

The NAROO project

A new astrometric reduction of old observations with the Gaia catalog

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Observation materials

Astro-photographic plates

- Astrometry
- Spectrometry
- Photometry

“Old” data

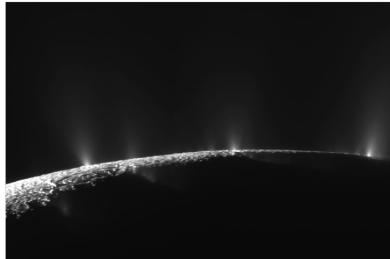
New informations are available with a new digitization and a new numerical analysis !

Quantity

Really too much !!!...

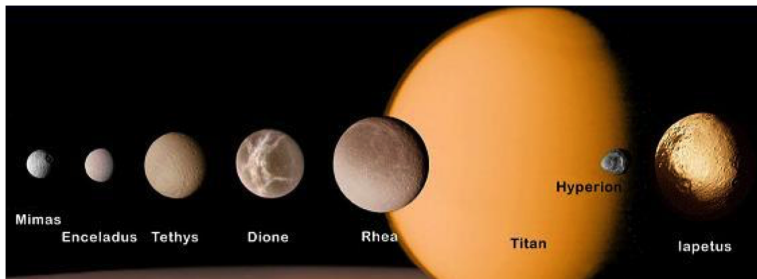
Paris Observatory, OHP, Bordeaux, U.S. Naval Observatory, Greenwich, Pulkovo, South African Astronomical Observatory...

Scientific purpose



Long-term elements (Lainey et al. 2009, WG Encelade).

Scientific purpose



New formation models (Lainey et al. 2015, WG Encelade).

Scientific purpose (miscellaneous)

Astrometry :

- Long-term dissipations.
- New ephemerides of solar system bodies.
- Pre-discovery of small bodies : comets, NEOs et TNOs.
- Dynamics of the galaxy and star proper motions.

Spectrometry :

- Be stars.
- Pre-discovery of extra-solar planets in old spectra.

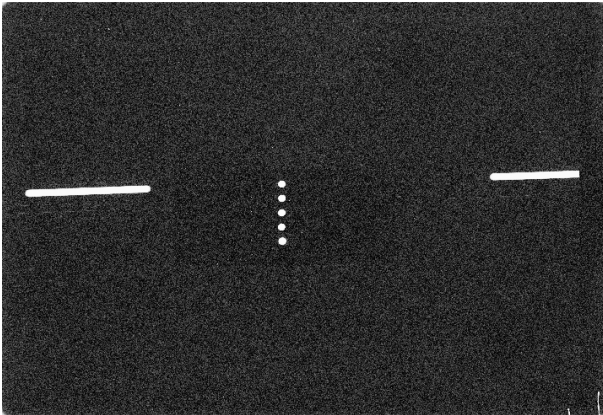
Photometry :

- New photometric models.

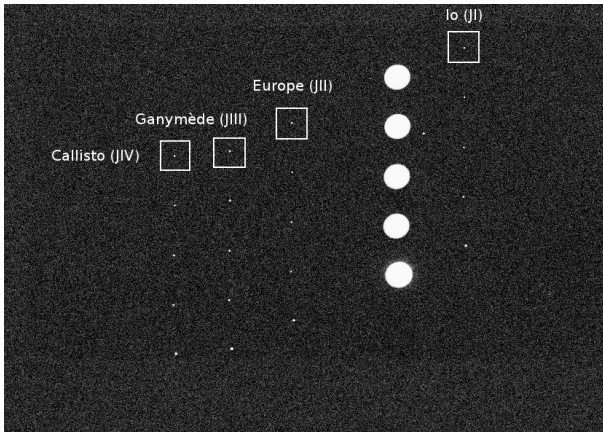
USNO photographic plates at ROB

- Partnership USNO, ROB, and IMCCE for tests covering the 1967-1998 period :
 - Estimation of the digitation errors (positioning, optical distortions, recording...)
 - Instrumental calibration
 - Optical improvements
 - New developments for the analysis, extraction, reduction
 - Application to the Jovian system
- FP7 ESPaCE European project :
 - Analyze of Martian USNO photographic plates
 - Analyze of Saturnian USNO photographic plates
 - Analyze of various photographic plates coming from other observatories

USNO DPJ21014 plate



USNO DPJ21014 plate



USNO DPJ21014 metadata

EXPOSURE NUMBER	EXPOSURE TIME	EXP. START (U. T.) CLOCK READING	EMULSION
1	20 ^s	01 ^h 50 ^m 30 ^s	103aG-
2	20	01 52 00	FILTER G-6-14(12) + J#6
3	20	01 52 40	OBSERVER DP
4	20	01 53 25	SERIES VG-
5	20	01 54 15	CLOCK ERROR Trans: Hazy
			REMARKS: Aper Full on 1 st exp; 16-inch on rest T _a α #5; 2cw; 01 58 ^m 46 ^s T = 84°F (ctf)

USNO plates of Jupiter

- 553 plates → 2650 observations
- Comparison of Hipparcos, Tycho-2, UCAC2 and UCAC3 catalogs
- Comparison with previous reductions
- Comparison of dynamical models
- Positions of the satellites and planet

A systematic error ?

Such error could be explained by the contribution of old observations (positions and weights) in the model fitting (Hog 1972, Standish et al. 1976, Seidelmann et al. 1985, Pascu et al. 1990, Stone et al. 2003).

Accuracy over 30 years (Robert et al. 2011) vs FASTT

- Intersatellite positions : 30 mas vs 100 mas !
- Equatorial positions : 70 mas (\simeq 200 km) for the first time !

USNO plates of Mars

- 425 plates → 1100 observations
- Comparison of Hipparcos, Tycho-2, UCAC2, UCAC3 and UCAC4 catalogs
- Comparison with previous reductions
- Comparison of dynamical models

A 15.4-year period

- Influence of the planetary model
- Height effect due to the inclination and eccentricity

Accuracy over 30 years (Robert et al. 2014, 2015) vs Probe

- Intersatellite positions : 40 mas.
- Equatorial positions : 62 mas (\simeq 20 km) compared to Mariner and Viking !

USNO plates of Saturn

- 526 plates → 1400 observations
- Comparison with previous reductions
- Comparison of dynamical models

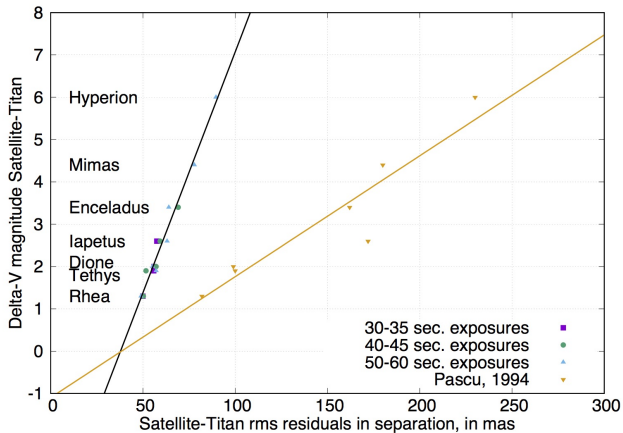
A 14.7-year period

- Influence of the planetary model
- Height effect due to the inclination and eccentricity

Accuracy over 30 years (Robert et al. 2016) vs FASTT

- Intersatellite positions : 45 mas.
- Equatorial positions : 68 mas (\simeq 400 km) for the first time !

USNO plates of Saturn



The error budget

Observation and extraction

- 20-40 mas (Lindegren 1977)
- 5 mas with SExtractor (Bertin & Arnouts 1996)

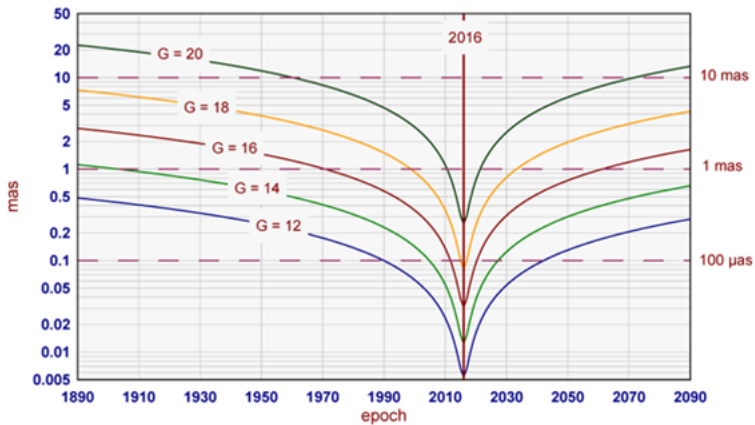
Physical part

- 1 mas for the spherical corrections (Kaplan et al. 1989)
- 5 mas for the total atmospheric refraction (Robert 2011)
- 5-10 mas for the local perturbations (Robert 2011)

Star references

- 15-30 mas with UCAC4 (Zacharias et al. 2013)

The Gaia-era



The NAROO project

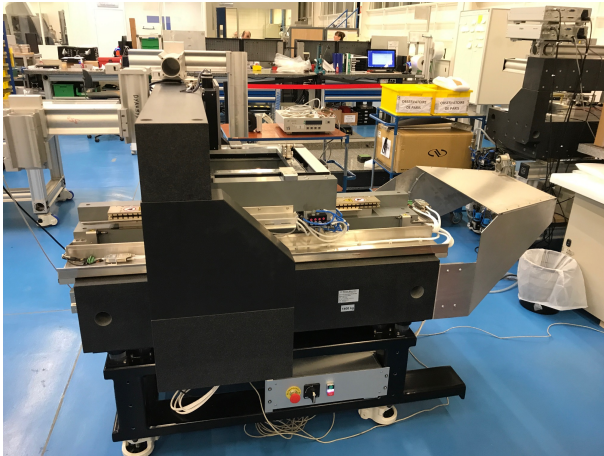
Goal

Digitization and analysis centre of “old” photographic plates (not only) for scientific purposes.

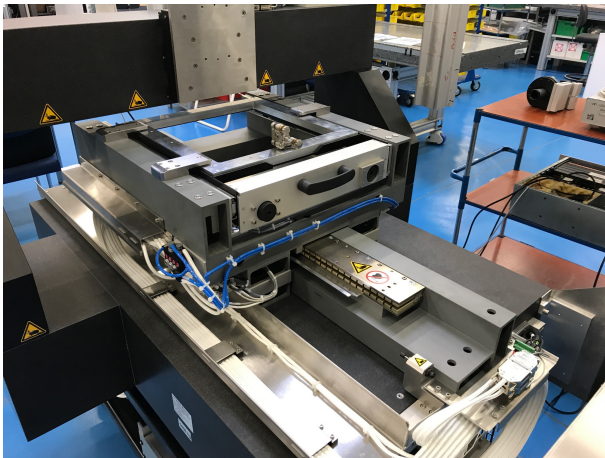
Budget

585 k€!... all-included.

NAROO digitizer



NAROO digitizer



Facilities

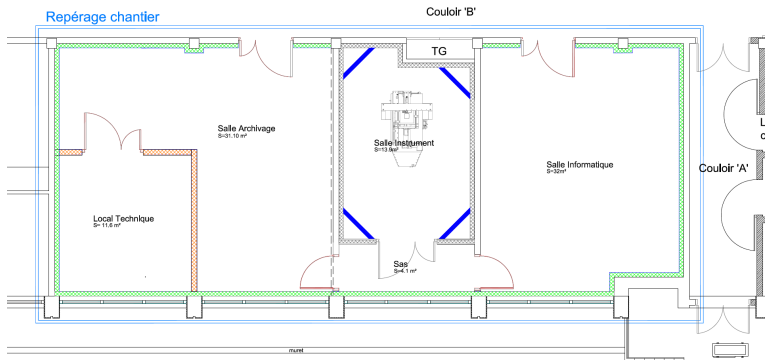
Technical part

- XY Microcontrol air-bearing table
- Granite base 1900mm × 1400mm
- Supports 350mm × 350mm
- Orthogonality, tilts, flips constraints Heindenhein 1nm
- Camera Andor CMOS 5.5 μ m
- Production 24/24 - 7/7

Environment

- 100m² in Meudon
- Computers, saving and instrument
- Regulated clean room 20°C±0.01°C with 50%RH±10%RH

Facilities



Planing

After the 5 first years for the project to “begin”...

$T_0 = 24/04/2017$

DCE 05/05/2017

Consultation 02/06/2017

Analysis of answers 16/06/2017

Analysis of the analysis 23/06/2017

$T_1 = 21/08/2017$

Validation 21/08/2017

Informations 21/08/2017

Signs 31/08/2017

$T_2 = 21/08/2017$

Works phase T_1+3 mois

The NAROO project

IMCCE

Federates the lab teams.

OBSPM

Federates the Observatory labs : GEPI, LESIA...

Institutions

Federates national and international institutes : PSL, OCA, ORB, USNO...

The NAROO project

Your interest

- Long-term evolution of variable stars
- Complement for database
- Pre-discoveries ?

The question

Are there astro-photographic plates of Be Stars spectra before the 90's ?

The OHP collections



The OHP collections



The OHP collections



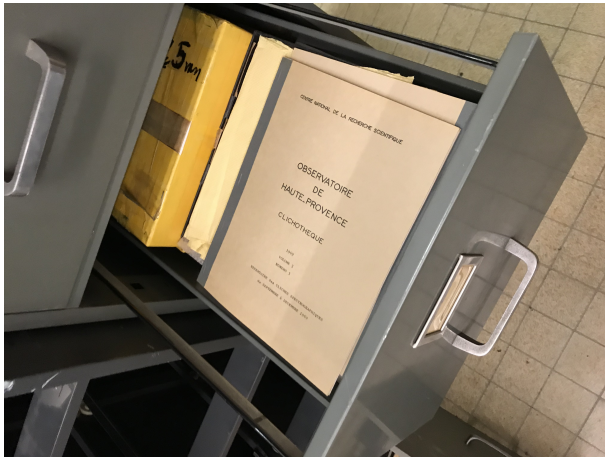
The OHP collections



The OHP collections



The OHP collections



The OHP collections



The NAROO project

Plates

First estimation (by myself) : 55 000 — “Incomplete” reality : 80 000 !!!

In more details

See the OHP dedicated website [▶ OHP link](#)

The questions that remains

- Who will use time to look for observatory collections ?
- Who will use time to look for specific plates ?
- Missions and transport. Who will pay ? A dedicated project ?
- The executive question.
- Who will analyze the digitizations ?

Questions

