

The NAROO digitization centre

Sub-micrometric digitization facilities at Paris observatory

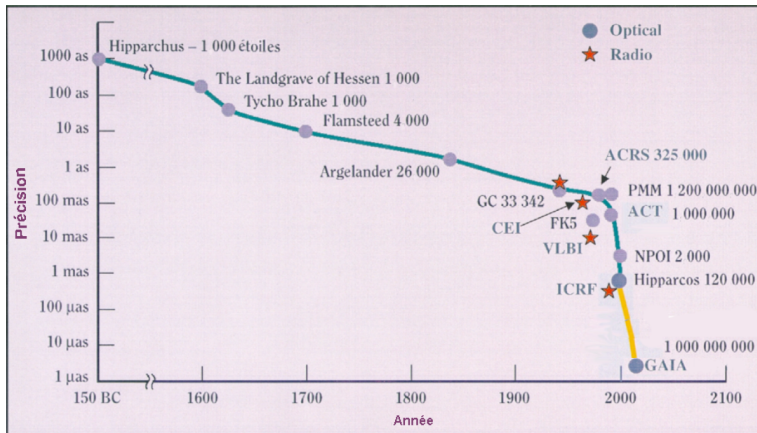
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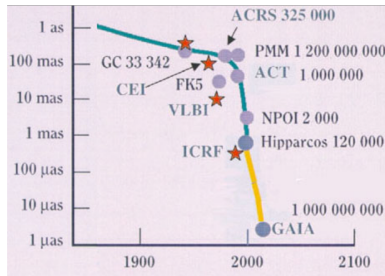
2019, October 7-9, Journées 2019, Paris



Astrometric accuracy : the history



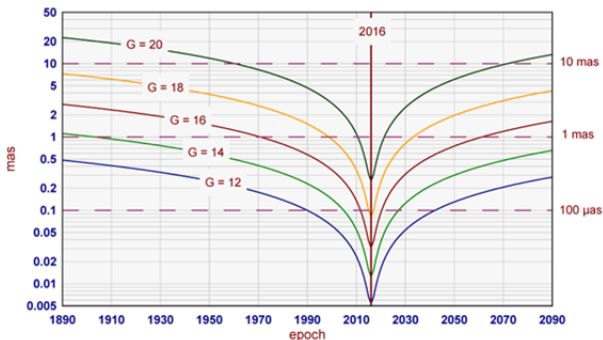
Star catalogs used for reductions



Most of the astrometric observations used until now were reduced with a 100 mas - 1000 mas accuracy for star catalogs, star proper motions, star dynamics, Solar System object dynamics.

Old observations are obviously useful for transient events and moving objects !

Observing in the past with Gaia catalog



A huge challenge !

Re-reducing old observations will allow to increase their accuracy from 1 arcsec to a few mas. It is necessary to accurately model periodic behavior, observable through astrometry for dynamics.

What is an “old” optical observation ?



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New definition !

An “old” optical observation is an observation made and reduced before the arrival of the final Gaia reference star catalog.

Why re-reducing old optical observation ?

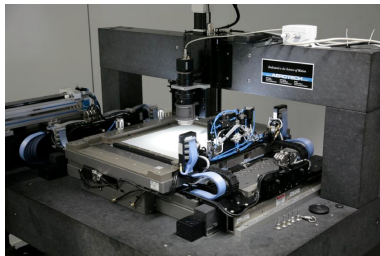
1. To increase the astrometric accuracy for old data analyzed several decades ago and reduced with old star catalog (biased !).
2. To express all data in the same reference system, eliminating biases between the different sets.

How to re-reduce such materials ?

- Old optical observations are mainly photographic plates : either measurements of all objects are available, or plates must be digitized.
- Having the “complete” observation metadata : measurements realized at the time of the observations, original photographic plates in good shape, all needed metadata.

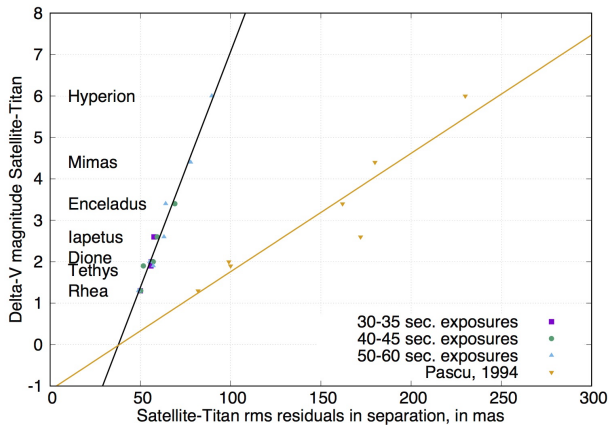
Tests have been made to calculate the intrinsic precision of the photographic plates.

Preliminary tests - USNO plates at ROB

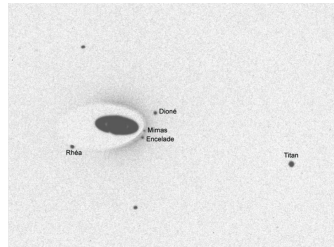
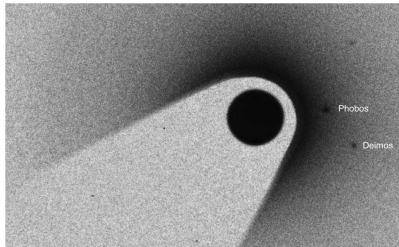


- Use of UCAC catalogs → accuracy of 70 mas for observations covering 1960-1998, that is better than more recent observations programs !
- Detection of very thin effects, such as the gravitational perturbation of Amalthea on Io.

Preliminary tests - USNO plates at ROB



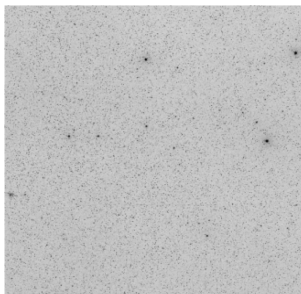
Planetology



Astrometry of planets and satellites

- Enlarging the time span of the observations allows to measure accelerations, and to quantify tidal effects in the motions.
- Accurate astrometry with old observations allows to measure cumulative effects.

Asteroids and comets



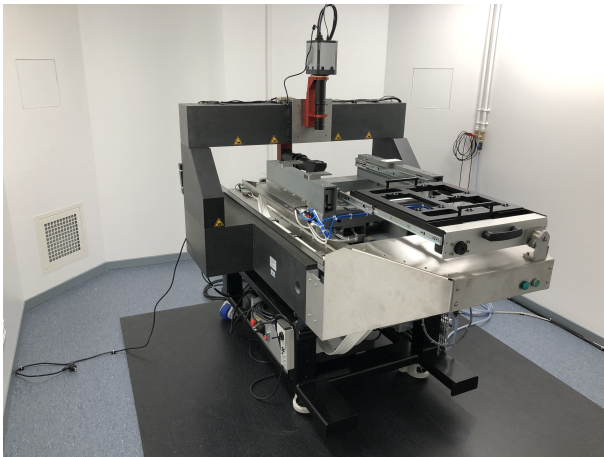
Astrometry of asteroids and comets

- Schmidt and astro-photographic plates contain a lot of unknown objects that are now detectable, thanks to Gaia catalog, that allow : pre-discoveries of TNO's, pre-discoveries of comets, pre-discoveries of NEA's/NEO's.
- A long time span allows to improve the dynamics of such objects and to quantify non-gravitational effects.

The NAROO centre

A unique digitization centre in the world, dedicated to the analysis at the best accuracy of old astro-photographic plates for scientific purposes !

NAROO digitizer



Facilities

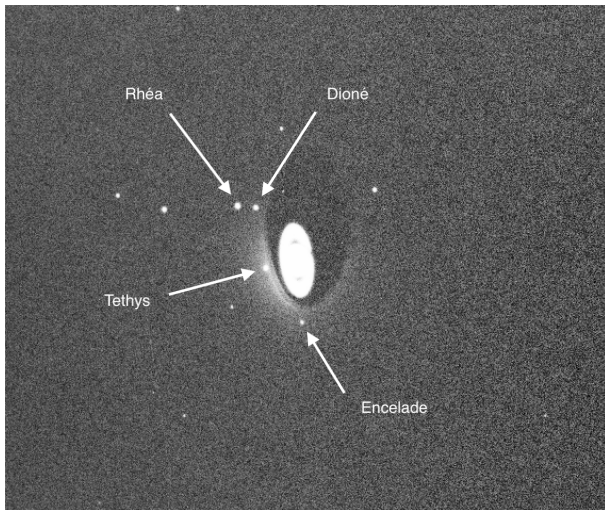
Instrumental part

- $3\mu\text{m}$ air-bearing Microcontrol XY-Table
- Granite base 1900mm x 1400mm
- Supports up to 350mm x 350mm
- Orthogonality, tilts, and flips constraints by 1nm Heindenhein encoders
- $6.5\mu\text{m}$ sCMOS Andor camera
- Newport stability 10-15nm — **Measured at 25nm with real data !**
- Newport repeatability 10-15nm — in progress XD

Environment

- 100m² in Meudon, Paris observatory
- Rooms dedicated : offices, (temporary) archiving space, and instrument
- Digitizer room regulated ISO5 20°C±0.1°C with 50%RH±10%RH, overpressured

First light - April 2019 - 1975 USNO plate



The NAROO centre

Digitizations of old astro-photographic plates are starting for scientific projects !

Our website will gather plate database and offer free access to the images !

See [▶ NAROO website](#) and [▶ NSDB link](#)

Partnerships

In France

- IMCCE, LESIA, GEPI (Paris Observatory) for planetology and astrophysics
- IPSA (engineering school) for high precision metrology
- OCA, OHP and LAB for astro-photographic and Schmidt plates

Worldwide

- U.S. Naval Observatory (Washington DC, USA) with a strong collaboration still engaged for photographic materials
- Queen Mary University of London for (re-)reducing Greenwich plates
- Pulkovo Observatory (Russia) for astro-photographic and Schmidt plates
- Bucharest Astronomical Institute (Bucharest, Romania) for astro-photographic and Schmidt plates
- Shanghai Observatory (China) for astro-photographic and Schmidt plates

Conclusion

Digitizing old photographic plates and (re-)reducing old observations will be an enormous challenge, for which we should make choice and define criteria for the digitizations.

Our digitizing machine and centre are now operating !

Questions

