Meeting the LQAC

J. Souchay[1], C. Barache[1], S. Bouquillon[1], D. Suchet[1], M. Baudin[1], A.M. Gontier[1], S.Lambert [1], C. LePoncin-Lafitte[1], F. Taris[1], F.E. Arias[2] and Alexandre H. Andrei[3,4]

1(Observatoire de Paris/SYRTE), 2(Bureau International des Poids et Mesures), 3(Observatório do Valongo/UFRJ), 4(Observatório do Valongo/UFRJ)

Abstract

The LQAC (Large Quasar Astrometric Catalogue, Souchay et al., A&A 2009) is a compilation of astrometric position as well as physical information at optical and radio wavelengths for 113,666 quasars. Due to its aim of completeness in what concerns objects with reliable astrometry plus the ready available information and further references it is a valuable companion for observational, statistical and theoretical studies of quasars. Here we highlight three such investigations made during the development of the LQAC.

1- Double objects. The combination of astrometric and redshift accuracy enables to assess the rate of doubles and binary pairs in the densest LQAC regions, and to estimate the number of missing or faint objects in the less surveyed regions.

2- Mapping the color loci. As the LQAC contains up to 7 indications of magnitude for each object, and the range of redshift extends to 2.5 for a statistically large population, the effects of reddening can be traced for samples 10 times larger than on prior investigations.

3- Radio loud quasars. The population of radio loud quasars can be traced as belonging to particular loci in the color/color diagrams. This opens interesting venues on the physical models for these objects, at the same that suggests additional criteria to survey them.

The LQAC

Context. The huge and always increasing number of quasars reckoned from various sky surveys leads to a large quantity of data which brings various and inhomogeneous information in the fields of astrometry, photometry radio astronomy and spectroscopy

Aims. We make a general compilation of the largest number of recorded quasars obtained from all the existing catalogues, with their best position estimates and by retaining a lot of physical information available both at optical and radio wavelengths. Thus we construct a catalog compilation named LQAC (Large Quasar Astrometric Catalogue) which gives for each quasar the equatorial coordinates, multiband photometry, radio fluxes, redshift, luminosity distances and absolute magnitudes.

Methods. For the purpose we gather the 12 largest quasar catalogues, 4 ones from radio VLBI programs, 8 ones from optical surveys and we carry out systematical cross-identifications of the objects. Information concerning *u,b,v,g,r,i,z* photometry as well as redshift and radio fluxes at 1.4Ghz (20cm), 2.3Ghz (13cm), 5.0 Ghz (6cm), 8.4 Ghz (3.6cm) and 24Ghz (1.2cm) are given when available. A small proportion of remaining objects not reckoned by the 12 catalogues and included in the Véron-Cetty and Véron catalogues of quasars are added in our LQAC compilation, with a flag indicating their catalogue of origin.

Results. Our final catalogue contains 113 666 quasars which is more than 25% bigger than the number of quasars recorded in the last version of the Véron-Cetty and Véron (2006) catalogue, which was the densest compilation of quasars up to now. We discuss the external homogeneity of the data by comparing the equatorial coordinates, the redshifts and the magnitudes of objects belonging to two different catalogues. At last we use up-to-date cosmological parameters as well as recent models for galactic extinction and K-correction in order to evaluate at best the absolute magnitudes of the objects.

Table 4. Number of cross-identified objects between the catalogues belonging to the LQAC

Catalog Name	A	B	C	D	E	F	G	H	I	J	K	L	M
A (ICRF-Ext2)	**716**	642	582	377	72	6	27	0	327	333	500	480	401
B (VLBA)	-	**3 355**	1 598	1 577	288	33	71	1	522	911	2034	1965	1079
C (VLA-015)	-	-	**1700**	1 272	203	10	52	0	413	576	1 133	1 090	724
D (JVAS)	-	-	-	**2 117**	253	6	53	0	287	547	1 306	1 267	670
E(SDSS)	-	-	-	-	**74 866**	2 053	553	4	1329	11 735	69 705	62 768	52 261
F (2QZ)	-	-	-	-	-	**22 965**	0	0	495	619	19 504	17 274	20 922
G(FIRST)	-	-	-	-	-	-	**966**	2	142	527	872	796	869
H(VLA+015)	-	-	-	-	-	-	-	**154**	19	17	31	35	23
I(Hewitt and B.)	-	-	-	-	-	-	-	-	**7 142**	1 175	3 306	3 014	5879
J(2MASS)	-	-	-	-	-	-	-	-	-	**13 647**	13 243	12 740	5 932
K(GSC23)	-	-	-	-	-	-	-	-	-	-	**91 061**	78 397	65 786
L(B1.0)	-	-	-	-	-	-	-	-	-	-	-	**81 662**	56 730
M(Véron V.)	-	-	-	-	-	-	-	-	-	-	-	-	**85 189**

Table 5. Photometry and redhift informations available according to each optical catalogue of the LQAC compilation

Catalog Name	*u*	*b*	*v*	*g*	*r*	*i*	*z*	z
E(SDSS)	74 863	-	-	74 864	74 864	74 863	74 863	74 868
F (2QZ)	22 971	22 971	-	-	22 338	-	-	22 971
G(FIRST)	-	969	-	-	969	-	-	969
I(Hewitt and B.)	798	-	7 048	-	-	-	-	7 166
K(GSC2.3)	-	97 302	44 562	-	94 876	62 082	-	
L(B1.0)	-	80 262	-	-	79 380	61 051	-	-

Table 6. Infrared photometry and radio flux informations available according to corresponding catalogues of the LQAC compilation

Catalog Name	J	K	1.4Ghz	2.3Ghz	5.0Ghz	8.4Ghz	24Ghz
A (ICRF-Ext2)	-	-	-	-	-	-	-
B (VLBA)	-	-	-	3 235	-	3 226	-
C (VLA-015)	-	-	731	-	822	870	61
D (JVAS)	-	-	-	-	-	2 118	-
G(FIRST)	-	-	969	-	-	-	-
H(VLA+015)	-	-	149	-	41	17	-
J(2MASS)	15 059	13 059	-	-	-	-	-

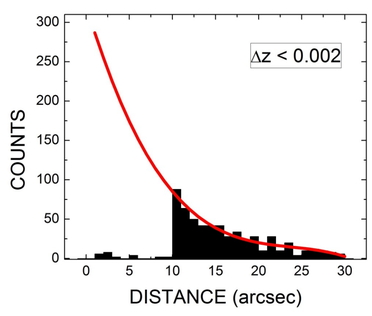
From left to right, the global presentation of the number of cross identifications found for each pair of catalogues among those which have participated of the LQAC construction; the number of entries of a given item concerning optical magnitude and redhift (Table 5), infrared magnitude and radio flux (Table 6), per catalog (Souchay et al., 2009). The most complete information is the redshift with about 94.4% of the total sample (113 666 QSO's).

_RAJ2000	_DEJ2000	Ref	Pg	Umag	Bmag	Vmag	Gmag	Rmag	Imag	Zmag	Jmag	Kmag	flux1_4G	flux2G	flux5G	flux8_4G	flux23G	redshift	rfr	distance	extinct_gal	correct_B	correct_I	magAbs_B	magAbs_I
250.72653688	21.20341869	----E----JKLM-------	--	17.702406	16.01	17.13	17.27614	16.953766	16.77373	16.781118	15.784	14.855	0.0020	0.0	0.0	0.0	0.0	1.53661	E	11098.584	0.052	-0.816	-0.862	-28.626	-27.699
250.7267	41.16998	--------I---M-------	--	0.0	18.8	18.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.03	I	15660.464	0.01	-0.969	-0.837	-26.247	0.0
250.72968652	21.30733838	----E-----KLM-------	--	20.320456	19.35	19.38	19.978046	19.921597	19.867561	19.58382	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.18187	E	17112.246	0.056	-1.069	-0.816	-25.988	-25.599
250.74277081	12.85260332	----E-----KL--------	--	19.94616	20.34	19.36	19.785933	19.594654	19.51155	19.437319	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.34198	E	9378.739	0.05	-0.697	-0.752	-24.039	-24.701
250.7436516	21.25690541	----E-----KLM-------	--	19.521046	17.68	19.36	19.412226	19.20777	19.124884	19.196247	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.14815	E	7722.77	0.054	-0.626	-0.667	-26.366	-24.76
250.745041	39.8102761	ABCDE-G-IJKLM-------	--	16.87622	16.19	15.96	16.55469	16.460108	16.26138	16.11226	14.255	12.398	8.0	5.66	7.8	5.31	0.0	0.593062	E	3411.603	0.013	-0.464	-0.393	-26.067	-26.037

The LQAC is at **http://cdsarc.u-strasbg.fr/viz-bin/qcat?lqac** *from CDS. There is also a LQAC extended results catalog in Votable format compatible with Astronomy OV Data Format and OV tools like Aladin, Topcat, Voplot. This version is still more complete than the ASCII one. All the original catalog references and nominal values (with uncertainties) are given for each data field (magnitude, redshift, radio flux) of a given quasar.*

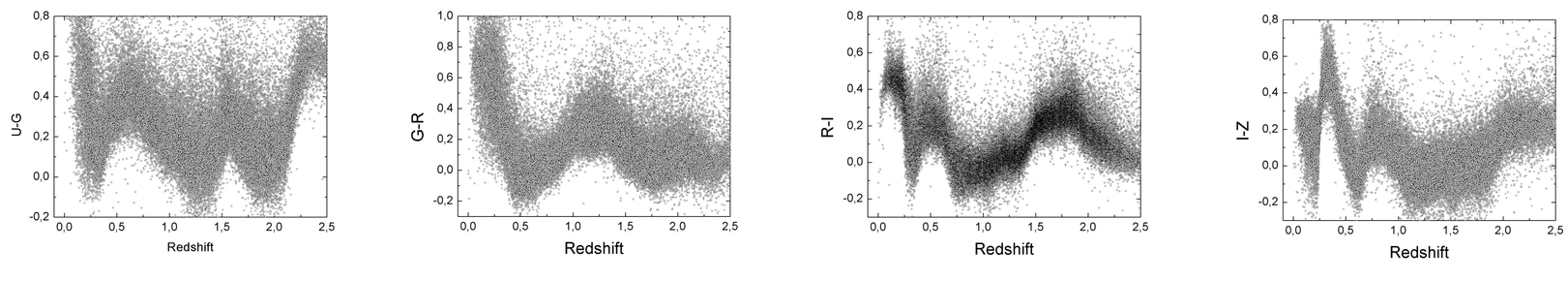
Double Objects

The probability rate of systemically linked quasars was examined by Hennawi et al. (2006). Such population rate was estimated at 10^{-3} from a SDSS sample. Andrei et al. (2006) found odds at a 10^{-2} ratio for both chance and systemically linked quasars based on a search at 2″ of any true object up to the 20*th* magnitude. As the LQAC combines surveys of very different astrometric precision, the authors had to be careful to prevent duplicity of entries. To this aim, close nearby objects of coincident redshift were filtered out. Nevedrtheless the LQAC completeness enables to estimate the actual rate of systemically linked quasars.



LQAC count for quasars closer up top 30 arcsec and with redshit coincident to 0.001. From the total LQAC compilation 296 pairs are found. However a negative bias is evident concerning objects closer than 10 arcsec (black columns histogram). Instead, the read line extrapolates the distribution as a second degree decay. In this case the total number of pairs increases to 1,122.

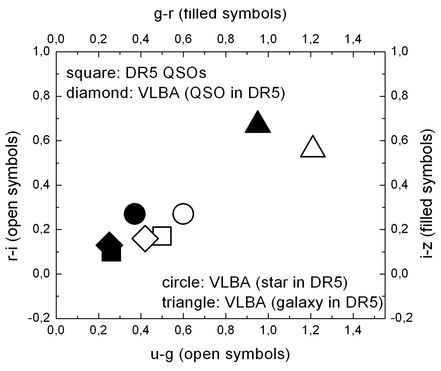
QSOs Color Loci and Reddening



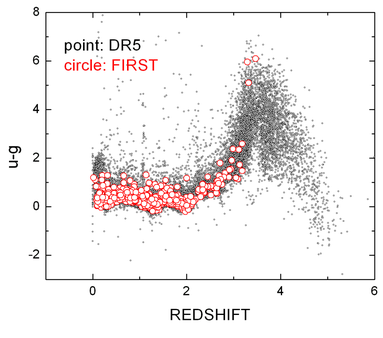
Plots revealing the effect of intrinsic reddening on the LQAC quasars (SDSS/dQz samples). The much larger distribution confirms the recent assumptions, by discarding QSOs with large magnitude errors and low confidence redshift. Here 62,061 quasars are plotted, while the prior (Hopkins et al., 2006) employed just 9,556 objects.

Radio Loud Quasars

The quasars color locci from the high sensitivity FIRST survey and from the radio loud only VCS calibrators sample were analyzed, It is suggested that the most suitable locus to find radio loud quasars is towards the bluer regions of the color/color spaces.



Two color-color planes are plotted. The (u-g) vs. (i-z) plane is shown by the bottom × left axes, and by open symbols. The (g-r) vs. (i-z) plane is shown by the top × right axis, and by filled symbols. The symbols represent the mean color locus of each category of sources. Squares are for the entire set of DR5 quasars; diamonds are for VLA sources identified in the DR5 as quasars.; circles are for VLA sources identified in the DR5 as stars.; triangles are for VLA sources identified in the DR5 as galaxies. Notice the coincidenceof squares and diamonds, whereas the circles and triangles stand apart always shifted to redder loci.



u-g vs. redshift distribution for the complete set of SDSS DR5 quasars (small points in background) and for the FIRST quasars (red circles in the foreground). Notice that the two distributions are in very good agreement.

Bibliography

Souchay, J.; Andrei, A. H.; Barache, C.; Bouquillon, S.; Gontier, A.-M.; Lambert, S. B.; Le Poncin-Lafitte, C.; Taris, F.; Arias, E. F.; Suchet, D.; Baudin, M.; 2009; A&A 494, 795

Andrei, A. H.; Souchay, J.; Zacharias, N.; Smart, R.L., Vieira Martins, R.; da Silva Neto, D.N.; Camargo, J.I.B.; Assafin, M.; Barache, C.; Bouquillon, S.; Penna, J.L.; Taris, F.; 2009; A&A submitted.

Andrei, A. H.; da Silva Neto, D. N.; Assafin, M.; Zacharias, N.; Vieira Martins, R.; Camargo, J. I. B.; Souchay, J.; de Melo, A. P. B.; 2006; IAU JD16, p5.

Hennawi, J.F.; Strauss, M.A.; Oguri, M.; Inada, N.; Richards, G.T.; Pindor, B.; Schneider, D.P.; Becker, R.H.; Gregg, M.D.; Hall, P.B.; Bahcall, N.A.; Brunner, R.J.; Brinkmann, J.; 2006; AJ 131, 1.

Hopkins, P.F.; Hernquist, L.; Cox, T.J.; Di Matteo, T.; Robertson, B.; Springel, V.; 2006; ApJ 163, 1.

Véron-Cetty, M.-P.; Véron, P., 2006; A&A 455, 773.