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VLBI Data Structure, Analysis Strategies and Software

Optical Characteristics of Astrometric Radio Sources

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Abstract. A new list of physical characteristics of 3914 astrometric radio sources, including all the 717 ICRF-Ext.2 sources, observed during IVS and NRAO VCS sessions have been compiled. The source list was taken from the Goddard VLBI astrometric catalog astro_2007c with addition of two ICRF-Ext.2 sources. At this stage the source characteristics were mainly taken from the NASA/IPAC Extragalactic Database (NED). Our list includes source type, redshift and visual magnitude (if available). In case of doubt detailed comment is provided. 667 sources from our list are included into the IERS list. Comparison of two lists has shown a significant difference in characteristics for about half of common sources. A list of frequently observed sources without known physical characteristics for urgent observations with large optical telescopes has been compiled.

1. Introduction

Information on physical characteristics of the geodetic radio sources is important for planning of VLBI experiments and analysis of VLBI data to do researches in cosmology, etc. In particular, the primary mainspring to this work was a support of the investigation of the systematic effects in apparent proper motion of geodetic radio sources [1–4].

The official list of the physical characteristics of the ICRF radio sources is supported by the IERS ICRS Product Center ([5]). The latest version of the IERS list is available in the Internet[1]. However this list has some deficiencies:

- Not all the sources observed in the framework of geodetic and astrometric experiments are included in the IERS list.
- The characteristics of some sources in the IERS list are outdated or doubtful.

[1]http://hpiers.obspm.fr/icrs-pc/info/car_physique_ext1

To overcome this problems, we performed a compilation of new list of the physical characteristics of all geodetic radio sources observed in the framework of the IVS and VCS programs using the latest information. In this paper we present our result of the first stage of this work.

The list of radio sources with their positions was taken from the Goddard VLBI astrometric catalog[2], version 2007c, with removing duplicate source 1616+85A (L.Petrov, private communication) and addition of two ICRF-Ext.2 [6] sources 1039-474 and 1329-665 not included in the Goddard catalog. This results in 3914 geodetic radio sources in total.

At this stage mainly the NASA/IPAC Extragalactic Database (NED)[3] was scoured for geodetic radio sources. Some of them were also checked with the CfA-Arizona Space Telescope LEns Survey (CASTLES)[4] and the HyperLeda[5] databases. We have included in our list only photometric and spectral optical characteristics, such as source type, redshift and visual magnitude. The source flux parameters are not included in our list because they are available from other sources.

2. List Description

As mentioned above, our primary interest was to collect all available redshift (z) determinations for for sources observed in the framework of the IVS and cooperative programs, such as VLBA Calibrator Surveys (VCS), to develop the previous studies on the quasar apparent proper motions [1–4]. In those papers, redshift values were taken from the ICRF list [5]. However, as rather tiny effects in the source motions are to be investigated, it is important to increase the number of sources involved in the processing. Searching the latest astrophysical databases, primarily the NED, we could considerably augment the list of geodetic radio sources with known redshift. Nevertheless, more than half of the geodetic radio sources have no measured redshift so far.

Evidently, the only direct way to get the redshift for other most frequently observed geodetic sources is to organize a dedicated observing program with large optical telescopes. The top list of the most frequently observed geodetic radio sources, for which measured redshift was not found, includes 0718+792, 1300+580, 1357+769, 1923+210, 0556+238, 0656+082, 0657+172, 1221+809. To help in preparation of such a program, we also collect the source type and its visual magnitude for radio sources if this information is available. Also, it makes a sense to include in this observational program those sources with existing but inaccurately measured redshift. The relevant comments are added to our list.

It should be noted, that not all geodetic radio sources were reliably identified in the NED. We use the following identification procedure. In the first step,

[2]http://vlbi.gsfc.nasa.gov/solutions/astro
[3]http://nedwww.ipac.caltech.edu/
[4]http://cfa-www.harvard.edu/glensdata/
[5]http://leda.univ-lyon1.fr/

we search for sources by source name using 'ICRF' and 'IVS' prefix. So, we rely on the source identification used in the literature and provided by the NED staff. Then about 500 sources, mostly from the VCS6 list, were searched by position. We took into account the angular distance between the VLBI and NED positions as well as the position uncertainty in the VLBI and NED catalogues. For some sources multiply NED objects within the error level were found. For 16 sources no appropriate objects were found in the NED, which is mentioned in the list comments. The problem of the source identification in the NED and other astrophysical databases hopefully will be solved once the VCS6 results are officially published and incorporated in the NED and other astronomical databases.

The list of optical characteristics of the geodetic radio sources is available at `http://www.gao.spb.ru/english/as/ac_vlbi/sou_car.dat`. Besides a common description, the following info for every source is given: IERS and IVS (if differs from IERS) source name, position, redshift (if available), visual magnitude (if available), source type (if available, otherwise, 'R' type is quoted), and comments.

3. Statistics

The overall statistics of the new list is the following.

Number of sources:

total		3914 (100%)
ICRF	717 (18.3%)	
N	2376 (60.7%)	
S	1538 (39.3%)	
with known type		2369 (60.5%)
AGN	1581 (66.7%)	
galaxy	461 (19.5%)	
other	327 (13.8%)	
with known redshift		1790 (45.7%)
≤ 1	825 (46.1%)	
> 1	965 (53.9%)	
N	1185 (66.2%)	
S	605 (33.8%)	
with known visual magnitude		2300 (58.8%)
with known both z and magnitude		1739 (44.4%)
with known z or magnitude		2351 (60.1%)
with known magnitude and unknown z		561 (14.3%)
without characteristics		1563 (39.9%)

Figure 1 shows the distribution of the sources with known redshift, and Figure 2 shows the distribution of the visual magnitude. The right part of Fig. 2 gives an impression about the magnitude of the sources, for which redshift yet not determined.

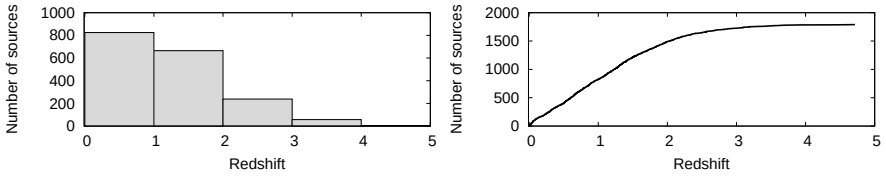

Figure 1. Distribution of the redshift (*left*) and cumulative number of sources (*right*).

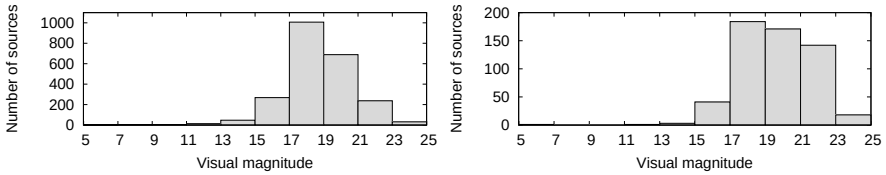

Figure 2. Distribution of the visual magnitude for all sources (*left*) and for sources without known redshift (*right*).

4. Comparison with the IERS List

We have compared the new list with the IERS list of 667 sources. All the 667 IERS sources are in our list. Comparison of these two lists results in rather large discrepancy.

- The first evident difference is in the number of sources: 3914 vs. 667 objects in total, 2351 vs. 555 objects with known redshift or visual magnitude. Our list contains 40 extra ICRF sources plus several hundreds other sources.
- Unlike the authors of the IERS list, we did not try to trace all the details of the Active Galactic Nuclei (AGN) classification that is not always stable and unambiguous. So, all the quasars and BL object are designated as AGN.
- Redshifts for 55 more ICRF sources were found; redshifts for 4 sources presented in the IERS list were not included in our list for various reasons; for 30 sources redshift differs more than by 0.01; the largest differences are 1.26 (1903-802), 1.20 (1600+431), 0.70 (0646-306).
- Visual magnitudes for 70 more ICRF sources were found; for 2 sources magnitudes were not confirmed in our list; for 195 sources magnitudes differ more than by 0.5; the largest differences are 5.2 (1758-651), 5.0 (1156-094, 1322-427), 3.9 (0241+622).

5. Conclusion

A new extended list of optical characteristics of the geodetic radio sources has been compiled. This is only the first stage of our work. We are planning the following steps:

- To continue a search for the missing characteristics through literature and astronomical databases.
- To continue a verification of the ambiguous characteristics through literature and astronomical databases.
- To organize photometric and spectroscopy observations of geodetic radio sources with missing redshift using large optical telescopes. In particular, such an observational program has been included in the plan of the Pulkovo Observatory for 2008. The application for observation time on the Russian 6-meter BTA telescope for the second half of 2008 was handed over in cooperation with Pulkovo astrophysicists Kirill Maslennikov and Alexandra Boldycheva.

The authors would be happy to know whether this new list is useful either as a database for VLBI data analysts or as a supplement material for the ICRF-2 compiling. We hope that this work will continue in cooperation with other interested groups.

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References

[1] Gwinn C.R., Eubanks T.M. , Pyne T., et al. Quasar proper motions and low-frequency gravitational waves. Astroph. J., **485**, 87–91, 1997.

[2] Macmillan, D.S. Quasar Apparent Proper Motion Observed by Geodetic VLBI Networks. In: ASP Conference Proceedings, **340**, 477–481, 2005.

[3] Titov, O. Proper motions of reference radio sources. Journees 2007, Paris, France, September 17-19.

[4] Titov, O. Systematic Effects in Apparent Proper Motions of Radio Sources. This volume.

[5] Archinal, B.A., Arias, E.F., Gontier, A.-M., Mercuri-Moreau, C. Physical characteristics of radio sources. IERS Technical Notes No. 23, III-11–III-24, 1997.

[6] Fey, A.L., Ma C., Arias, E.F., et al. The second extension of the International Celestial Reference Frame: ICRF-Ext.2. Astron. J., **127**, No. 6, 3587–3608, 2004.