THE LQAC (LARGE QUASAR ASTROMETRIC CATALOGUE): PRINCIPLE OF COMPILATION AND RELATED STUDIES

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ABSTRACT. We have recently achieved at SYRTE (Paris Observatory) the construction of the Large Quasar Astrometric Catalogue (LQAC) including 113 666 objects (Souchay et al.,2008). The main purpose consisted in compiling all the quasars already discovered and archived in more than 200 individual catalogues, in a single file. We also added the maximum of information concerning the redshifts, the photometry and the radio fluxes. We were very careful at giving the best determination for the celestial coordinates of the quasars. We show some results related to cross-identifications and completeness of information. A catalogue like the LQAC will be undoubtedly very useful for the preparation of the GAIA mission.

1.INTRODUCTION

A new era appeared in the fields of astrometry in 1988, when the IAU decided to adopt the ICRF (International Celestial Reference Frame) as the reference frame to be conventionally chosen by the astromomical community. The ICRF in its original version is a set of 212 quasars which have been intensively studied with the VLBI (Very Long Baseline Interferometry) technique, and which offers all the guarantees of astrometric stability (Ma et al.,1998): in other words, their relative displacements perpendicular to the line of sight are negligible so that they can be considered as quasi inertial objects. This is due to their very far distance (typically of the order of several billion light-years), although their recession speed (and also their transversal one) is significant with respect to the speed of light.

Therefore any newly discovered quasar is potentially dedicated to astrometric purpose. Thus the discovery of new quasars at present time and in the future is a real challenge for modern astrometry. Generally a density of several tens of astrometric standards per square degree is required in order to determine with the best accuracy the positions of all the objects of a given field in the sky. With the dramatic sensitivity of new astronomical techniques, it is already possible to reach this density for quasars in some given selected celestial fields. Thus we believe that in the near future a good part of the celestial sphere will be covered by a large number of quasars so that a direct astrometric calibration with the help of these extragalactic quasi inertial targets will be possible at a large scale.

2. LARGE SURVEYS AND QUASARS CATALOGUES

The number of newly discovered quasars increases year after year in an exponential way thanks to the arrival of very large and deep surveys as the SDSS (Sloan Digital Sky Survey) and the 2-degree Field quasar Redshift Survey (2dF). The Sloan Digital Sky Survey (Adelman-McCarthy et al., 2007) covers one quarter of the sky observed from a dedicated 2.5 m telescope located at Apache Point, New Mexico. Images of the explored zone were obtained at seven bandwidths, namely u,b,v,g,r,i,z, that is to say from the ultraviolet cutoff to the near infrared, and the redshifts were determined precisely from spectroscopic complementary measurements. The typical accuracy per coordinate of the positions of the quasars of the SDSS are typically 45 mas (milliarcseconds) when measured against the USNO Astrograph catalogue and 75 mas when measured against Tycho 2 (Pier et al., 2003). The 5th release of the SDSS contains 74 868 objects whereas the DR6 release contains several additional thousands of objects. The 2dF quasar redshift survey, quoted as 2QZ (Croom et al.,2004) is based on a pre-selection of quasars candidates from well defined criteria based on broadband u, b,r photometric measurements obtained from plate scanning of UKST photographic plates. It contains 22 971 quasars. The SDSS and 2QZ quasars catalogues are by far the densest of a very large set of other quasars catalogues : more than 200 can be counted for which

	VV06	A–L	LQAC	% of completness
u	74 367	96 343	**99 665**	87.8
b	79 488	96 253	**106 801**	93.9
v	54 542	48 466	**75 396**	66.3
g	0	74 862	**74 862**	65.9
r	1 540	99 537	**100 811**	88.7
i	101	86 143	**86 238**	75.9
z	0	74 861	**74 861**	65.9
J	9	13 647	**13 656**	12.0
K	3	13 647	**13 650**	12.0
1.4 GHz	8 405	1 811	**8 934**	7.8
2.3 GHz	0	3 234	**3 234**	2.8
5.0 GHz	3 585	862	**3 951**	3.4
8.4 GHz	0	3 858	**3 858**	3.3
24 GHz	0	61	**61**	0.0
redshift	85 182	101 535	**110 745**	97.4

Table 1: Number of entries per item for the following catalogues: VV06, A–L, and final LQAC. The difference between the 4th and the 3rd column gives the contribution of VV06 to the LQAC.

the number of objects range from a few ones to several hundreds (see the CDS website).

3. THE L.Q.A.C. (LARGE QUASAR ASTROMETRIC CATALOGUE

We have recently achieved the construction of the Large Quasar Astrometric Catalogue (LQAC) whose details can be found in Souchay et al.(2008). The LQAC consists in compiling a large majority of the overall population of recorded quasars at the present time. One of the goals consists in selecting the best astrometric determination of the equatorial coordinates (α,δ) with respect to the ICRF. In that aim we have selected a hierarchical order according to the astrometric quality of the catalogues in which the quasar could been found. In the case of cross-identifications between two or more catalogues, the a priori most trustable coordinates have been kept, according to the supposed accuracy of the catalogues involved.

Although the various catalogues contributing to the LQAC are quite inhomogeneous in term of number of objects, quality of astrometric determinations, number of photometric bandwidths etc... we have observed that more than 90 % of the total sample of the quasars compilated are found by gathering only 8 catalogues, which insures quite a good global homogeneity. In decreasing order of accuracy we have set a flag from "A" to "H" to these catalogues which are : the ICRF-Ext2 (flag "A", Fey et al.,2004)), the VLBA (flag"B", Beasley et al,2002), the VLA (flages "C" and "H"), the JVAS (flag "D", Wilkinson et al.,1998), the SDSS(flag "E", Adelman-Mc Carthy et al.,2007), the 2QZ (flag "F", Croom et al.,2004), the FIRST (flag "G", Gregg et al.,1996), and the Hewitt and Burbridge (flag "I",1993) catalogues. Note that the first four catalogues have been constructed from very precise radio measurements, at the level of the sub-milliarcsecond, from long or very long baseline interferometry (VLBI). One of the advantages of selecting a flag is to know directly, for a given quasar, all the catalogues in which it is included, as this can be viewed directly inside the final LQAC ASCII catalogue (Souchay et al.,2008). Note that 3 further very dense catalogues, the 2MASS (flage "J"), the GSC2.3 (flag "K") and the B1.0 (flag "L") were used not for the inclusion of additional quasars, but in order to complete the gaps in photometric information. the "M" flag is reserved to the quasars which are present in the Véron-Cetty and Véron (2006) release of their compiled catalogue.

The LQAC contains 113 666 quasars, and it is the largest compiled catalogue available now. Notice that this last number corresponds roughly to the number of stars in the Hipparcos catalogue release, which means that the average number of objects per square degree is about the same in the two cases.

	A	B	C	D	E	F	G	H	I	J	K	L
A	**716**	642	582	377	72	6	27	0	327	333	500	480
B	-	**3 355**	1 598	1 577	288	33	71	1	522	911	2034	1965
C	-	-	**1700**	1 272	203	10	52	0	413	576	1 133	1 090
D	-	-	-	**2 117**	253	6	53	0	287	547	1 306	1 267
E	-	-	-	-	**74 866**	2 053	553	4	1329	11 735	69 705	62 768
F	-	-	-	-	-	**22 965**	0	0	495	619	19 504	17 274
G	-	-	-	-	-	-	**966**	2	142	527	872	796
H	-	-	-	-	-	-	-	**154**	19	17	31	35
I	-	-	-	-	-	-	-	-	**7 142**	1 175	3 306	3 014
J	-	-	-	-	-	-	-	-	-	**13 647**	13 243	12 740
K	-	-	-	-	-	-	-	-	-	-	**91 061**	78 397
L	-	-	-	-	-	-	-	-	-	-	-	**81 662**

Table 2: The various catalogues participating to the quasars compilation named LQAC (Large Quasar Astrometric Catalogue) (Souchay et al.,2008). Each flag represents one of the catalogues involved. The nomenclature is the following one : (A) Icrf-Ext.2 (radio) ; (B) VLBA (radio) (C) VLA-015 (radio) (D) JVAS (radio) ; (E) SDSS (optical) ; (F) 2QZ (optical) ; (G)FIRST ; (H)VLA+015 ; (I) Hewitt and Burbridge ; (J) 2MASS ; (K) GSC2.3 ; (L) B1.0 ; (M) Véron-Cetty and Véron. The VLA has been divided into two parts : VLA-015 and VLA+015 according to the a priori accuracy of the determination of the celestial coordinates of the quasars (with respect to the 0".15 threshold). The number of common quasars of each cross-identification must be compared with the total number of quasars in the LQAC, i.e. 133 666 objects

	Mean (mas)		σ (mas)			
	$\Delta\alpha\cos\delta$	$\Delta\delta$	$\Delta\alpha\cos\delta$	$\Delta\delta$	N_1	N_2
VLBA	−0.010	0.039	0.767	0.585	94	4
VLA	−0.054	−0.009	1.025	1.391	63	10
JVAS	−3.287	−0.081	9.793	12.629	90	5
SDSS	1.210	−12.203	52.022	51.728	96	4
2QZ	86.242	45.991	193.667	181.214	98	3
FIRST	−30.282	0.010	286.750	319.342	96	3
HB	97.800	100.152	726.512	785.789	85	5
VV06	30.393	286.513	582.571	586.322	97	3

Table 3: Determination of the astrometric accuracy of the catalogues used in the LQAC. N_1 stands for the percentage of quasars remaining after a 3σ rejection threshold algorithm, and N_2 for the number of necessary iterations. Each catalogue has been compared with a compilation of the catalogues preceding it (the first one ICRF-Ext.2 is not indicated).

Thus we can imagine that at long term the absence of proper motion of quasars will certainly constitutes a great advantage with respect to stars as ideal astrometric standards.

In Table 1 we present the number of quasars per item (magnitude band, radio flux, redshift). We compare the Véron-Cetty and Véron (2006) release(noted VV06) with our compilation gathering only the quasars belonging to the 8 dense catalogues with flags A to I above (the VLA catalogue is represented by two flags) , and with magnitude information completed with the help of the catalogues J,K,L. Notice that objects belonging to the VV06 compilation and not present in our A to L compilation where added in order to have a completeness. A new flag "M" was given for these objects, with an identification number to determine the original catalogue or survey where it has been firstly detected.

When available, photometric informations were given at u,b,v,g,r,i,z, J,K optical and infrared bandwidths, and radio flux at 1.4 GHz, 2.3 Ghz, 5.0 Ghz, 8.4 Ghz and 24 Ghz. The percentage of quasars for which radio flux is available is very small in comparison of the whole sample. Notice that for a large majority of objects (97.4 %) the redshift is given. In addition to these informations we calculated the absolute magnitudes of the quasars M_i and M_b respectively at infrared and blue bandwidths. In that aim we used a very recent model of galactic extinction, of the K correction and of determination of the luminosity distance.

In Table 2, we represent the leading catalogues with flags from A to L participating to the LQAC compilation, with the number of cross-identifications between two given catalogues of this set.

In Table 3 we present the mean values and the residuals between the positions of quasars in a catalogue with a given flag with the positions of this same quasar given by the pre-compilation of a priori better catalogues in terms of astrometric accuracy.

We think that the LQAC (Souchay et al.,2008) and its future extensions through regular updates will be very useful for future investigations towards densest and most accurate celestial reference frames as well as a good preparatory work to the GAIA mission consisting in gathering the maximum of information with respect to the quasars which constitute the ideal objects for 21th Century astrometry.

4. REFERENCES

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