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Optical monitoring of QSO in the framework of the Gaia space mission

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Abstract: This poster presents the set of optical telescopes used to observe the targets chosen for the link between the ICRF and the future GCRF. We will focus on results obtained with the TJO, Telescopi Juan Oro (Observatori Astronomic del Montsec, Spain), together with an application of the Lomb-Scargle method to the data obtained with the TAROT telescopes (OCA, France, ESO, Chile).
A morphological index is defined and applied to the 5000 images obtained during a first observation campaign.

The Gaia astrometric mission of the European Space Agency has been launched the 19th December 2013. It will provide an astrometric catalogue of 500 000 extragalactic sources that could be the basis of a new optical reference frame (the **GCRF**, Gaia Celestial Reference Frame) after the Hipparcos satellite one.

On the other hand, the current International Celestial Reference Frame (**ICRF**) is based on the observations of extragalactic sources at radio wavelength.

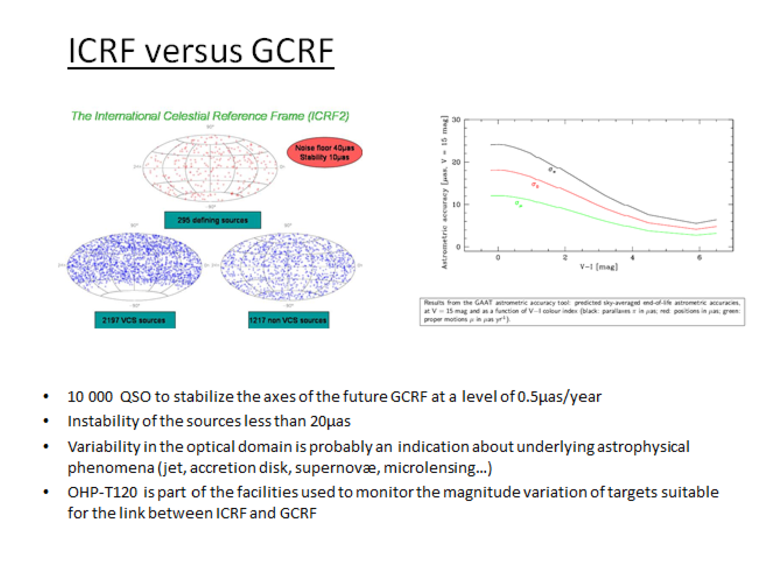
The astrometric coordinates of sources in these two reference systems will have roughly the same uncertainty. It is then mandatory to observe a set of common targets at both optical and radio wavelength to link the ICRF with the GCRF.

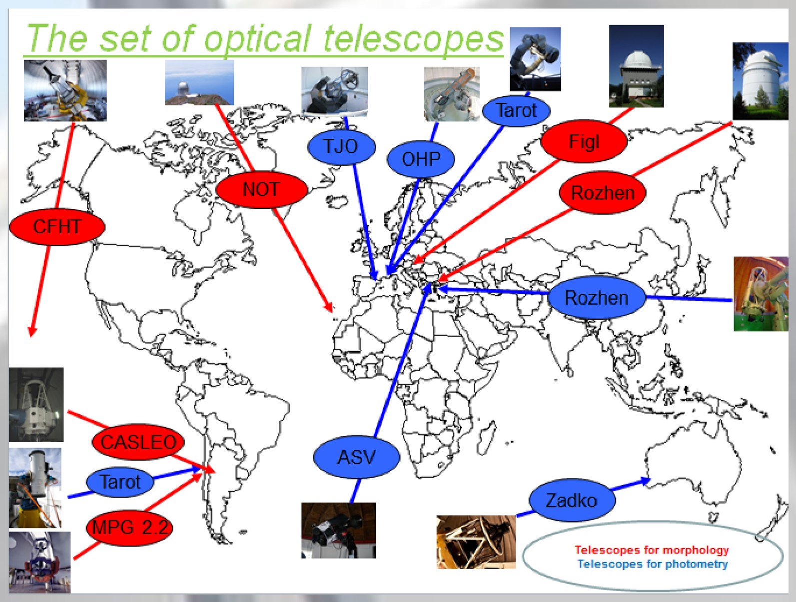
This work about the link between radio and optical reference system is achieved in the frame of the ICRS Product Center.
It has been shown that a clean sample of less than 10000 QSO could stabilize the axes of the future GCRF at a level of 0.5µas/year, with the assumption that the random instability of the sources is less than 20µas.
This random instability is a very stringent limit and the chosen targets must be carefully scrutinized both from the point of view of morphology and photometry. In the radio domain the morphology of an extragalactic radiosource (structure with size up to the mas level) is correlated to its flux variability (jets). The effect of source structure on position as been studied and has been found as large as tens of mas. In the same way the variability in the optical domain is probably an indication about some underlying astrophysical phenomena. They could be “intrinsic” such as instabilities in the jet or in the accretion disc around the black hole, supernovae explosions, etc… or “extrinsic” such as microlensing.

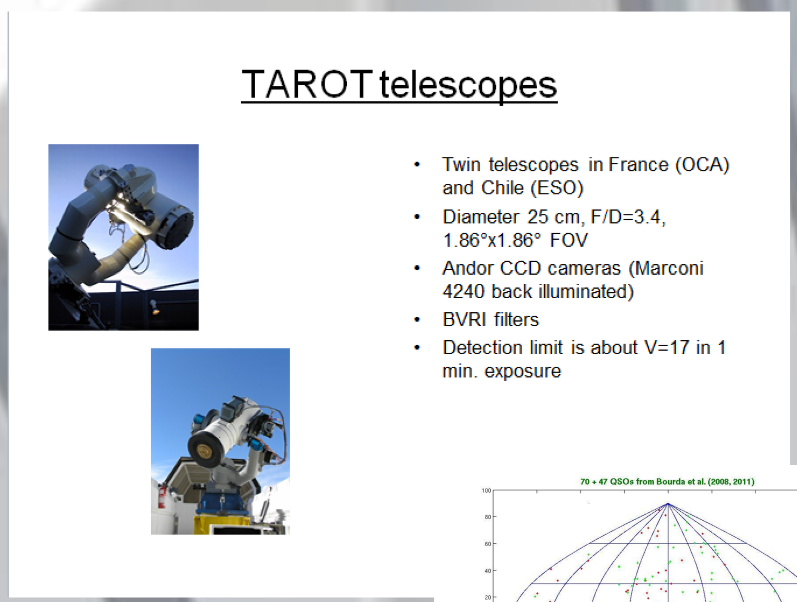
A set of optical telescopes is currently used both for morphology (large facilities) and for photometry (robotic/manual and small/medium telescopes). This poster is more particularly dedicated to the photometry aspect, the morphology being currently under study and will be presented elsewhere.
The photometric program (magnitude monitoring) has begun in 2010 and is currently under progress. Among all the telescopes used, three of them, **The Telescopi Joan Oró (TJO)** from the Observatori Astronòmic del Montsec (OAdM, Spain) and the two twin **TAROT telescopes** from Observatoire de la Côte d’Azur (OCA, France) and European Southern Observatory (ESO, Chile), provide **light curves** that are presented and used in the frame of this poster.

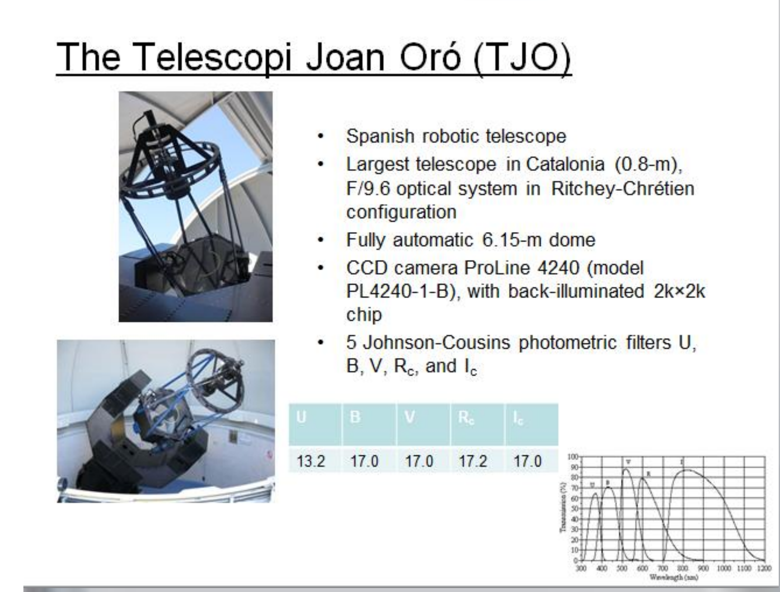
The **Lomb-Scargle periodogram** is a common tool in the frequency analysis of unequally spaced data equivalent to least-squares fitting of sine waves. This method is applied to the time series of magnitude (one obs./2nights during 4 years) to search for periodic phenomena. Results are compared with what is known in term of periodic phenomena for some well-known targets.

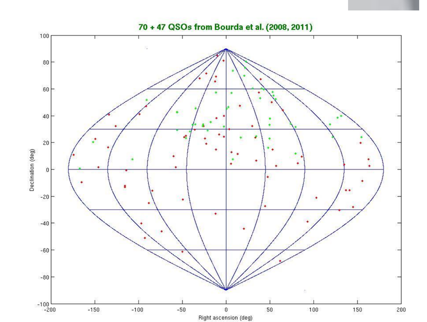
Morphological indexes have been defined in the optical domain to characterize the “pointlikeness” of a target. They are also presented here as an information coming from the Gaia Initial QSO Catalogue (GIQC).

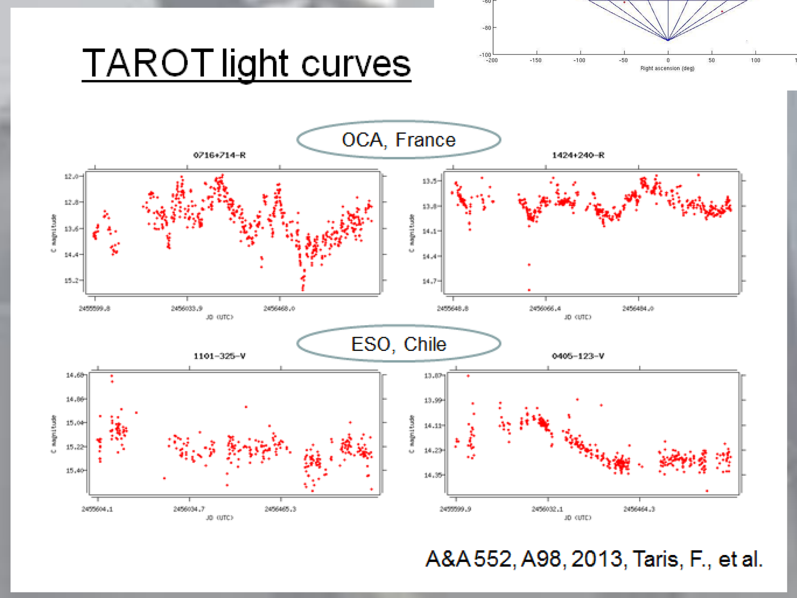


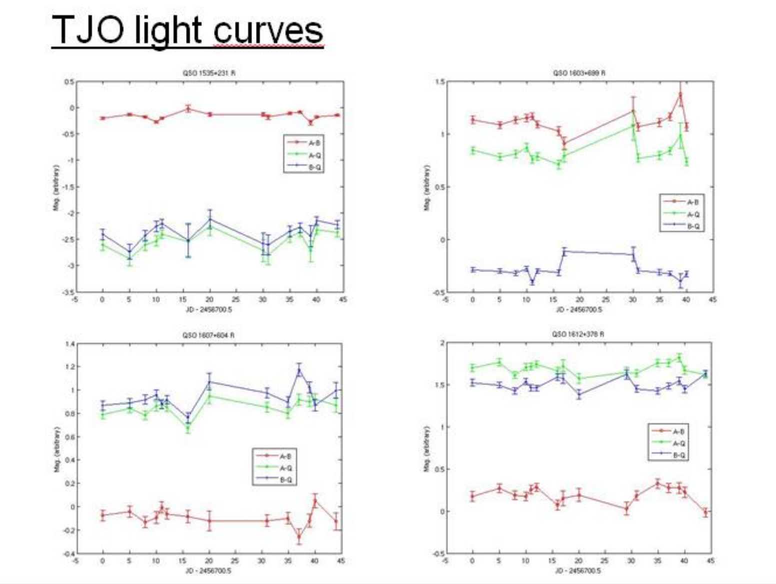




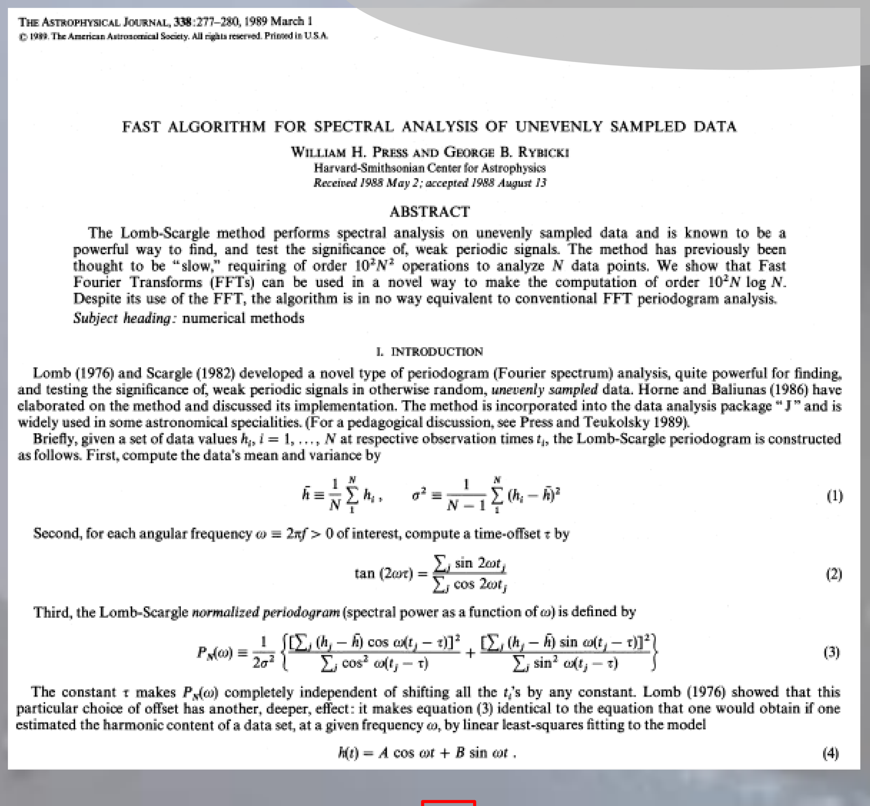








The Lomb-Scargle method


FAST ALGORITHM FOR SPECTRAL ANALYSIS OF UNEVENLY SAMPLED DATA

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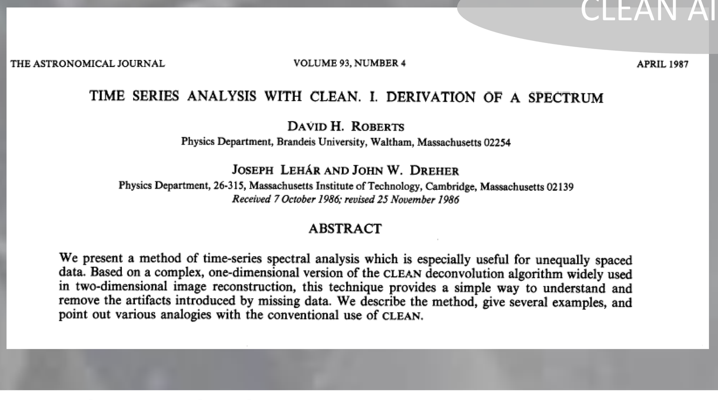
ABSTRACT

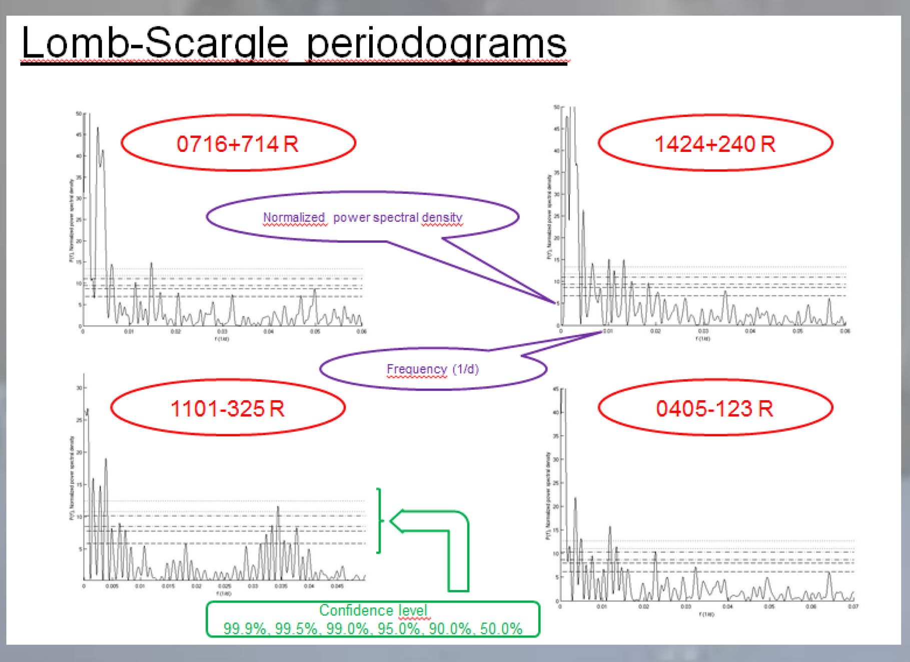
The Lomb-Scargle method performs spectral analysis on unevenly sampled data and is known to be a powerful way to find, and test the significance of, weak periodic signals. The method has previously been thought to be “slow,” requiring of order 10^2N^2 operations to analyze N data points. We show that Fast Fourier Transforms (FFTs) can be used in a novel way to make the computation of order $10^2N \log N$. Despite its use of the FFT, the algorithm is in no way equivalent to conventional FFT periodogram analysis.

I. INTRODUCTION

CLEAN Algorithm


TIME SERIES ANALYSIS WITH CLEAN. I. DERIVATION OF A SPECTRUM

ABSTRACT



Detected periods

QSO	Lomb-Scargle Period (99.9% conf. level) in day	Ref.	Roberts et al. Period (90.0% in day) ApJ 93,4,968 1987
0716+714	1000	AA552, A11, 2013	1055
	316		310
	235		215
	163		
	68	Astron. Astrophys. Suppl. Ser. 143, 357,368 (2000)	68
1424+240	423		442
	816		847
	214		216
	99		
	151		159
	76		76
0405-123	1228		1169
	277		
	84		87
	201		
1101-325	1759		2060
	262		
	655		603
	359		366

The Gaia Initial QSO Catalogue (GIQC)

Number of sources	1,248,372
Sources with magnitude	1,246,512
Sources with redshift	1,157,285
Astrometry precision	1 arcsec
Magnitude precision	0.5
Redshift precision	0.01
Average density	30.3 sources/deg²
Average neighbor distance	3.7 arcmin (σ 4.9 arcmin)
Maximum distance to neighbor	5.2 deg
Maximum distance to neighbor (average of 100 larger values)	3.0 deg (σ 0.6 deg)