THE UPDATE OF THE LARGE QUASAR ASTROMETRIC CATALOG (LQAC)

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ABSTRACT. We present the characteristics of the Large Quasar Astrometric Catalog which gathers more than 180 000 objects in its second up-date (LQAC-2), insisting on its advantages: improved accuracy of the equatorial coordinates of the sources, extensive photometry, calculation of the absolute magnitudes, morphology indexes.

1. INTRODUCTION

Quasars a priori materialize quasi-inertial directions in space. For this reason they represent ideal objects for modern astrometry. As they are supposed to undergo no detectable proper motion on contrast to stars, they constitute the basis of a primary reference frame, as is the case of the ICRF2(Ma et al. 2009; Boboltz et al. 2010) from VLBI observations. Since the identification of the first quasar 3C273 by Maarten Schmidt in 1962 as an extragalactic radiosource with high redshift and the construction of the first quasars catalog by De Veny et al. (1971) containing 202 objects, the number of known quasars has steadily increased, in particular in the past decade, thanks to huge surveys like the 2dF QSOs survey (Croom et al. 2004) and for a large part to the Sloan Digital Sky Survey (Fan et al. 1999; Adelman-McCarthy et al. 2007). Nowadays the number of recorded quasars that can be compiled reach more than 180 000 objects. Considering this dramatic increase, once in a while one needs to gather all the quasars into a single catalog that is as homogeneous as possible. This has been done for a long time through several releases by Véron-Cetty and Véron from 1984 to 2010.

In parallel, Souchay et al. (2009) have constructed what they call the LQAC (Large Quasar Astrometric Catalogue), which can be considered as an alternative catalog to the one from Véron-Cetty & Véron (2006, 2010). Some interesting points can be found in the LQAC. First, it is oriented towards astrometric reliability and performance as its name shows it. For the sake of homogeneity, it systematically privileges large surveys over small catalogs. Second it is based on a compilation strategy related to the astrometric level of the constituent catalogs; in other words, when an object is available in two or more catalogs, only the positions (in terms of celestial coordinates) provided by the most accurate catalog are retained. Third the LQAC contains exhaustive information on the photometry of the objects, thanks to crossidentifications between the constituent catalogs as well as between large surveys such as the 2MASS catalog (Cutri et al. 2003), the USNO B1.0 catalog (Monet et al. 2003) or the GSC2.3 catalog (Lasker et al. 2008). Finally the LQAC determines the absolute magnitudes of quasars in both bands i and r, by using up-to-date models of galactic extinction and recent values of cosmological parameters.

2. THE LQAC-2 : AN IMPROVED VERSION OF THE LQAC

Several reasons led us to construct a new version of the LQAC, called the LQAC-2 (Souchay et al., 2012). At first we considered a significant amount of new data from different origins, such as the ICRF2 (Ma et al. 2009; Boboltz et al. 2010) and the VCS (Petrov et al. 2008) at radio wavelengths, as well as the 8th release (DR8) of the Sloan Digital Sky Survey at optical wavelengths (Aihara et al. 2011). A second important reason is the inclusion of equatorial coordinates of the quasars as determined from the LQRF (Large Quasar Reference Frame), which a priori gives a more accurate optical determination of

Catalog Name	Flag	Nature	Nbs of quasars (LQAC2)	Nbs. of quasars (LQAC)
ICRF	A	radio	3 414	717
VLBA	B	radio	5 198	3 357
VLA	C	radio	1 858	1 857
JVAS	D	radio	2 118	2 118
SDSS	E	optical	126 577	74 868
2QZ	F	optical	23 660	22 971
2df-SDSS LRG	G	optical	9 058	0
FIRST	H	radio	969	969
HB	I	opt. & radio	6 721	7 245
2MASS	J	infrared	25 252	13 647
GSC2.3	K	optical	154 900	91 061
B1.0	L	optical	148 894	81 662
V&V (-SDSS)	M	optic. & radio	80 667	85 189

Table 1: Characteristics of the catalogs participating to our compilation of quasars both for the LQAC-2 and the LQAC. From Souchay et al. (2012)

	VV2010	A-L	LQAC-2	%
QSO's	168941	165065	187504	100.00
z	168324	160399	183652	97.94
u	152624	156178	167983	89.58
b	32085	156799	164721	87.84
v	131934	75713	102774	54.81
g	0	134881	134881	71.93
r	3939	162910	166033	88.54
i	551	149735	150278	80.15
z	0	134884	134884	71.93
J	0	25252	25252	13.46
K	0	25252	25252	13.46
1.4 Ghz	18111	1814	11797	6.29
2.3 Ghz	0	3482	3482	1.85
5.0 Ghz	5809	863	5358	2.86
8.4 Ghz	0	4551	4551	2.43
24 Ghz	0	61	61	0.03

Table 2: Comparison of the number of entries for each data item between the VV2010 catalog, the compilation of the catalogues A-L of the LQAC-2 and the final LQAC-2 catalog. From Souchay et al. (2012)

celestial coordinates with respect to the ICRF, compared with those given by original catalogs, for a large percentage of objects (except of course those, a minority, observed with the VLBI technique). Finally another reason comes from a decision to densify the data compared to the first LQAC catalog. One of the adding items is a LQAC identification number based on the celestial coordinates of the objects. Another significant additional information is the determination of three kinds of indexes, there by allowing a morphological classification. These indexes are obtained by comparison to the average morphology of the surrounding stars, thus freed of image aberrations. They are obtained from B, R, I images and their first interpretation is to point out the signature of the host galaxy.

As mentioned above one of the important qualitative improvements of the LQAC-2 with respect to the LQAC is due to the inclusion for a large part of the sample of LQRF coordinates. This inclusion deserves some further explanations : the Large Quasar Reference Frame (LQRF) was built by Andrei et al.(2009) in order to give the positions of the LQAC quasars with an optimized accuracy with respect to the original catalogs, the care of avoiding incorrect matches of its constituents quasars, the homogenization of the astrometry from different catalogs and the aim of obtaining a milli-arcsecond global alignment with the ICRF, as well as typical individual source position accuracies higher than 100 mas (milliarcseconds).

The methodology for building the LQRF is the following one : starting from the updated and presumably complete Large Quasar Astrometric Catalog (LQAC) list of QSOs, the initial optical positions of the quasars were taken from the USNO B1.0 catalog (Monet et al. 2003), the GSC2.3 catalog(Lasker et al. 2008), and from the SDSS Data Release 5 (Adelman-McCarthy et al. 2007). Then, the initial positions were placed onto UCAC2-based reference frames (Zacharias et al.,2004), followed by an alignment with the ICRF, to which were added the most precise sources from the VLBA calibrator list and the VLA calibrator list (when reliable optical counterparts exist). Finally, the LQRF axes were inspected through spherical harmonics, to define right ascension, declination and magnitude terms. In its first version (Andrei et al.,2009) the LQRF contains 100.165 quasars, represented with a rather homogeneous spatial density across the sky, from -83° to +88.5° in declination. For these reasons it can be considered as a good densificiation of the ICRF, the average angular distance between adjacent elements being roughly 10 arcmins.

In Table 1 we show the comparison of the number of objects included in the LQAC-2 release with respect to the initial LQAC for each constituent catalog, represented by a flag, whose the meaning can

be found in Souchay et al. (2012) The ICRF referenced catalog is the ICRF2 (Ma et al.,2009) with 3414 radiosources instead of the 717 ones of the ICRF-Ext.2 (Fey et al.,2004). The largest contribution is by far the SDSS with 126 577 quasars to be compared with the 187 504 objects of the whole LQAC-2, that is to say roughly 67.5 %. Notice that the 2MASS, GSC2.3, and B1.0 catalogs do not add any quasar to the sample, but contribute significantly to the addition of photometric information for cross-identified quasars.

In Table 2,we show the comparative number of entries per item. The last column indicates the corresponding percentage of entries in the LQAC-2 compilation. For instance we can notice that 97.94 % of the recorded objects have an information concerning their redshift, but that the radio flux information does not exceed 6.3 % (at 1.4 Ghz). This small value is not surprising. We must remind that it is generally considered that roughly only 10 % of QSO's have a significant radio emission.

3. FUTURE PROSPECTS AND CONCLUSION

A compilation of all the known quasars as the LQAC(Souchay et al., 2009) and its new release, the LQAC-2 (Souchay et al., 2012) looks like a useful and fundamental tool given the importance of QSO's in astrometry in general. One of the important points in the LQAC compilations concerns the optimization of the determination of coordinates through the LQRF catalog, and also degree of completeness of the photometry through a systematic cross-identification between the constituents of the various catalogs belonging to the compilation.

A new release including a significant proportion of new objects is scheduled in 2014, in particular by including the DR9 up-date of the SDSS quasars catalog.

4. REFERENCES

Adelman-McCarthy, J. K., Ageros, M. A., Allam, S. S., et al. 2007, ApJS, 172, 634
Aihara, H., Prieto, C. A.., An, D., et al. 2011, ApJS, 193, 29
Andrei,A.H., Souchay, J., Zacharias, N. et al.,2009, AA 505,385A
Boboltz, D. A., Gaume, R. A., Fey, A. L., et al. 2010, BAAS, 42, 512
Croom, S.M., Smith, R.J., Boyle, B.J., et al. 2004, MNRAS, 349, 1397
Cutri, R.M., Skrutskie, M.F., van Dyk, S., et al. 2003, NASA/IPAC Infrared Science Archive, http://irsa.ipac.caltech.edu/applications/Gator/=20
De Veny, J. B., Osborn, W. H., =Janes, K. 1971, PASP, 83, 611
Fan, X., Strauss, M. A., Schneider, D. P., et al. 1999, AJ, 118, 1
Fey, A.L., Ma, C., Arias, E.F., et al. 2004, AJ, 127, 3587
Lasker, B. M., Lattanzi, M. G., McLean, B. J., et al. 2008, AJ, 136, 735
Ma, C., Arias, E. F., Bianco, G., et al. 2009, IERS Technical Note No. 35
Monet, D.G., Levine, S.E., Canzian, B., et al. 2003, AJ, 125, 984
Petrov, L., Kovalev, Y. Y., Fomalont, E., Gordon, D. 2008, AJ, 136, 580
Souchay, J.,Andrei, A.H., Barache, C. et al., 2009, AA 494,799
Souchay J., Andrei,A.H., Barache,C. et al., 2012, AA537,A99
Véron-Cetty, M.-P., & Véron, P. 2006, A&A, 455, 773
Vron-Cetty, M. P., Vron, P. 2010, AA, 518, A10
Zacharias, N., Urban, S. E., Zacharias, M. I., et al. 2004, AJ, 127, 3043