A GAIA ORIENTED ANALYSIS OF A LARGE SAMPLE OF QUASARS

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ABSTRACT. GAIA photometric capabilities should distinguish quasars to a high degree of certainty. With this, they should also be able to deliver a clean sample of quasars with a negligible trace of stellar contaminants. However, a purely photometric clean sample could miss a non negligible percentage of ICRF sources counterparts - and this interface is required to align with the ICRS and de-rotate the GCRF (GAIA Celestial Reference Frame), on grounds of continuity. To prepare a minimum clean sample forming the initial quasar catalogue for the GAIA mission, an all sky ensemble was formed containing 128,257 candidates. Among them there is at least one redshift determination for 98.75%, and at least one magnitude determination for 99.20%. The sources were collected from different optical and radio lists. We analyze the redshift, magnitude, and color distributions, their relationships, as well as their degree of completeness.

Complementary, the candidate sources enable to form an optical representation of the ICRS by its first principles, namely, kinematically non-rotating with respect to the ensemble of distant extragalactic objects, aligned to the mean equator and dynamical equinox of J2000, and realized by a list of adopted coordinates of extragalactic sources.

1. GAIA'S INITIAL QSO CATALOGUE AND CLEAN SAMPLE

The establishment of an initial quasar catalogue for the GAIA mission must fulfill criteria of quantity and sky distribution. The expected quantity of quasars to be detected by GAIA is of 400,000 objects or more, that is about four times the number of objects presently known. A much smaller number, between 6,000 to 10,000 (Mignard, 2001) is required for the definition of the fundamental frame. This sets the minimum requirements for the initial quasar catalogue clean sample, that is to zero level of contaminants. Since the all sky distribution (exempting the galactic disk) is also desirable, direct observations are out of question and the pre-existing quasar catalogues ought to be scrutinized. Figure 1 brings the schematics of the search strategy.

In practice, the major sources of known quasars are found in the following lists (i) Véron-Cetty & Véron (12th ed., 85,221 quasars with measured redshift); (ii) the SDSS DR5 release (74,869 quasars, selected from color criteria and confirmed through spectroscopic redshift); (iii) the 2dF 2QZ survey (22,655 quasars, selected from color criteria and confirmed through spectroscopic redshift); (iv) the ICRF and its extensions (717 radio-quasars and active galaxies); (v) the VLBA calibrator list (2005 version, 3,357 radio-flux stable quasars); (vi) the VLA calibrator list (2003 update, 1,860 radio-flux calibrators); (vii) the JVAS catalog (Jodrell Bank-VLA survey, 2,118 compact radio-sources); (viii) FIRST optical counterparts list (2,300 unresolved and 5,300 resolved stellar-like sources true matches with Cambridge APM scans of the POSS-I plates).

So, as the first step the common entries are sorted and a consolidated list is produced, including a

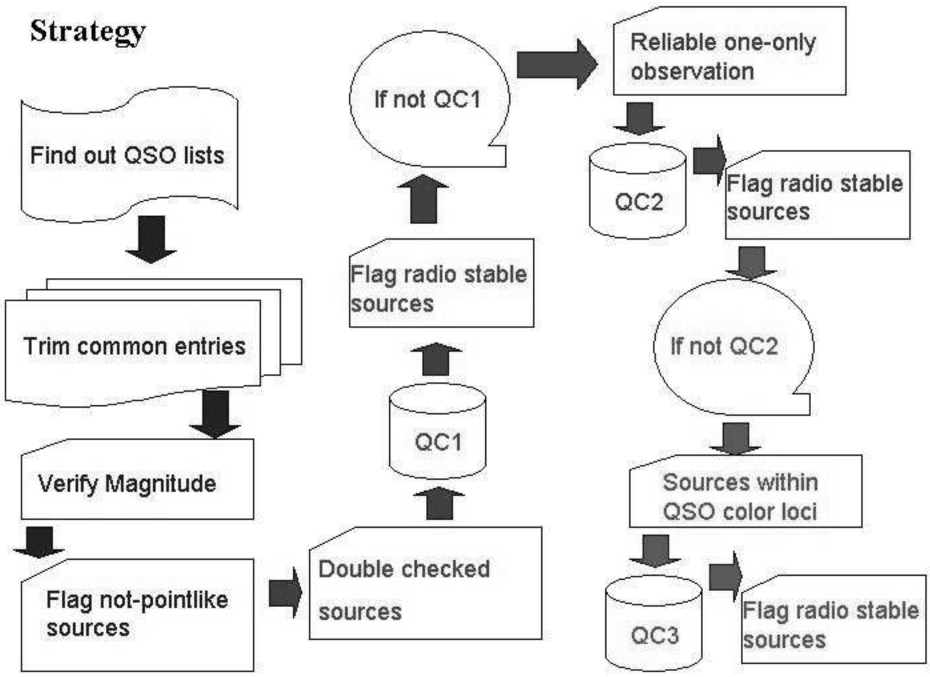

Figure 1: Schematics of the strategy of construction of the GAIA initial quasar catalogue and clean sample

reliability estimator and the radio astrometric accuracy. The consolidated list, plus details of redshift, multi-band magnitude and radio flux, is the aim of the VLQAC (Souchay et al., 2007) (see Table 1).

Since the consolidated list in none of its constituents derives from apparent magnitude limits in the G band, a check must then be performed to test each source G magnitude. The B1.0 and GSC2.3 catalogs present the whole sky complete up to magnitude V=20 (though reaching beyond in some zones). For most of the sky they contain the B, R, and I magnitudes, and so the G magnitude can be acceptably derived (Drimmel et al., 2005, have found that G $\approx$ R GSC) . With this the list is trimmed of its weaker sources (which will nevertheless be flagged as such and then kept), which would give rise to poor GAIA centroid determination.

Next, from available optical images, the objects PSF is compared to the stellar neighbors, in order to reject no point-like objects. Finally, the objects observational history is followed, to the effect of retaining a core of (at least) double-checked quasars. The objects passing through all checks form the clean sample. They are further flagged according to their history of stable radio emission.

However, the clean sample does not meet the even sky distribution desirable. In order to densify the initial quasar list the sources failing to enter the clean sample are included, and accordingly flagged to, based on two additional tests. The assured quality of the single observation reported. The placement in the QSO color loci. These additional criteria involve a one-by-one examination of sources resulting to a slower pace of each decision. Currently about one thousand of objects are being examined.

2. OPTICAL CELESTIAL REFERENCE FRAME

The construction of the OCRF (Optical Celestial Reference Frame) starts from the updated and presumably complete VLQAC (Very Large Quasar Catalog) list of QSOs, initial optical positions for those quasars are found in the USNO B1.0 and GSC23 catalogues, and from the SDSS Data Release 5. The initial positions are next placed onto UCAC2 based reference frames, following by an alignment to the ICRF, as represented by the optical counterpart of ICRF sources as well as of the most precise sources from the VLBA calibrator list and from the VLA calibrator list. Finally the OCRF axis are surveyed through spherical harmonics, contemplating right ascension, declination and magnitude terms.

The OCRF contains 105,000 quasars, well represented on all-sky basis, from -88.5 to $+89.5$ degree

Catalog Name	A	B	C	D	E	F	G	H	I	J	K
A (ICRF)	717	643	582	377	72	6	27	232	333	500	480
B (VLBA)	-	3,358	1,598	1,577	288	33	71	375	911	2,034	1,964
C (VLA)	-	-	1,702	1,272	203	10	52	308	576	1,133	1,090
D (JVAS)	-	-	-	2,110	253	6	53	238	547	1 306	1 267
E(SDSS)	-	-	-	-	74,885	2,053	553	1,316	11,736	69,705	62,764
F (2QZ)	-	-	-	-	-	22,974	0	479	619	19,508	17,277
G(FIRST)	-	-	-	-	-	-	972	141	528	874	798
H(H. & B.)	-	-	-	-	-	-	-	7,259	904	2,225	2,087
I(2MASS)	-	-	-	-	-	-	-	-	13,499	13,086	12,601
J(GSC23)	-	-	-	-	-	-	-	-	-	90,550	77,722
K(B1.0)	-	-	-	-	-	-	-	-	-	-	81,233

Table 1: Characteristics of the catalogs participating in the VLQAC.

of declination, and with 0.5deg as the average distance between adjacent elements. The global alignment to the ICRF is of 1.5mas, and the individual position accuracies are represented by 80mas + 0.1R (where R is the red magnitude). As a by product, significant equatorial corrections appear for all the used catalogues (but the SDSS DR5); an empirical magnitude correction can be discussed for the GSC23 intermediate and faint regimens; both the 2MASS and the preliminary northernmost UCAC2 positions show consistent astrometric precision; and the harmonic terms come out as always small.

The OCRF contains J2000 referred equatorial coordinates, and is completed by redshift and photometry information from the VLQAC. It is aimed to be an astrometric frame, and the basis for the GAIA mission initial quasars' list. It can be used as a test bench for quasars' space distribution and luminosity function tests. The OCRF is meant to be updated when of the release of new quasar identifications and newer versions of the used astrometric frames. In the later case it can itself be used to examine the interrelations between those frames.

Figure 2 brings the performance of the local astrometric correction by the UCAC2, in the left plot; the performance of the different director cosines rotations onto the VLBI frame, in the central plot; and the amplitude of the spherical harmonics, in the right plot.

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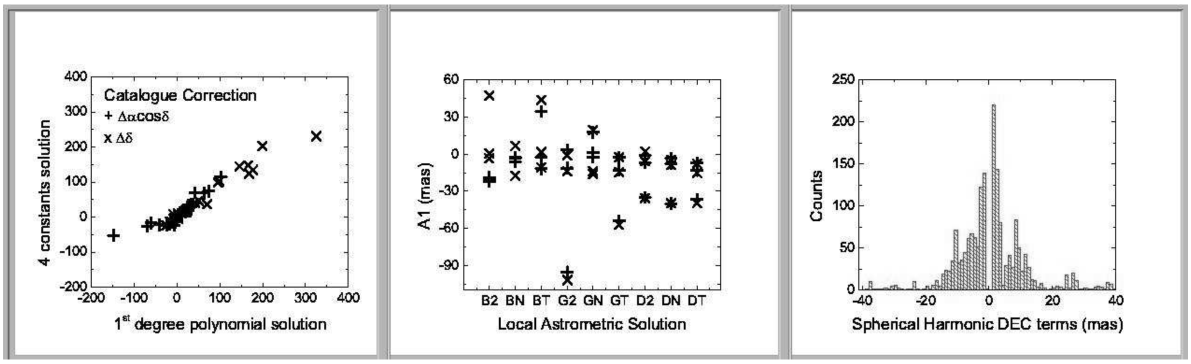

Figure 2: In the left plot, a comparison between the two representations used for the local astrometric correction towards the UCAC2 based frames. In the central plot, values obtained for the orientation angle A1 (rotation about the polar axis) from the different input (B-USNO B1.0, G- GSC23, D-SDSS DR5), different sets of coordinates (A, DEC, and both), and different local astrometric corrections ("+" $1s^{st}$ degree and "x" 4 constants). In the right plot, the amplitude of the significant spherical harmonics terms affecting the declination coordinates (the plot for RA is similar).

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