Data mining with Pulkovo photographic plates archive.

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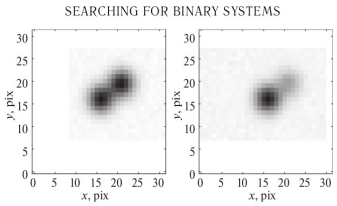
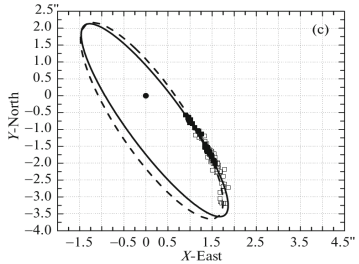
LASA = Lab of Astrometry and Stellar Astronomy

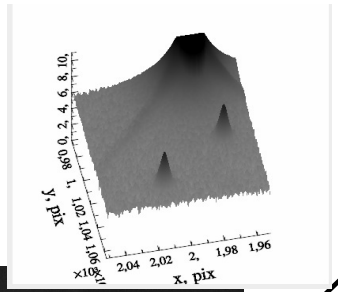


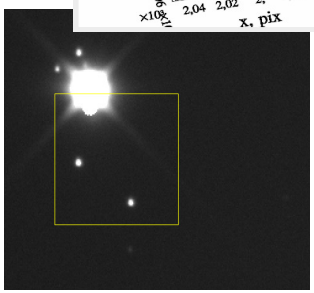
Kinematics and duplicity of dwarf stars in the solar neighborhood

LASA

Visual Double stars. Orbits and invisible satellites.



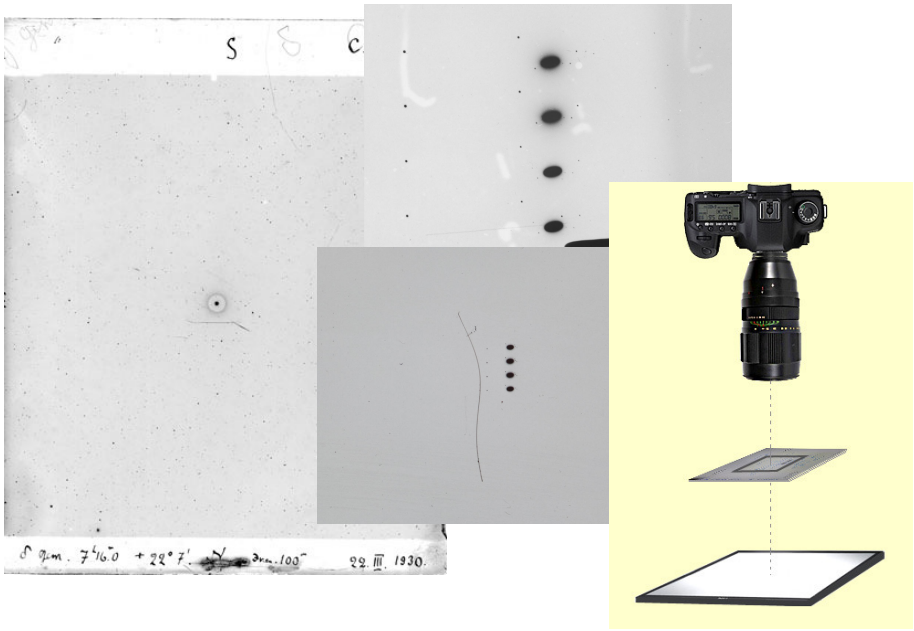




Astrometry of the natural planetary satellites

Basic data sources

Plates collection of the Pulkovo Observatory contains more than 48000 astronegatives

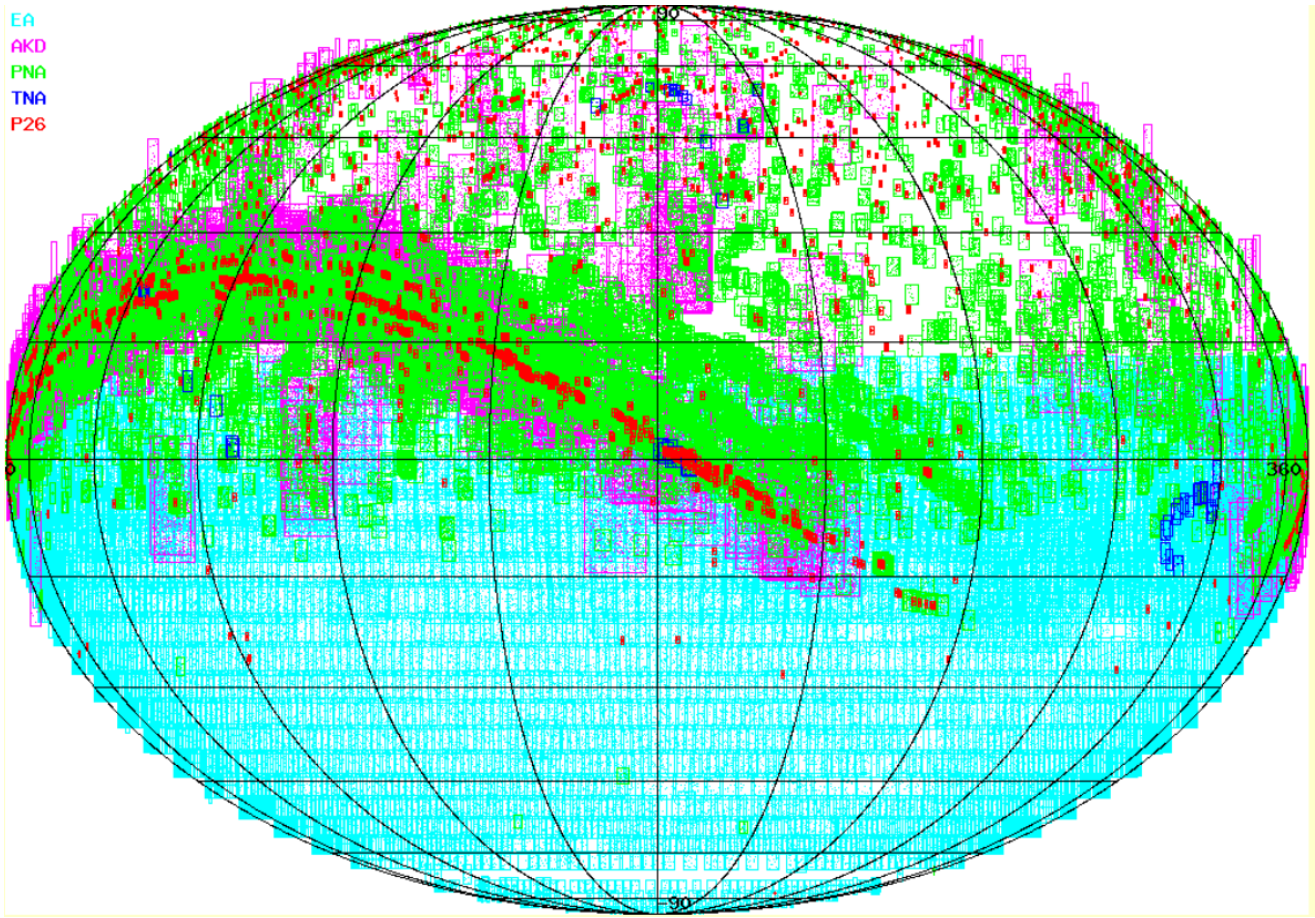


26-inch refractor - 22,222 pl. (1956 - 2007)
Normal Astrograph - 16,353 pl. (1894 - 2004)

Expeditionary Astrograph
Ordubad, Azerbaijan - 2255 pl. (1974-1994)
Tarija, Bolivia - 5486 pl. (1982-1994)

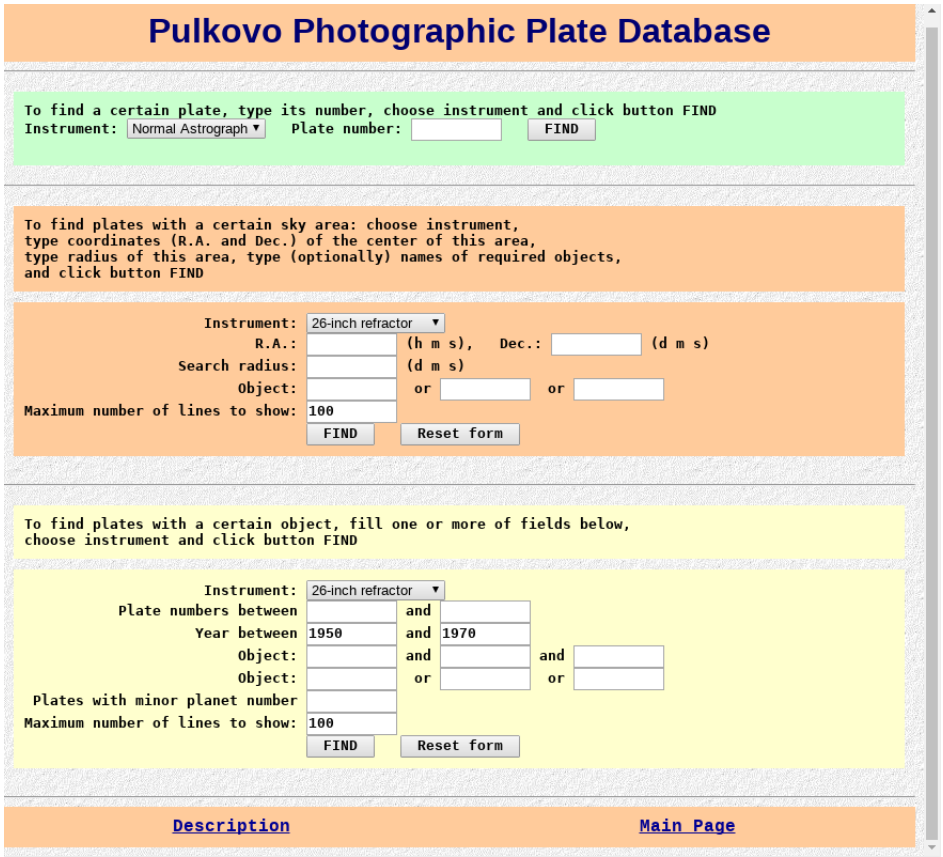
Pulkovo plates collection

Distribution of the plates over the celestial sphere



Pulkovo plates collection

http://www.puldb.ru/db/plates - Pulkovo plates database



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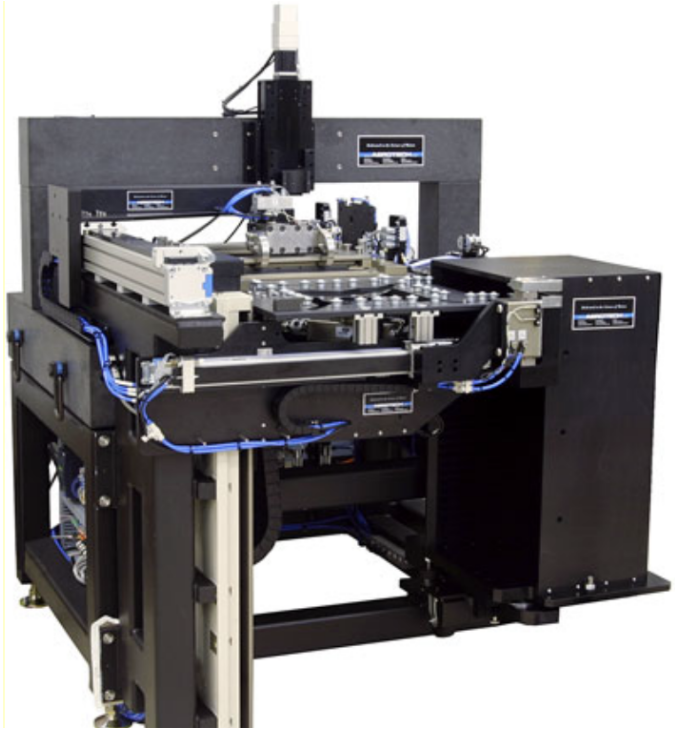
Digitization techniques

We used various techniques during last decade. From accurate scanners to large digitizing machines (Fantasy and ROB Digitizer (DAMIAN)).

Average accuracy is about 3 - 5 μm.
Relatively large systematic errors. Hard to parametrization.

$\Longrightarrow$



Average accuracy is better than 1 μm.
Small systematic errors. Relatively easy to correct within 'imaget'.

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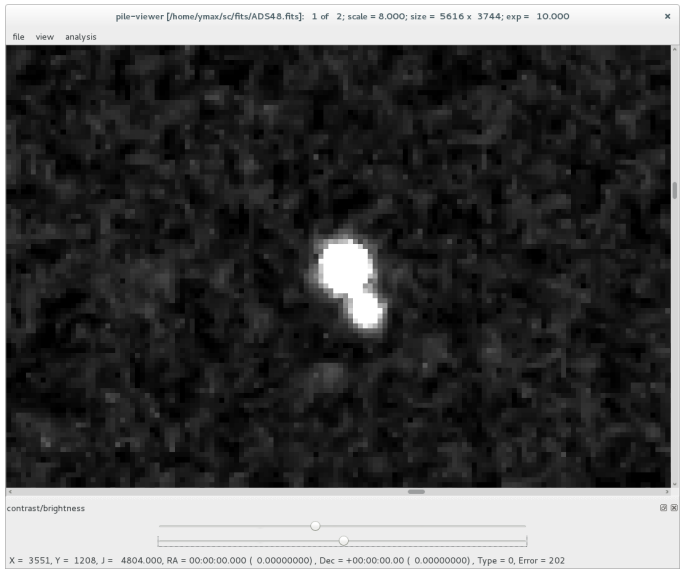
Why the way from digitized plate to x, y is so difficult?

Where is nano-accuracy of modern digitizing systems?



Granular structure of photographic image

Homogeneous pixel-to-pixel noise of astronomical CCD

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Mobile Digitizing Device (MDD)

scale=21 μm per pix (0.415 arcsec per pix for 26-inch refractor)

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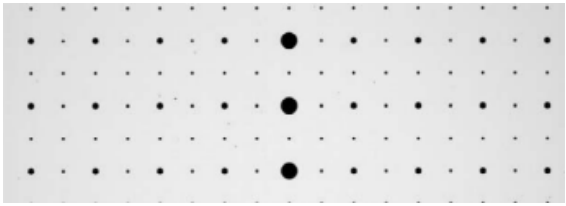
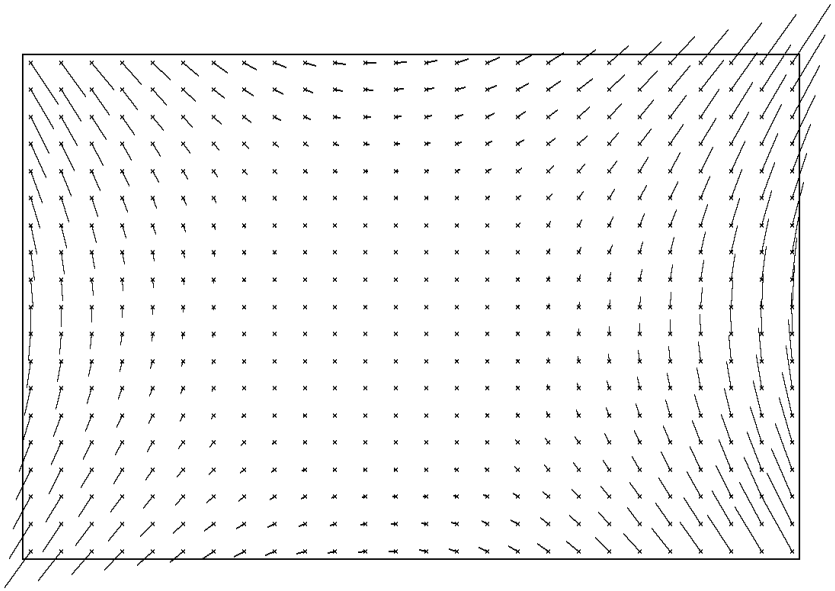
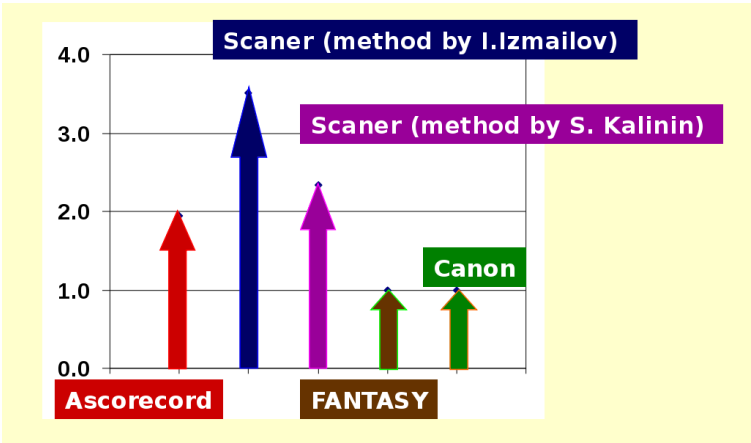
MDD-systematics





Template should be measured with high precision machine (like ROB-digitizer).

And field distortion pattern should be calculated.



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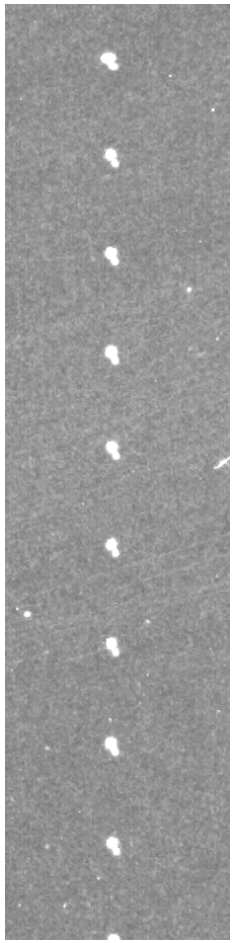
The main object of interest: visual double and multiple stars



The new digitization, measurement, and calibration method allowed about 9000 plates with the observations of visual double stars to be reduced in a short time and with minimal costs.

PHOTOGRAPHIC OBSERVATIONS OF VISUAL DOUBLE STARS

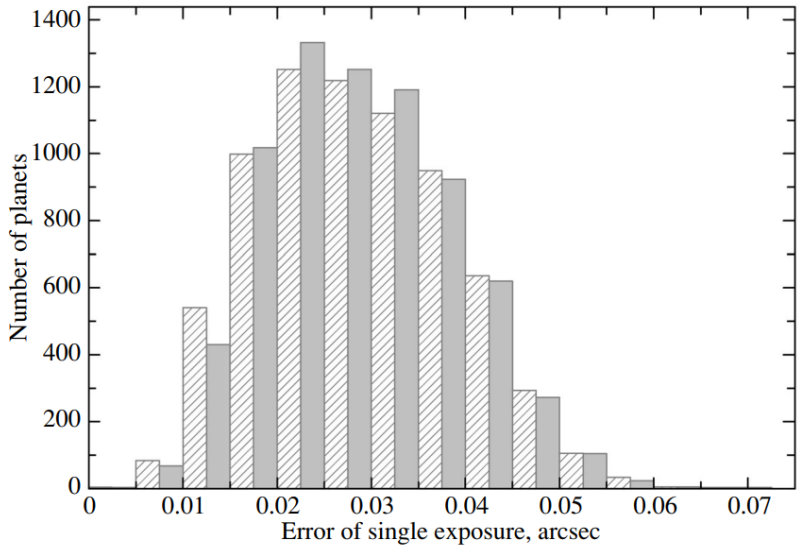


Fig. 9. Distribution of measurements in accuracy. The hatched and gray columns correspond to the measurements in the radial and transversal directions, respectively.

Izmailov I. S. et al. Photographic observations of visual double stars at Pulkovo: Digitization, measurement, and calibration. Astronomy Letters, Volume 42, Issue 1, pp.41-54 (2016)

Pulkovo plates collection

Solar system bodies. Some statistics.

Jupiter and Galilean satellites – 500 pl.(1976-2005)
Saturn – 800 pl. (1972 -2007)
Mars – 763 pl. (1960 -1988)
Uranus – 250 pl. (1910-2004)
Neptune – 237 pl. (1899-1955)
Pluto – 272 pl. (1930-1994)
Asteroids – 2655 pl. (1949-2004)

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1545 photographic observations of 14 selected asteroids.

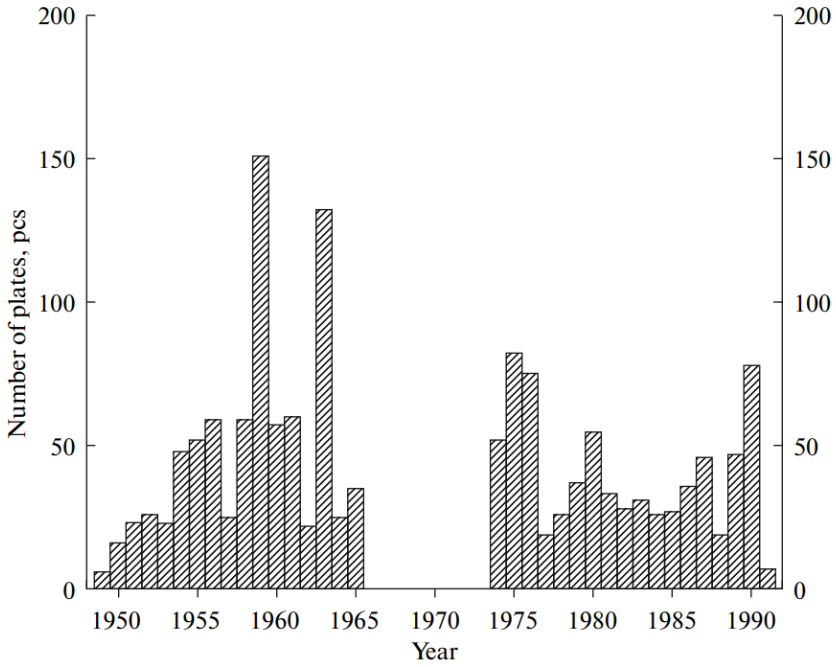

Fig. 1. Distribution of photographic plates by years.

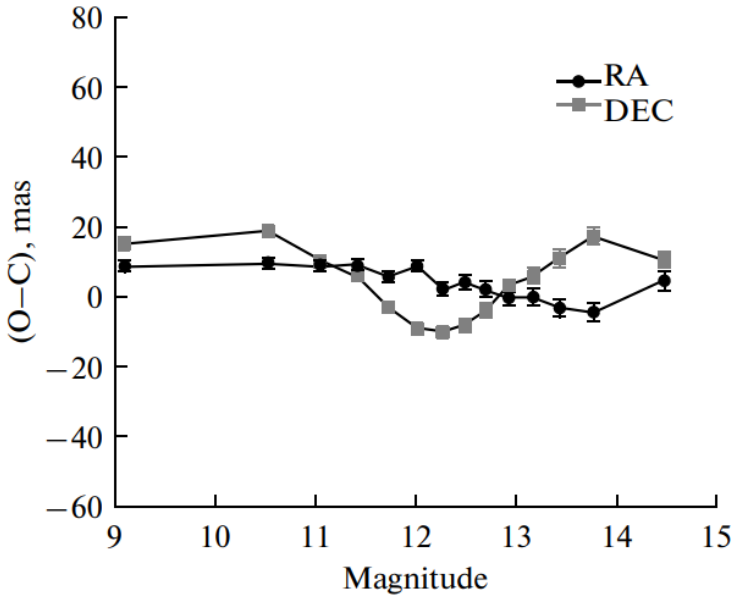

Fig. 4. Dependence of averaged differences (O−C) of magnitude after accounting for the systematic error.

Berezhnoi A.A. A new reduction of digitized photographic plates with selected asteroids obtained with the normal astrograph of the Pulkovo Observatory from 1948 to 1990. Solar System Research, Volume 47, Issue 3, pp.203-212 (2013)

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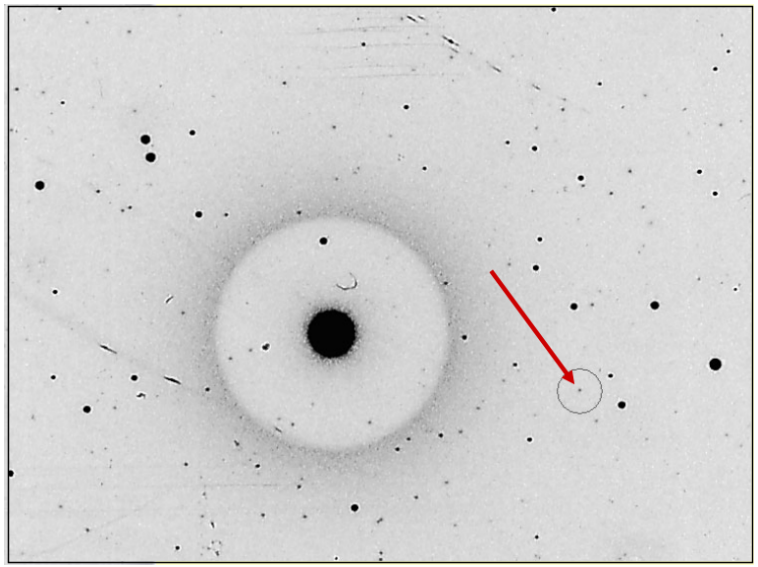
Pluto observations 1930 - 1960

Standard errors of equatorial coordinates are within 85 to 100 mas. Final table contains 63 positions of Pluto referred to the HCRF/UCAC4 frame.



Khrutskaya, E. V.; De Cuyper, J.-P.; Kalinin, S. I.; Berezhnoy, A. A.; de Decker, G. Positions of Pluto extracted from digitized Pulkovo photographic plates taken in 1930 - 1960. eprint arXiv:1310.7502 (2013)

Pulkovo plates collection

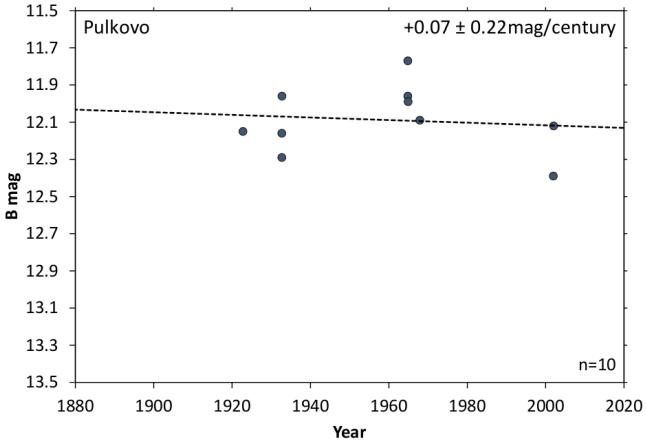
Requests for photometry in the stellar fields

The historic light curve of GR290 from plate archives

plate N	date DD MM YYYY	exp	rms	slope	B
K235	16 11 1935	1h 00m	0.05	0.78	16.90
K397	30 09 1937	1h 40m	0.28	1.20	18.67
K412	07 10 1937	1h 30m	0.20	1.02	18.45
K413	07 10 1937	1h 45m	0.08	0.84	17.95
K508	27 11 1938	1h 06m	0.12	0.84	17.93
K510	17 12 1938	1h 20m	0.08	1.09	18.54

Polcaro V.F.et al.GR 290 (Romano's Star): 2. Light history and evolutionary state, AJ, 151, 149, (2016)

Boyajian's Star



Hippke M,... Roshchina E., Vasileva T., Izmailov I., Samus N.N. et al. Sonneberg Plate Photometry for Boyajian's Star in Two Passbands. The Astrophysical Journal, Volume 837, Issue 1, article id. 85, 11 pp. (2017)

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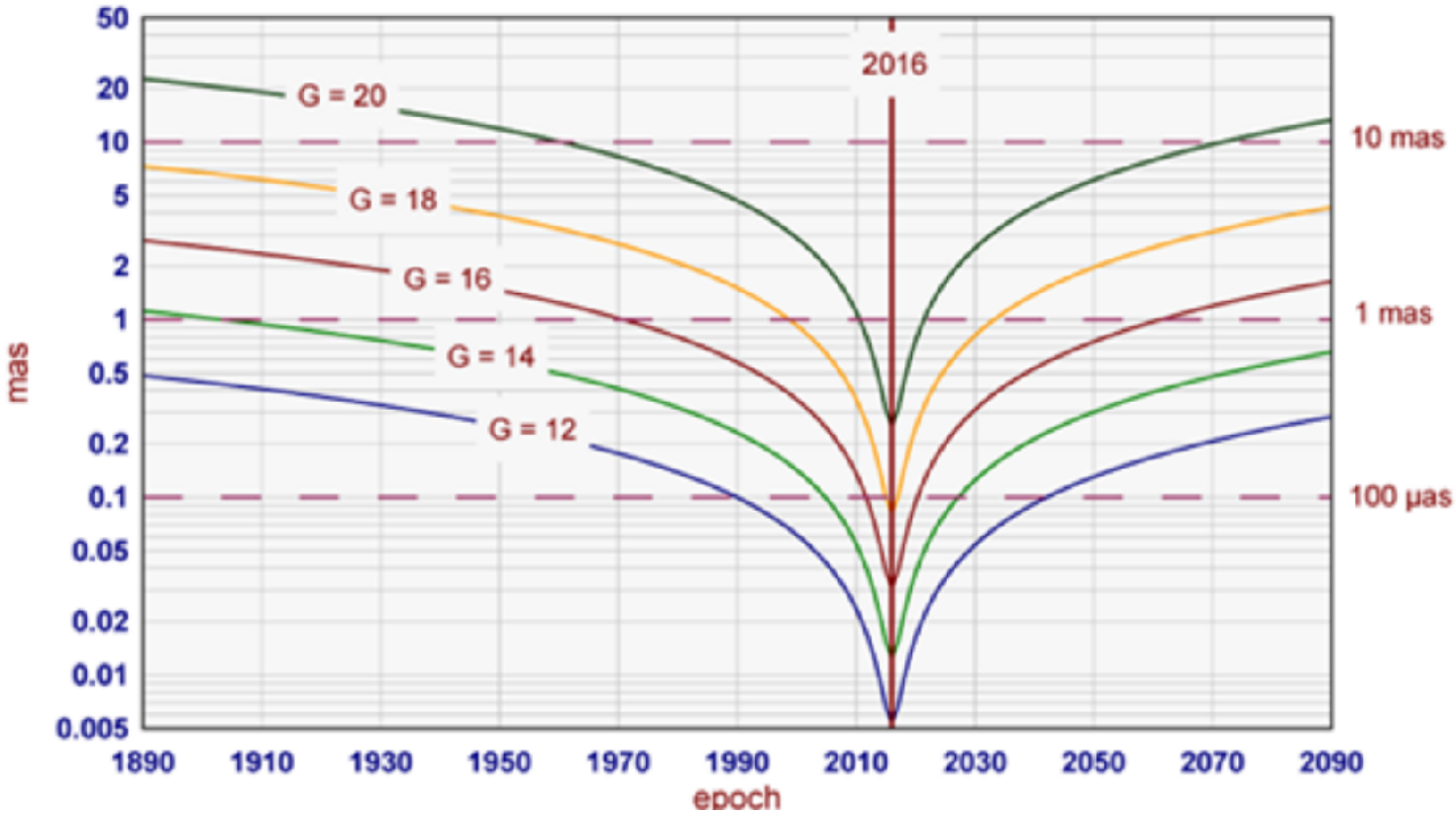
Degradation of Gaia accuracy as a function of time



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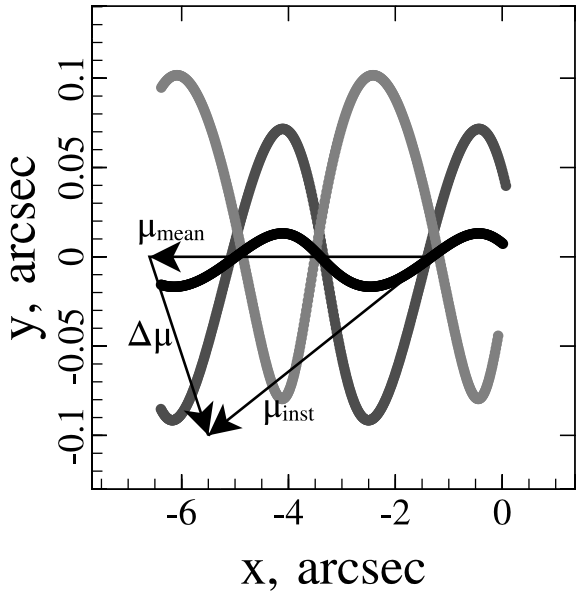
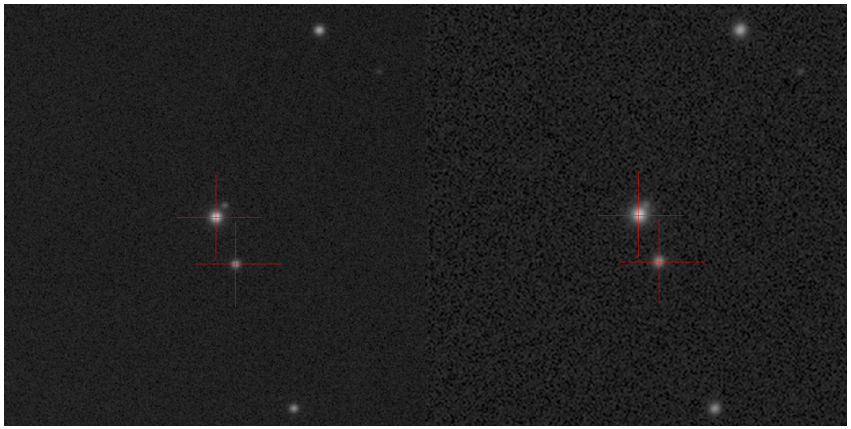
Stellar cluster and stellar field plates

A search for $\Delta\mu$-binary



Black line is a trajectory of the photocenter of binary system.

A search for microlensing events



Detecting of lensing by improvement proper motions of potential lens stars

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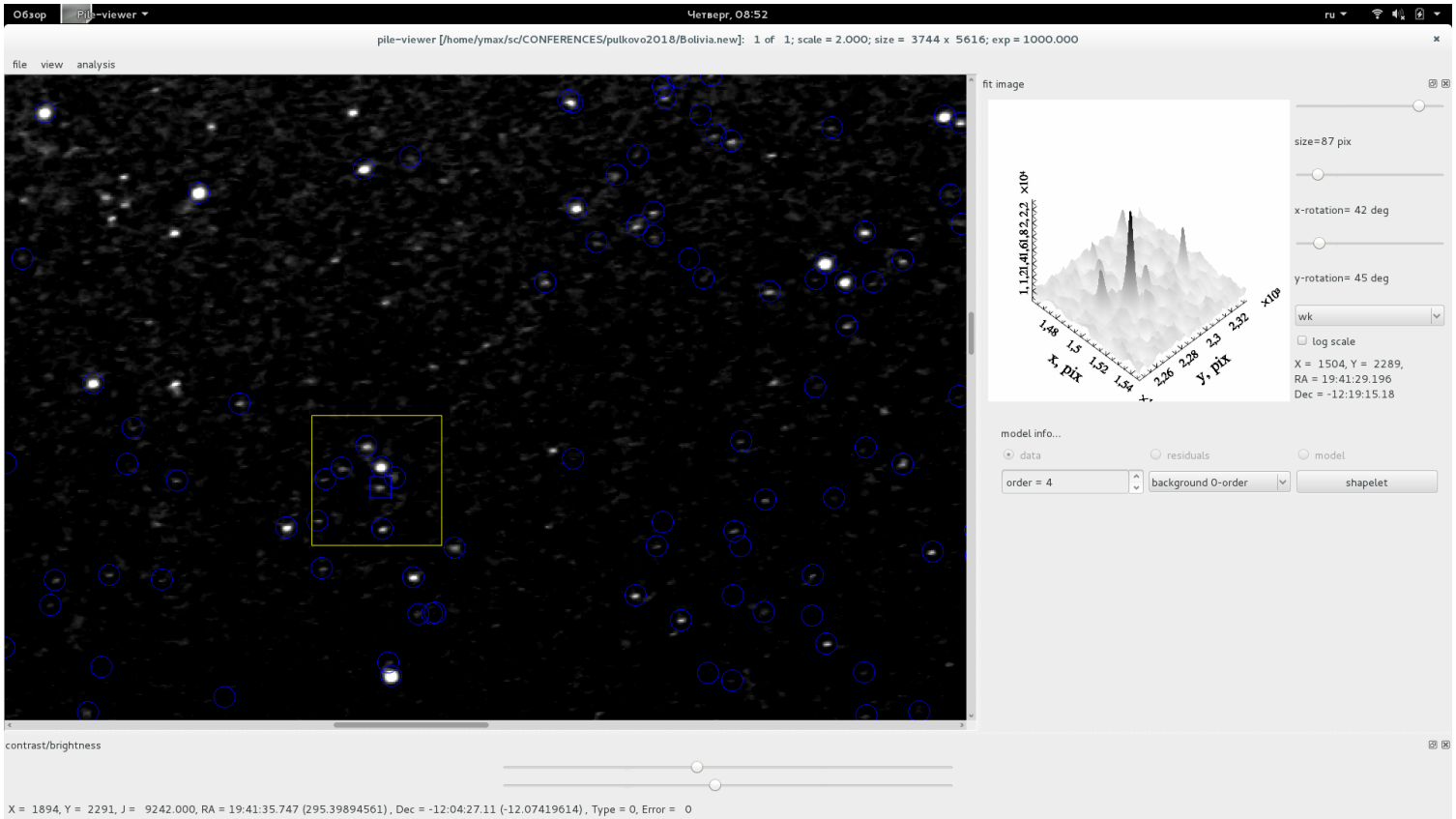
Small area of the astronegative taken in Bolivia



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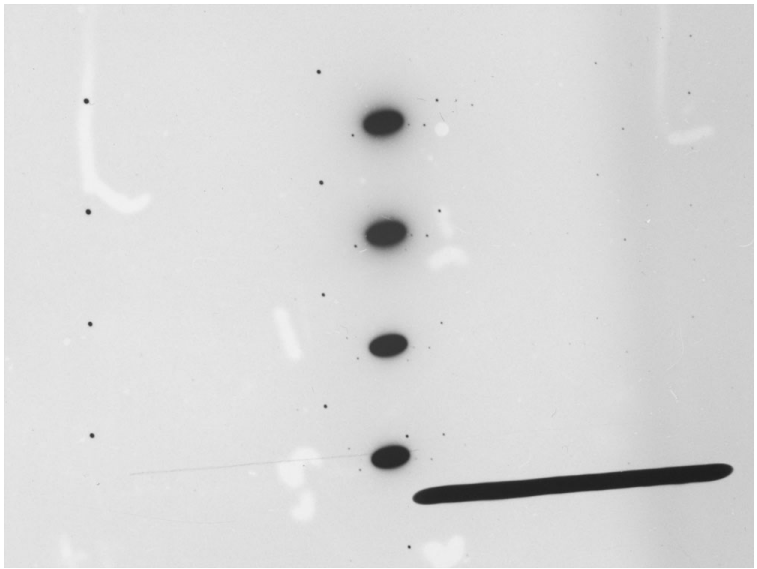
A new reduction of the negatives with planetary satellites in the Gaia reference frame



Conclusions

- Pulkovo plate collection is widely used for investigations;
- New methods of digitization and analysing of astronegatives have been developed at LASA;
- Future investigations will be concentrated in the fields of: astrometry of asteroids and planetary satellites in GaiaCRF2 at old epochs, binary stars searching by proper motion analysis, revealing of long-term photometric behaviour of stars.

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Thank you!