

# On selection of astrometric radio sources for ICRF–GCRF link

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# Selection of objects for ICRF-GCRF link

Preparation of radio sources for ICRF-GCRF link (Bourda et al., 2008, 2010, 2014, ...):

1. Selection of optically bright astrometric radio sources.
2. Check of suitability for precise VLBI positioning: flux, structure, compactness.
3. Intensive observations of selected sources by IVS.

**The goal of this work is to improve (1) and thus encourage revising (3).**

# How could we enrich the list?

- Include more optically bright sources.
- Use more sources of photometry data.
- Intensify photometry observations of radio sources.

# Radio source selection

**Possible extensions:**

- Consider all astrometric radio sources, not only ICRF-2 list.
- Consider more sources of different types, not only quasars:
  - all AGN,
  - galaxies with magnitude > $16^m$ .

# OCARS: main features

**OCARS** (Optical Characteristics of Astrometric Radio Sources)
**http://www.gao.spb.ru/english/as/ac_vlbi/ocars.txt**

- Includes all reliable detected astrometric sources.
- Currently contains 9186 sources:
  - 5106 (2381 ICRF2) sources with redshift info;
  - 7044 (3047 ICRF2) sources with known optical/NIR magnitude;
  - 4096 (2244 ICRF2) sources known as AGN;
  - 2827 (1698 ICRF2) sources known as quasars.
- New cross-identifications radio-optics-gamma-X suggested.
- Updated regularly, about once a month in average. Thus generally contains most complete and accurate data; e-mail alert about updates is available on request.
- Extended photometry data at 13 SIMBAD bands (uUBgVrRiIzJHK).
- **Contains already VLBI-observed and successfully correlated objects!**

# OCARS: main sources of information

**Source type, redshift, and optical magnitude are taken from:**

1. NED.
2. SIMBAD.
3. Different catalogs/surveys, e.g., SDSS, LQAC, HMQ, etc.
4. Literature.
5. Unpublished results from the authors, e.g., redshift measurements from Oleg Titov.

# OCARS photometry

| | u | U | B | g | V | r | R |
|---|---|---|---|---|---|---|---|
| Nsou | 2378 | 487 | 5834 | 3462 | 3623 | 2446 | 5908 |
| V - | -0.8 | -0.1 | -0.4 | -0.2 | | 0.2 | 0.6 |

| | i | I | z | J | H | K |
|---|---|---|---|---|---|---|
| Nsou | 2506 | 2297 | 2374 | 3185 | 2679 | 3224 |
| V - | 0.4 | 1.1 | 0.6 | 2.0 | 2.7 | 3.4 |

Color indices are practically the same for different sub-sets of sources: quasars, all AGNs, galaxies.

# Using color indices

199 sources have only NIR magnitudes (J, H, K)

158 of them have J<=16 (expecting V<=18), including

- 13 ICRF sources
- 1 AGN
- 132 galaxies, 39 galaxies with J>14 (expecting V>16)
- 25 sources of unknown type

So, about 50 sources having only NIR photometry may be suitable for ICRF-GCRF link.

# OCARS extension with dedicated campaigns

**Dedicated observing campaigns:**

1. Redshift, BTA 6-m, PI: Zinovy Malkin, 2008-2011
2. Redshift, NTT, NOT, Gemini, PI: Oleg Titov, 2010-2014
3. Photometry, TJO proposal, PI: Francois Taris, 2015

# OCARS advantages

- Due to relatively small size (as compared with large catalogs like LQAC) manual data check is possible, which mitigates errors.
- Unlimited number of sources of information is used including unpublished data provided by the authors.
- Rapid update: additions and corrections become available immediately.
- OCARS contains source names from general radio source catalogs like 87GB, NVSS, PKS, PMN, which is important for control and inter-science applications.
- OCARS provides detailed comments when needed.

# OCARS advantages

**Examples:**

- 87GB 205751.6+233506 is used by Bourda et al. as a prospective source for ICRF-GCRF link because V-C&V catalog and SIMBAD have V=17.0. My check has shown that this value is of unknown origin and quality. NED has recent measurement V=19.50 ± 0.02.
- The same situation with source 87GB 212822.7+331916 used by Bourda et al., for which V-C&V and SIMBAD give V=17.9 of unknown origin and quality. NED has recent measurement V=22.65 ± 0.05.
- In several cases, optical magnitude can be related to a nearby star, not to the object observed by VLBI. OCARS provides a note to warn the user.

# Comparing OCARS to LQAC-2

## Number of OCARS sources not found in LQAC-2

| Tolerance | 1" | 2" | 3" | 5" | 10" |
|---|---|---|---|---|---|
| All sources | 2835 | **2682** | 2660 | 2643 | 2635 |
| ICRF2 sources | 1 | **1** (!) | 1 | 0 | 0 |

## Redshift

- No new redshifts was found in LQAC-2.
- 974 sources have redshift in OCARS and haven't in LQAC-2.
- 134 sources have different redshift in OCARS and LQAC-2 ($\Delta z > 0.02$).

## Optical and NIR magnitude

- 744 sources have optical magnitudes in LQAC-2 and haven't in OCARS (mainly coming from USNO B1.0); incorporated in OCARS.
- 362 sources have optical magnitude in OCARS and haven't in LQAC-2.

# Radio stars

Structure of radio sources, often variable, core shift effect, and other problems make ICRF-GCRF link very difficult at microarcsecond level of accuracy.

Radio stars being observed in both radio and optics can be an important contribution to radio-optics link.

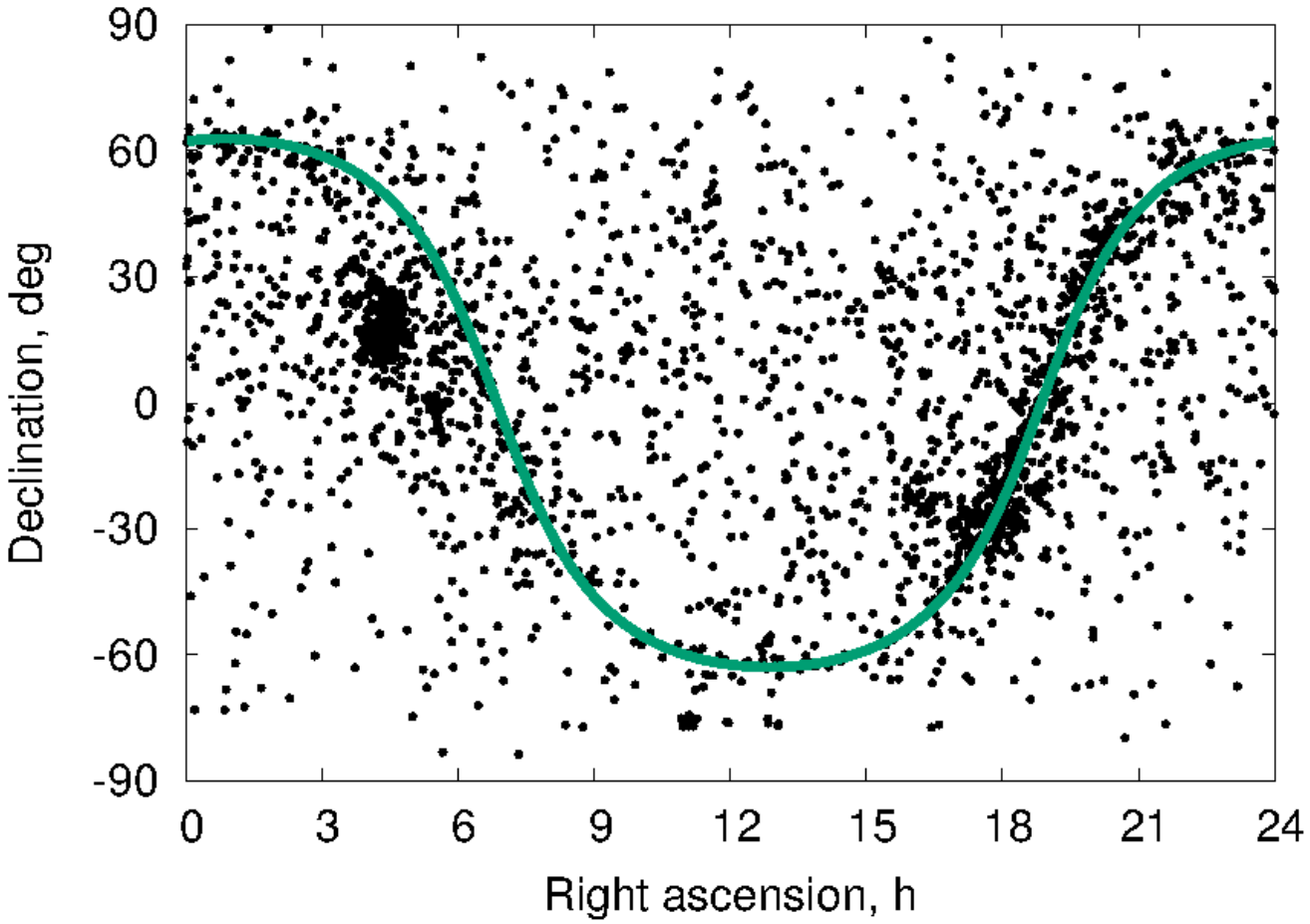
# Radio stars

Using catalog of 3021 radio stars (Wendker, 1995)

Almost all (~2980) have optical magnitude <= $18^m$

Not considered for ICRF and not observed by IVS!

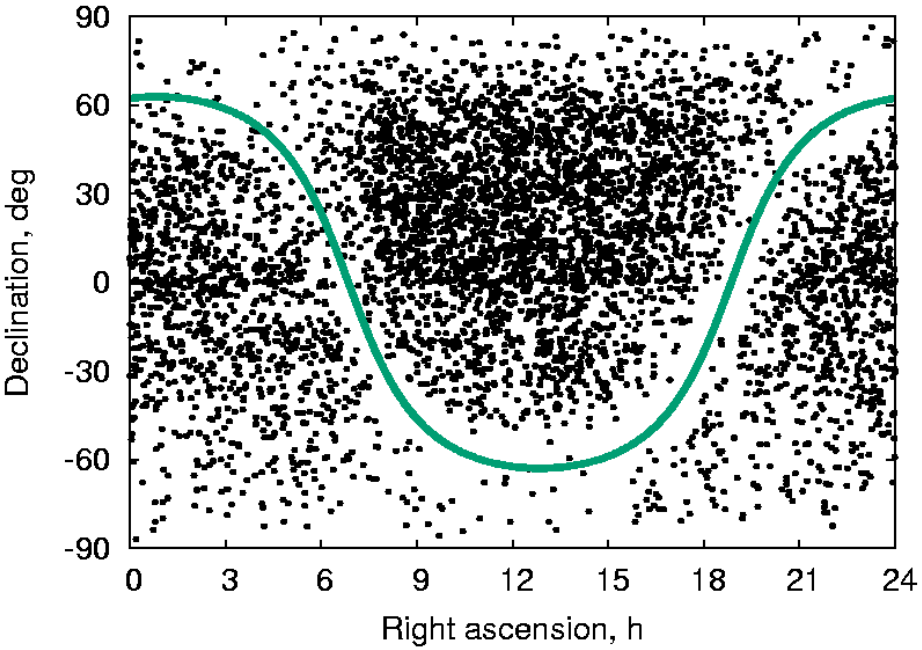
# Radio stars



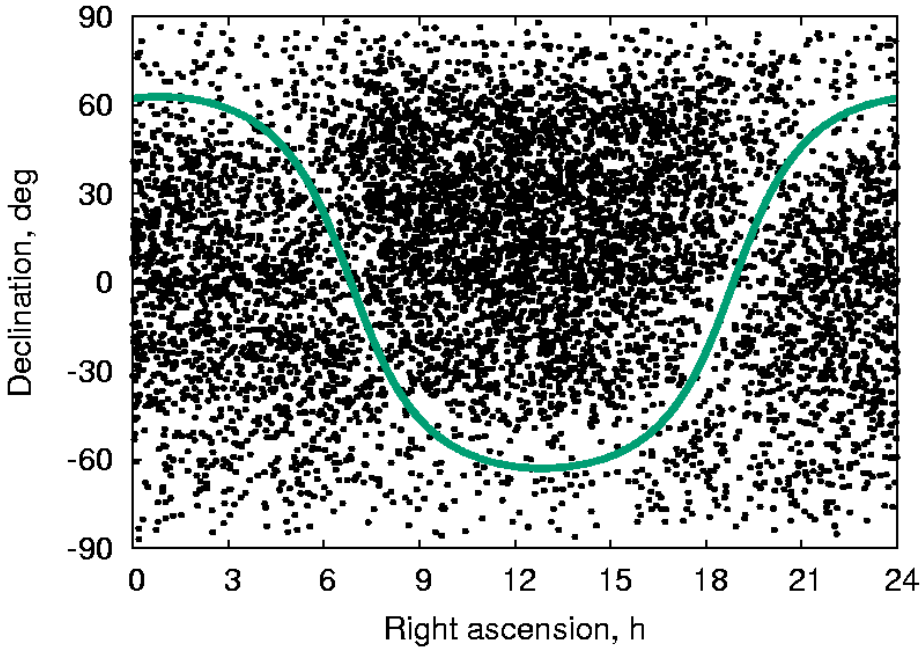

**(Galactic equator)**

# OCARS sources

with redshift




with opt./NIR magnitude




**(Galactic equator)**

# Conclusions

1. List of prospective optically bright radio sources for the ICRF-GCRF link can be substantially enriched with non-ICRF and non-quasar and.

2. Photometry of the optical counterparts of the CRF radio sources should be much encouraged. In particular, the TJO project will be a very substantial contribution. However, because of optical variability of most sources, follow-up photometry campaigns are important.

3. Radio stars can be a valuable contribution to the ICRF-GCRF link.

Thank you for your attention!