

Strengthening the ICRS optical link in the northern hemisphere

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Aims

- To investigate the link between the International Celestial Reference Frame (ICRF) and its optical Hipparcos-based representation on the northern hemisphere;
- Astrometry of the optical bright quasars with high accuracy; astrometric positions extracted from Large Quasars Astrometric Catalogue – LQAC (Souhay et al 2009).

Tools

- -The link between the ICRF and Hipparcos Catalog Reference Frame (HCRF) was investigated by direct astrometry of ICRF optical counterparts;
- -More recently, using the best available representation of HCRF - the UCAC2 catalog, precise optical astrometry of ICRF sources was performed in both southern (Assafin et al.2005) and northern (Assafin et al. 2007) hemispheres;
- -CCD astrometry using small telescopes, available for long term programs furnish FOVs with significantly less distortion and it is easier to observe the relatively brighter reference stars and the fainter targets within the linear range of CCD detectors.

Current achievements

- In 2005 Astronomical Institute of the Romanian Academy has started an observational program using the 0.6m Belogradchick Zeiss Telescope (Bulgaria);
- 59 astrometric positions of ICRF optical counterparts were obtained with average values of the optical – radio offsets of +6 mas and +7mas in R.A. and declination and standard deviations of 51mas and 57mas respectively;
- A total of 113 quasars were observed with an average of 22 CCD images per source (Apogee AP47P, FOV 6.7' x 6.7', 1kx1k CCD camera, in work 2005-2007);
- For 54 fields the quasar was too faint (the limiting magnitude was 20) or not enough UCAC2 reference stars were found in the field;
- Position reductions were made with the new astrometric package, **PRAIA** (Platform for Reduction of Astronomical Images Astrometrically; Assafin 2006);
- A new, larger format, ProLine PL-4240-1-B Back-illuminated, CCD Sensor e2v 4240, Grade 1, 2kx2k, fast download CCD camera was installed (in work from 2008). In 2x2 binning mode the FOV is 12'x12' with a pixel scale of 0.764".

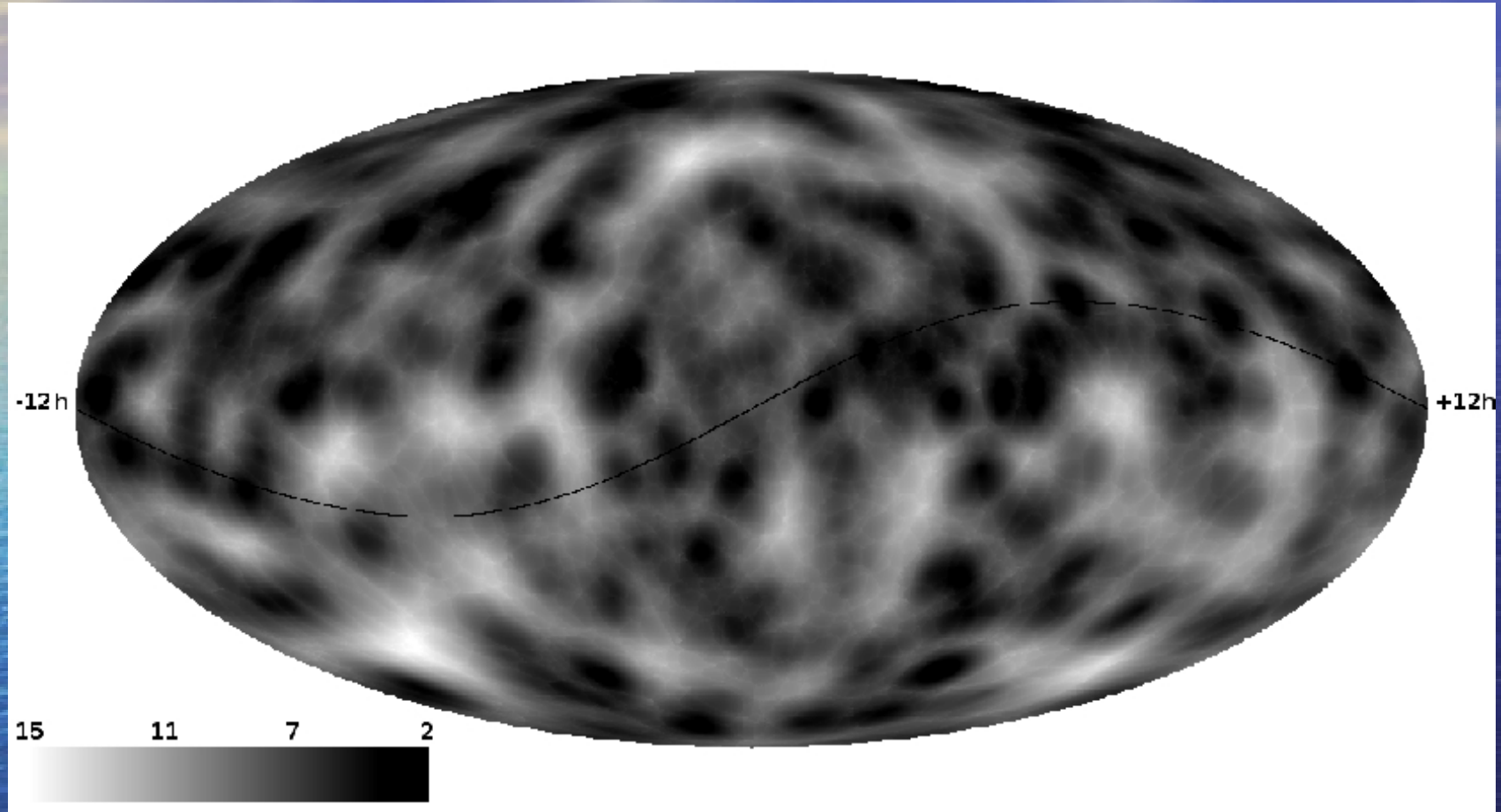
Large Quasar Astrometric Catalog LQAC (Souchay et al 2009)

- The radio-stars astrometry programs has to be extended to include additionally quasars having good astrometric positions;
- Large Quasar Astrometric Survey (LQAC) is a compiled catalogue aiming to provide a homogenous description of the largest 12 quasars catalogues;
- It includes 4 catalogs from radio interferometry programs and 8 from optical surveys;
- It provides the quasars' best position estimates and includes physical information in both optical and radio domains;
- With 113666 quasars included, it is currently the largest compiled catalogue;
- The coordinates of all the objects are given with the best accuracy with the existing catalogues ranked according to their astrometric quality;
- Three catalogues, ICRF-Ext.2, VLBA/VCS and VLA were designated in the LQAC by the flags A, B and C in the decreasing order of their astrometric accuracy;

Large Quasar Astrometric Catalog LQAC (Souhay et al 2009)

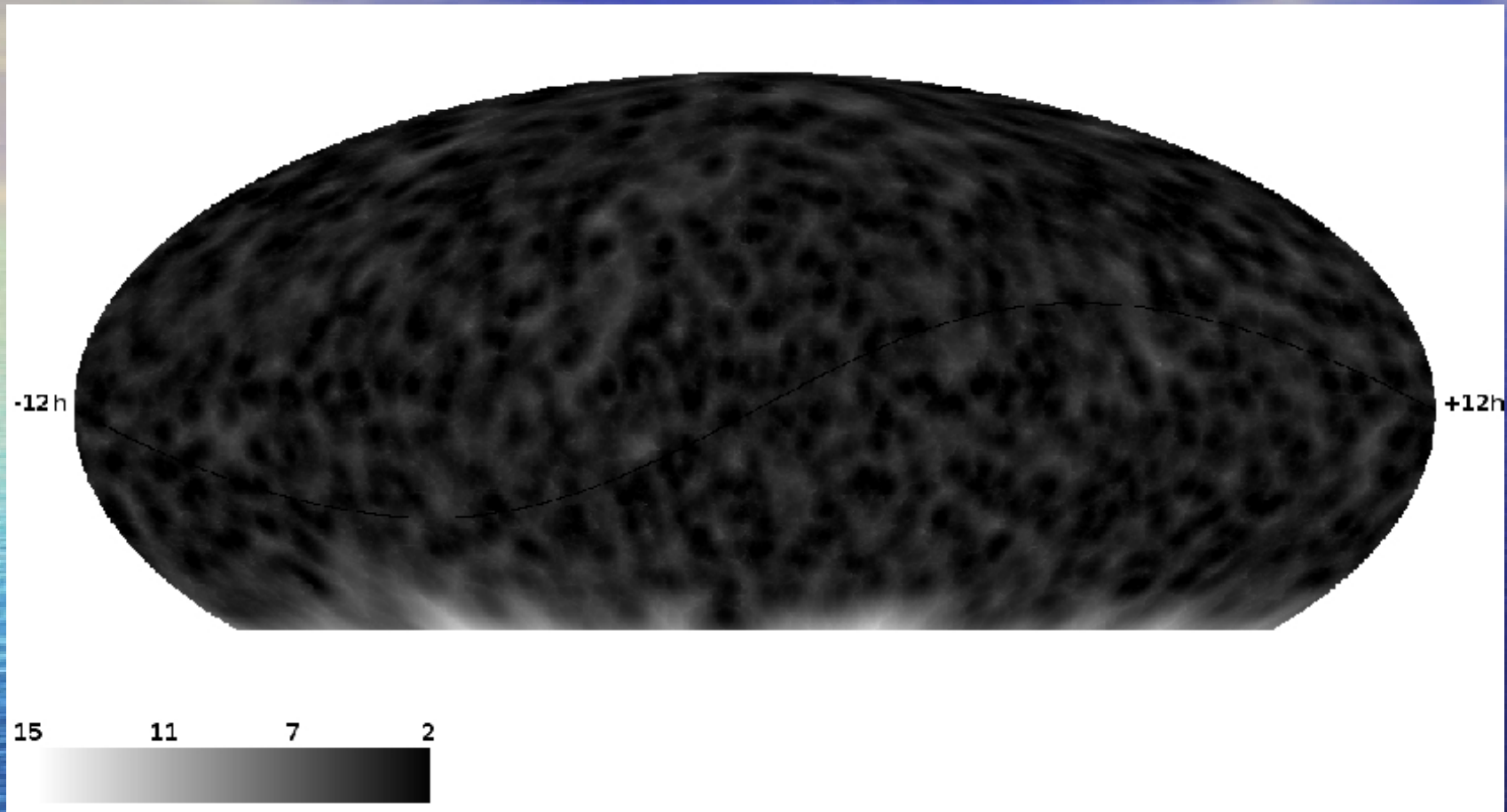
- With a total of 3530 (uniquely identified) quasars having astrometric positions accurate to miliarcsecond level these 3 catalogs are useful for future investigations on the construction of a denser celestial reference frame at optical and radio wavelength and on the connection between the optical, radio and dynamical reference frame;
- We have estimated the sky density of these 3 catalogs by conventionally defining a sky-coverage metric as the average distance to the nearest 5 sources;
- This sky density provides direct information on the number of the quasi-inertial reference points available for differential astrometry in a given region of the sky;
- It also identifies the low-density area that need future improvement of the celestial reference frame in terms of astrometric quality and density.

ICRF-Ext2



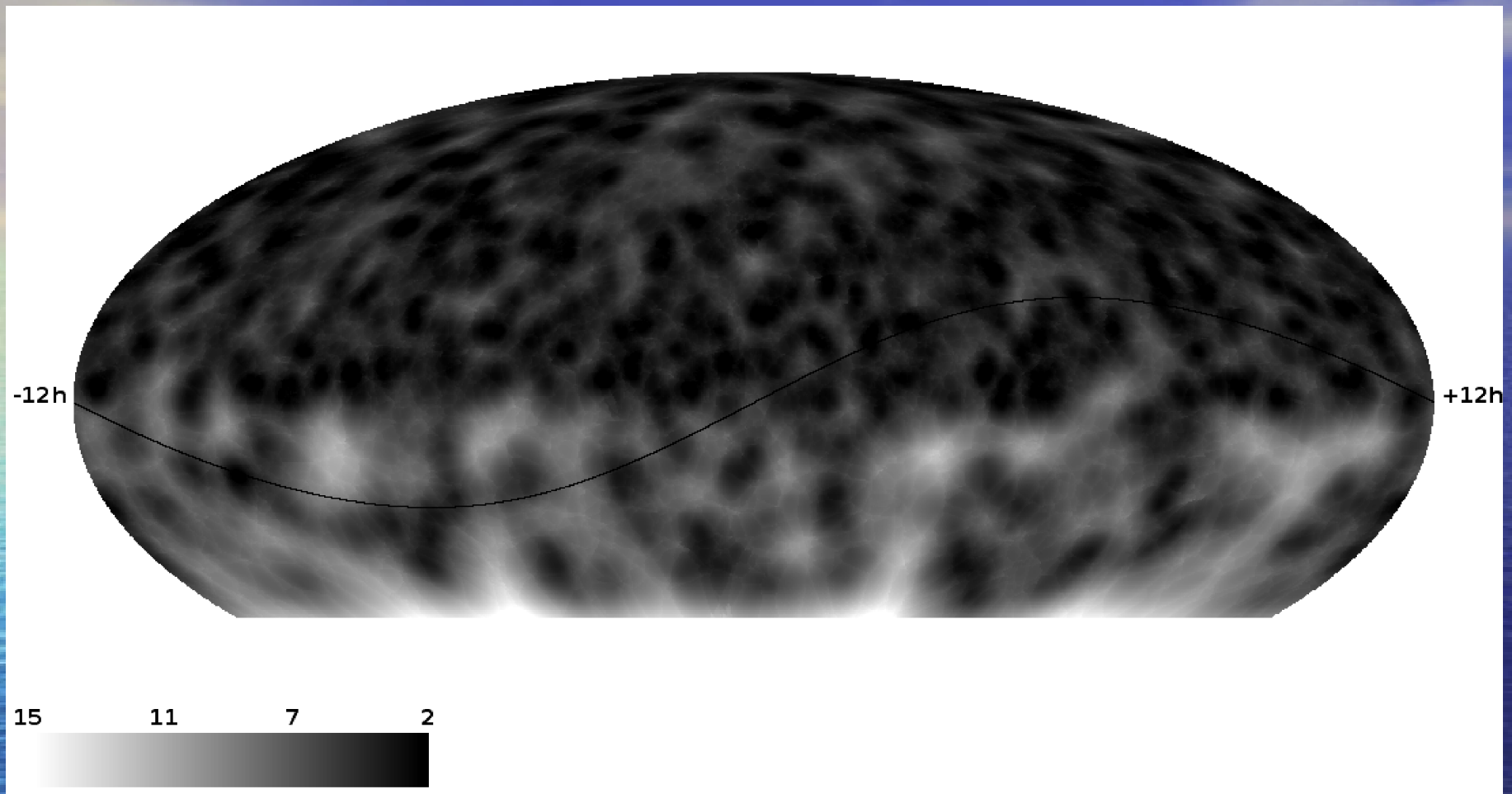
The ICRF constructed from S and X bands VLBI observations is the current realization of the International Celestial Reference System at radio wavelengths.

VLBA Calibrator Survey



The VLBA Calibrator Survey (VCS) catalog included in the LQAC contains 3357 sources (mainly quasars) having accuracies similar with those of ICRF - Ext. 2 catalogue: 1 mas. These positions have been derived from astrometric analyses of the dual frequency VLBA observations.

The Very Large Array (VLA)



The Very Large Array (VLA) is the last catalog of quasars with highly accurate, astrometric positions included in LQAC. The positions were obtained using the VLA interferometer consisting of 27 radio-antennas in a Y shaped configuration located in New Mexico. Based on the accuracy of source positions, 1701 quasars with astrometric precision around 10 mas were included in the LQAC.

Future plans for quasar astrometry

- Establishing a link between the ICRF (represented by the quasar as an fiducial point) and the HCRF requires an accurate astrometric reduction of the CCD images;
- We have to investigate the possibility to perform accurate astrometry in the quasar's field by finding the number of stars that could be used as astrometric standards;
- Using the *cdsclient* package we have queried the VizieR service to obtain the number of UCAC2 stars together with their associated positional errors in a 10'x10' field centered at the quasars J2000 position;
- The results show that most of the quasars from ICRF-Ext 2, VLBA-CS and VLA catalogs are located in regions with enough UCAC2 stars to allow an accurate astrometric calibration of the instrument field;
- Moreover, the presence of UCAC2 stars in the quasar vicinity means that the same CCD observations of the quasar itself could also be used for the astrometric calibration of the telescope field and to eventually derive a field distortion pattern.

UCAC2 stars in 10'x 10' fields around quasars from ICRF-Ext2, VCS and VLA catalogues

	(no.)			R. A. average error (mas)		Dec. average error (mas)	
	<4	4-10	> 10	<30	>30	<30	>30
ICRF-Ext2	123	168	425	360	249	404	205
VCS	622	761	197 2	1620	1190	1863	947
VLA	401	348	951	756	581	848	489

The first 3 columns represent the number of quasars fields having <4, between 4 - 10 and >10 reference stars from UCAC2 catalog. The next 4 columns denote the number of fields with the average positional errors of the UCAC2 stars < 30 mas and >30 mas (for all the fields this value was < 60 mas in both coordinates).

Conclusion

- Many quasars with accurate astrometric position (from radio observation) are located in fields with enough UCAC2 reference stars;
- It allows accurate astrometric reduction of CCD images obtained with long focus small aperture telescopes;
- The link between ICRF and HCRF can be strengthened by a deeper survey that can also be extended to include new quasars (others than ICRF).

Acknowledgements

- Thanks to our Brazilian colleagues: Marcelo Assafin and Alexandre Andrei for initiating this program and for data reduction.
- We are much indebted to our Bulgarian colleagues Kiril Panov, Tanyu Bonev, Alexander Antov and Lubomir Iliev for the facility of using Belogradchik Zeiss telescope by means of Academic collaboration

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