Astrofísica Extragaláctica y Gaia

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Workshop Extragalactic Science with Gaia
Paris, 14-16 de junio

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SOC: Kontizas, Rocca Volmerange, Slezak, Maudit, Petitjean, Souchay

web: www.oca.eu/rousset/EGSG

- Physics and properties of Active Galactic Nuclei
- Unresolved Galaxies
- Reference Frame ← physical processes in AGN with an in impact in astrometry
- Intergalactic Medium

- DPAC pending issues/information
- GREAT to arise key science oportunities

▪ How extragalactic objects will be detected and characterised

PROGRAM

- Unresolved galaxies (june 14) * mostly restricted to DPAC
- Astrometry (june 15 morning)
- QSOs (june 15 afternoon + june 16)

ASTROMETRY (DPAC tasks)

- **"Initial QSO Catalogue".** LQAC (Large Quasar Astrometric Catalogue). Souchay et al. (2009)
  - 12 catalogues ordered in decreasing precision (the first catalogues selected in radio VLBI)
- LQRF (Large Quasar Reference Frame) Andrei et al. (2009)
  - It is the alignment of LQAC to the ICRF (International Celestial Reference Frame)
- Maintenance of LQRF Andrei + Souchay+ etc

- ICRF2
  - Lab. Astrophys. Bordeaux (Bourda, Charlot) :
    - VLBI revision to check that the QSOs give accurate and stable positions. Mostly unresolved.

      (radio emission sometimes variable in distribution and intensity).
    - Select radio sources with bright optical counterpart and obtain VLBI observations, to increase the number of sources (accurate and stable) for the alignement with **Gaia Reference Frame**.

      ICRF2 40 µas Gaia 15 < V < 18 16-70 µas

– **Is there a photocenter-radiocenter offset in QSOs?** DPAC, but also Science

- Optical = **Accretion disk** BLR 0.1 pc
- Radio = jet **synchrotron with knots** (distances from 1pc to Kpc).
  The radio core is in fact the first knot
- Moreover, jets also detectable in the optical (**Blazars**)

- + variability

- Jitter: different position of the centroid of the PSF of an AGN due to variations in the relative intensity of its components (acrettion disk, star formation, jets)

- A lot of discussion about the importance of jets in the optical. M87, 3C 273, 3C 120 cases, are rare?. Are there tangential motions?.

This high resolution makes everything new. But what will Gaia give us as data?

z = 0.5 1pc 160 microarcsec

z = 1 1pc 125 microarcsec

z = 2 1pc 120 microarcsec

z = 3 1pc 130 microarcsec

M87 elliptical giant (gE) with radiojet

Core knots

0” - 3,2” - 8” - 12” …

- 250 pc - - 1 kpc

16 mag

Other things:

Identify new gravitational lenses, in a systematic way and over all the sky. Cosmological parameters.

Identification of pairs or groups of QSOs. IGM. Merging.

QSOs (or better AGN)

- **"QSO Gaia Survey"**

  Not a clean-sample lije the initial QSO catalogue, but a complete sample

  Expected numbers: 500k QSOs with G < 20 2/3 new

  The task is to identify QSOs from the whole catalogue

  - (Position)
  - BP/RP spectra
  - G magnitude
  - Variability (30-100 observations in 5 years)
  - Proper motion (parallax doesn't seem to help much)

CU8 **BP/RP**

libraries (QSOs, stars, galaxies) → simulations → machine learning

Star-Galaxy-QSO + unknown QSO selection, photo-z

DSC (SVM) + OCA (clustering)

DSC results: Bailer-Jones et al. (2009) 65% compl. V < 18.5

– **In which way can this survey compete with previous QSO surveys, in particular, with respect to SDSS? SDSS=100k QSOs**

• **All sky** (to increase/duplicate the number of sources doesn't impress a lot, but very important for statistics)

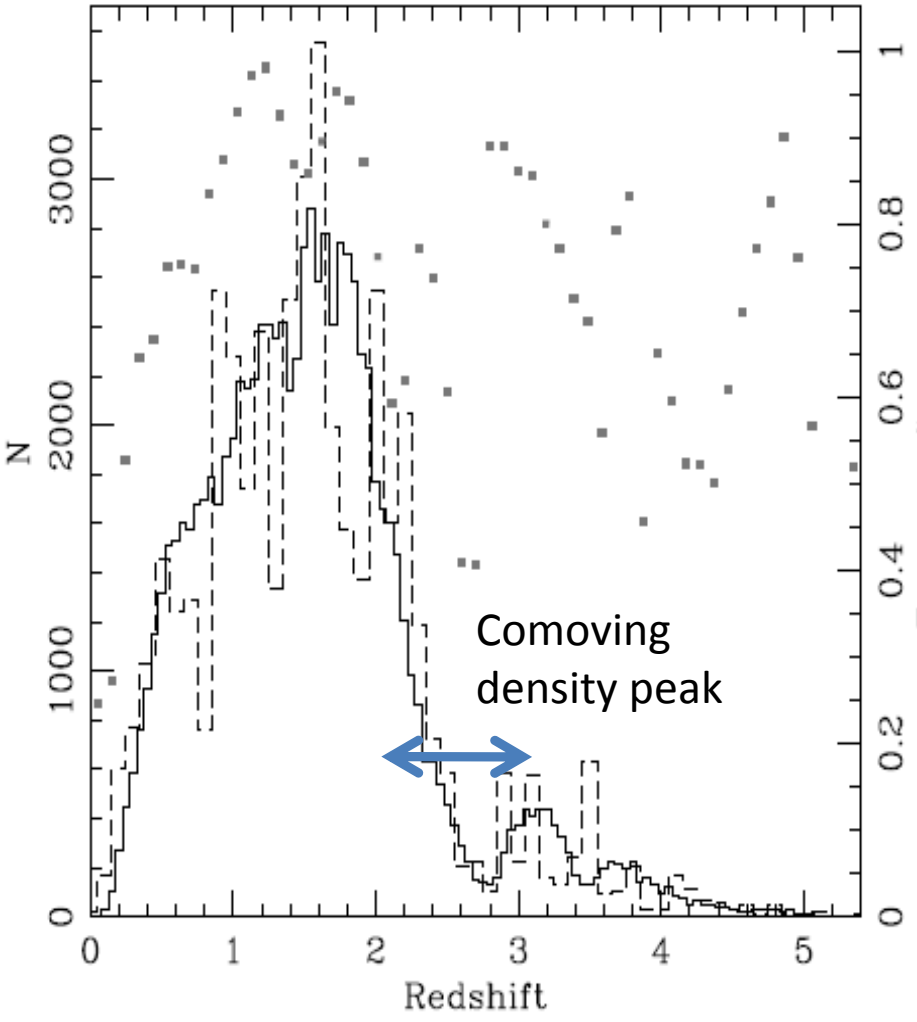
• Sample in the South. Facilities in the South not present in the North?.

ESO ⟶ ALMA, VLT

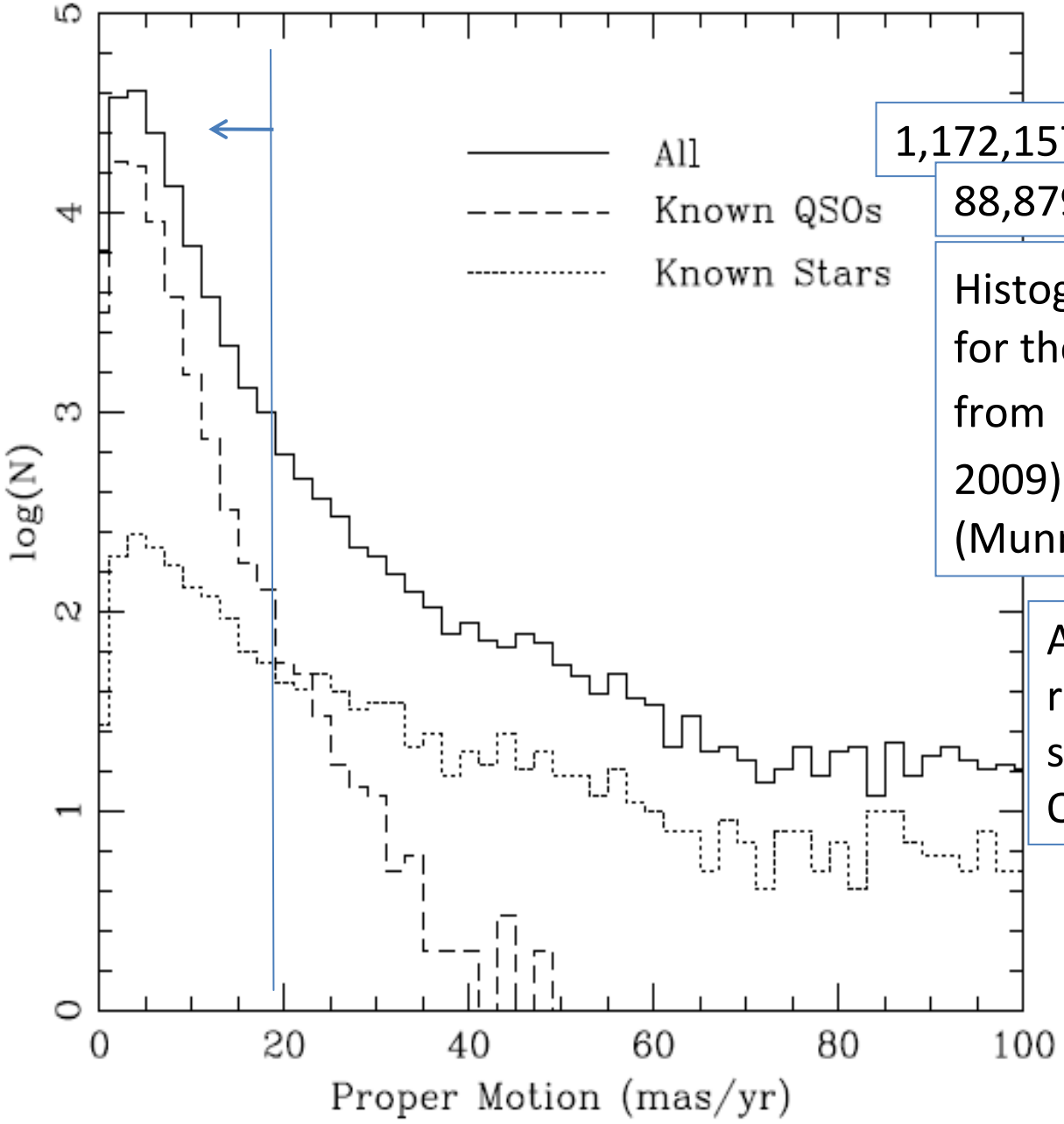
• Explore redshift ranges for which SDSS target selection is highly incomplete.

But it is being done by BOSS
z=2.2 - 3.5 is the aim
12k QSOs observed g<22 (Yèche talk)

NN: colours+errors+variability



• Use other variables useful as discriminants or to flag contaminants, such as **Proper motions** and/or **variability** . This will allow us to select QSOs whose colours are not similar to typical QSO colours, and that therefore are not selected from their SEDs.



- **Proper motions**

1,172,157

88,879

Histogram of **proper motions** for the unresolved QSO candidates from **SDSS DR6** (Richards et al. 2009). pms from **USNO-B** (Munn et al. 2004, limit g ≈ 19.7).

A cut pm > 20 mas / year rejects 93.8% of the known stars and 0.2% of the known QSOs.

- **Variability** (QSOs vary from days to months)

Light-curve **structure function**.

Given N observation epochs, there are N(N-1)/2 pairs of observations. Computing

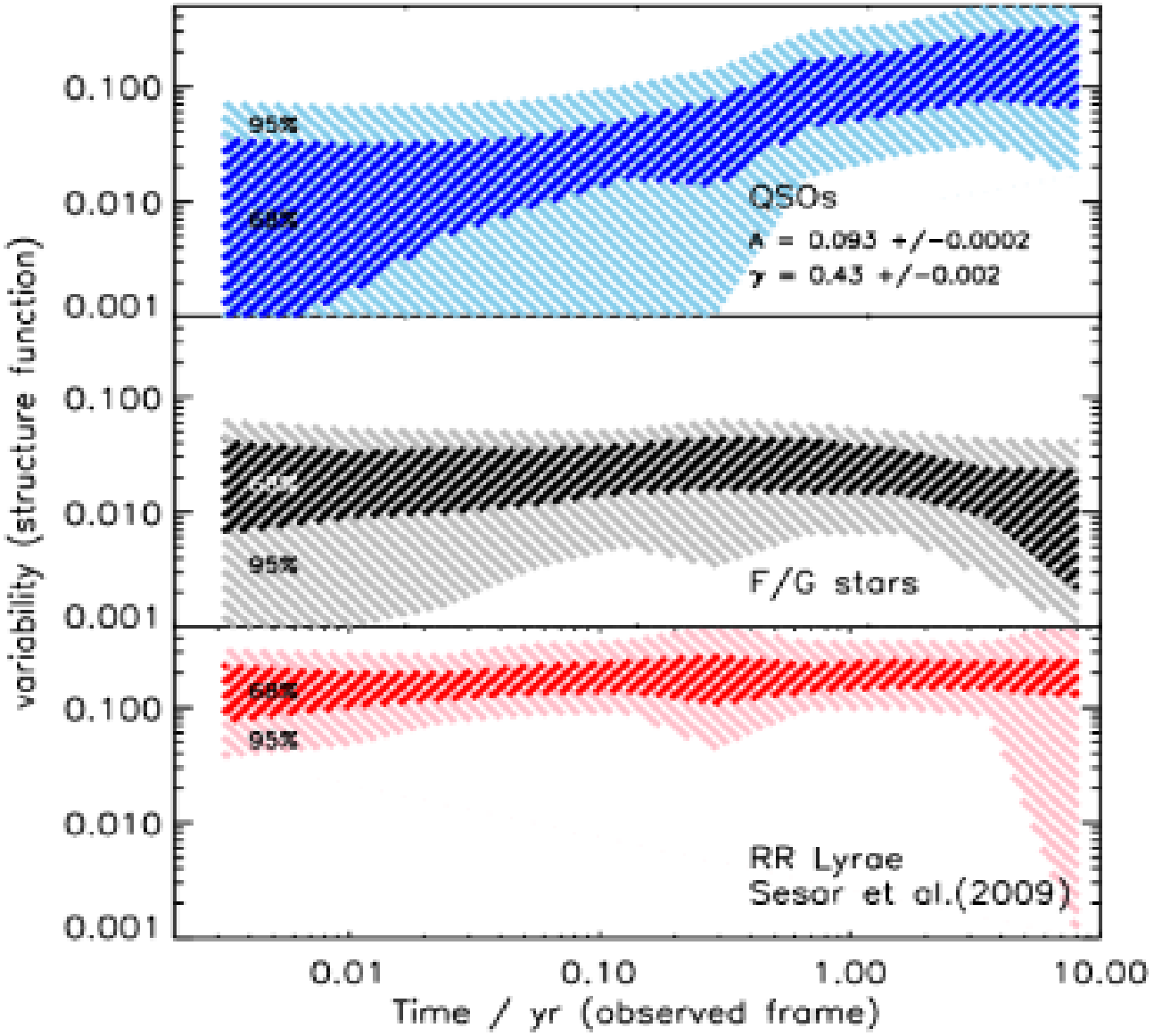
$$V_{i,j}\left(\Delta t_{i,j}\right) = m_{i,j} - \sqrt{\sigma_i^{\,2} + \sigma_j^{\,2}}$$

The function V(Δt) is parametrized as $V = A\,(\Delta t)^{\gamma}$

The structure funcion is different for QSOs and variable stars. The location of the sources in a **A vs γ** plot gives the classification in one class or the other.

Schmidt et al. (2010, ApJ 714, 1194)

Selecting Quasars by Their Intrinsic Variability


0.100
0.010
0.001
95%
68%
QSOs
A = 0.093 +/−0.0002
γ = 0.43 +/−0.002
0.100
0.010
0.001
95%
F/G stars
0.100
0.010
0.001
68%
95%
RR Lyrae
Sesar et al.(2009)
variability (structure function)
0.01
0.10
1.00
10.00
Time / yr (observed frame)

“Physics of AGN”

For RL QSOs it will be interesting to measure if there are displacements between the optical and the emission.

Other things:

Identify new gravitational lenses, in a systematic way and over all the sky.

Identification of pairs or groups of QSOs.

UNRESOLVED GALAXIES

- Radio galaxies, Seyfert, starbursts, nucleated dwarfs
- CU8

  libraries (galaxies of different types) → simulations (**BP/RP**) →

  machine learning → Spectral type, redshift, extinction,

  mas-to-ligh ratio, etc.
- Relation QSOs-galaxies

- Particular types of extended sources also detected with Gaia

New GREAT working group

- Physics of AGNs, or AGNS
- Facilitator: Sonia Antón (Oporto)
- Active web page will be available soon
- Another meeting in one year