preliminary studies show that the distribution is almost the same for all 260 sources. Our next step is to study the whole sample of 6,301 variable radio sources with better statistics.

References

- Ahn, C. P., Alexandroff, R., Allende Prieto, C., *et al.* 2013, *ApJS*, in press.
- Becker R. H., Helfand D. J., White R. L., *et al.* 2012, *ApJ* 475, 479 (1997), VizieR online version 2012Feb16
- Condon J. J., Cotton W. D., Greisen E. W., *et al.* 1998, *AJ* 115, 1693
- Cutri R. M., Wright E. L., Conrow T., *et al.* 2012, *WISE All-Sky Data Release, IPAC/Caltech, VizieR On-line Data Catalog II/311*
- Massaro E., Giommi P., Leto C., *et al.* 2009, *A&A* 495, 691
- &McMahon, R. G., Irwin, M. J., Maddox, S. J., 2000, *IoA*, Cambridge, UK
- Veron-Cetty M. P., Veron P. 2010, *A&A* 518, A10