The new Division A Working Group on Multi-waveband ICRF

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Formation of Working Group

- Established in 2021
- Takes over two former IAU working groups
  - Third Realization of the International Celestial Reference Frame (ICRF3) – WG terminated in 2018 after the adoption of the ICRF3 (IAU 2018 Resolution B2; Charlot et al. 2020)
  - Multi-waveband realizations of the International Celestial Reference System (ICRS) – WG terminated in 2021 after the adoption of the Gaia-CRF3 as the optical realization of the ICRS (IAU 2021 Resolution B3; Gaia Collaboration et al. 2022)
- Objective:
  - Work towards the realization of a multi-waveband celestial reference frame, incorporating positions in radio and optical bands and ensuring maximum consistency over the bands

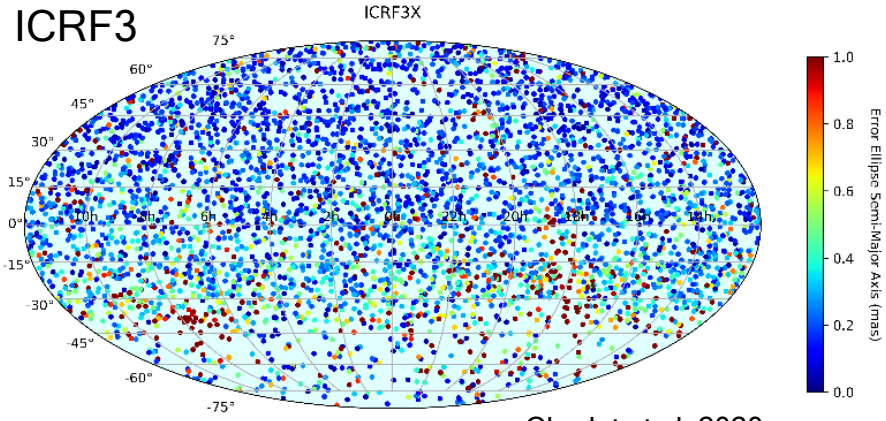
Membership

P. Charlot (Chair)	R. Heinkelmann	V. Makarov
S. Anton	C. S. Jacobs	Z. Malkin
E. F. Arias	S. Klioner	F. Mignard
A. de Witt	H. Krasna	E. Skurikhina
B. Dorland	S. Lambert	J. Souchay
D. Gordon	L. Lindegren	O. Titov

- 18 members coming from 14 institutions in 10 different countries
- Expertise of WG members covers a wide-range of topics, from VLBI and Gaia to reference frames and active galactic nuclei.
- First meeting held on-line on July 22, 2022, discussed several issues related to the construction of a multi-waveband frame

Inhomogeneity in sky distribution

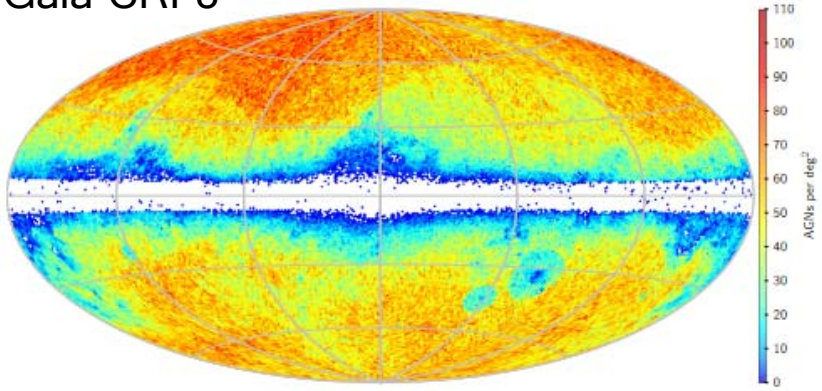
ICRF3



Charlot et al. 2020

- ICRF3 shows a significant North-South asymmetry
- Due to the lack of VLBI antennas in southern hemisphere
- Unfortunately a situation we will have to live with in the future

Gaia-CRF3

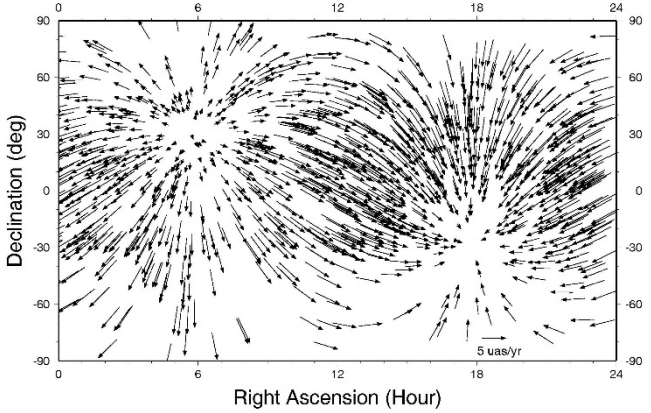


Gaia collaboration et al. 2022

- Gaia-CRF3 includes only few sources along Galactic plane
- Due to Galactic extinction, hence will not improve in future releases
- VLBI may help to identify quasars among Gaia data in this region

Galactocentric acceleration

- Manifest itself through apparent proper motions of the extragalactic sources
- Acceleration vector is an estimated quantity for both VLBI and Gaia, first considered in ICRF3 and Gaia-CRF3



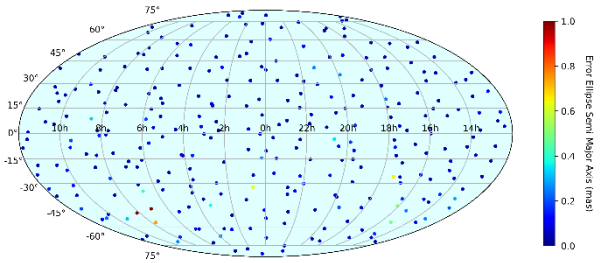
Charlot et al. 2020

- Amplitude of vector in the two determinations differs by 1.8σ: 5.8 ± 0.3 μas/yr (ICRF3) vs 5.05 ± 0.35 μas/yr (Gaia-CRF3)
- Acceleration vector + epoch of frame must be made consistent in the different bands to have optical and radio positions directly comparable
- New values from Gaia expected by ~ 2025 (DR4) and ~ 2030 (DR5), VLBI value to be updated on the same time scale
- Need to redefine vocabulary since estimates reflect proper motion of the solar system barycenter relative the background of quasars

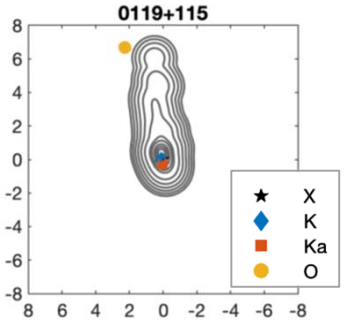
Alignment of frames

Questions to be addressed:

- Should all common sources or only a subset of them be used to align frames in the different bands?
- How to treat offsets between bands which are found for an increasing portion of sources?
- How to treat time-dependent source positions revealed by VLBI?



Charlot et al. 2020



Lambert et al. (2021)

Ideally, identify a subset of “defining” sources with stable positions and no measurable offsets between bands

Terminology

- "ICRF" originally defined without waveband in mind but in practice implicitly connected to the VLBI frame since it has been the only available technique until the advent of Gaia
- Now two celestial reference frames – both adopted by the IAU – co-exist: ICRF3 (radio) and Gaia-CRF3 (optical)
- Proper vocabulary must be defined to handle the naming of the frames in a consistent way
  - keep ICRF and attach waveband (optical, radio), identifier (3, 4,…) and frequency setup within waveband (S/X, K, X/Ka,…) ?
- Terminology must be valid beyond Gaia and VLBI and be able to accommodate any new waveband, instrument or frequency that may emerge in the future

Thank you for your attention