

Pulkovo observations in last campaigns of GAIA FUN SSO

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Saint-Petersburg, Russia

ZA-320M

at Pulkovo observatory (Saint-Petersburg)

084

Cassegrain
system

$D = 320 \text{ mm}$
 $F = 3200 \text{ mm}$

CCD-camera
SBIG STX-16803

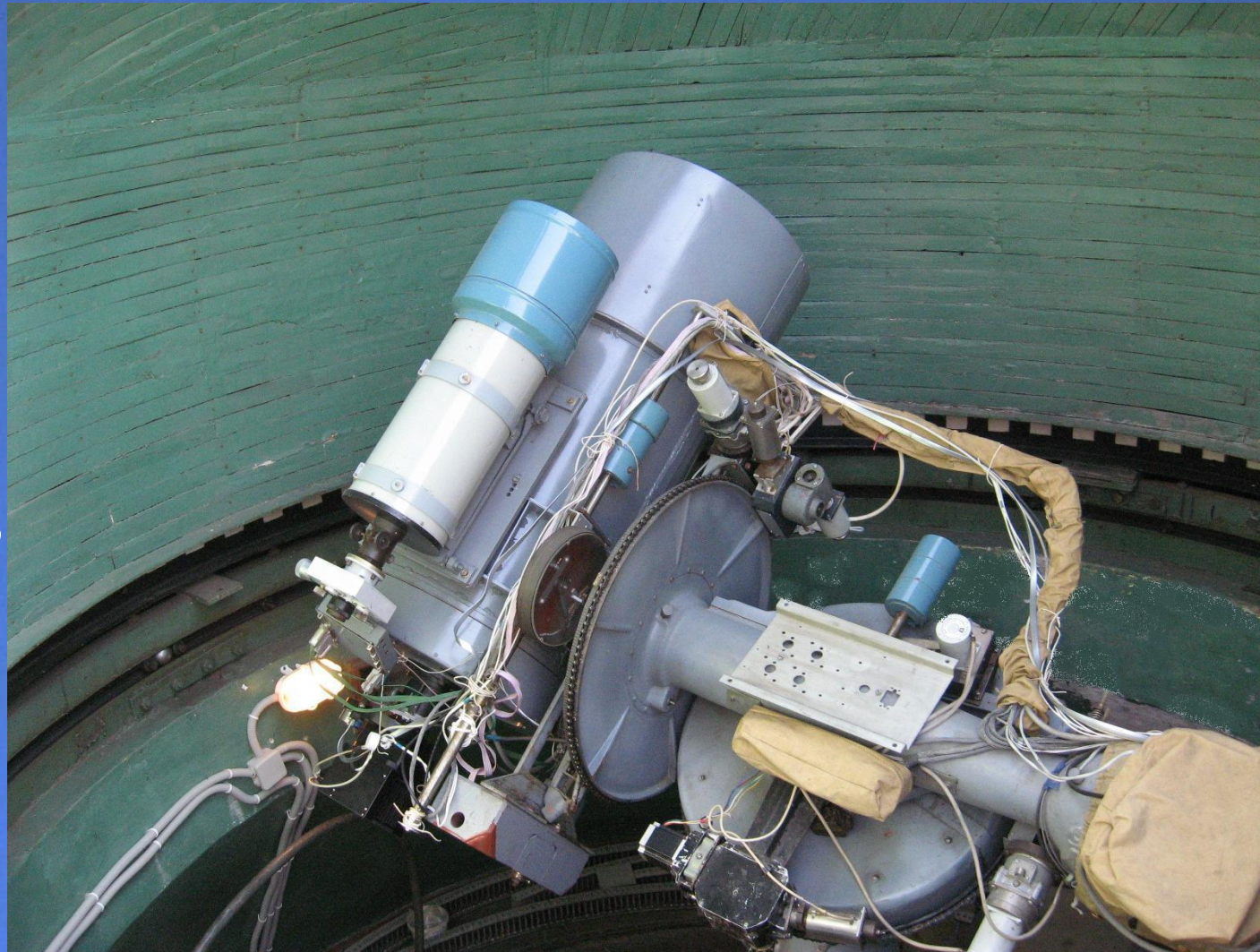
$4096 \times 4096 \text{ pix.}$

$9 \times 9 \mu\text{m}$

(binning $3 \times 3 \text{ pix}$)

$\text{FoV} \approx 39' \times 39'$

BVRI filters



MTM-500M

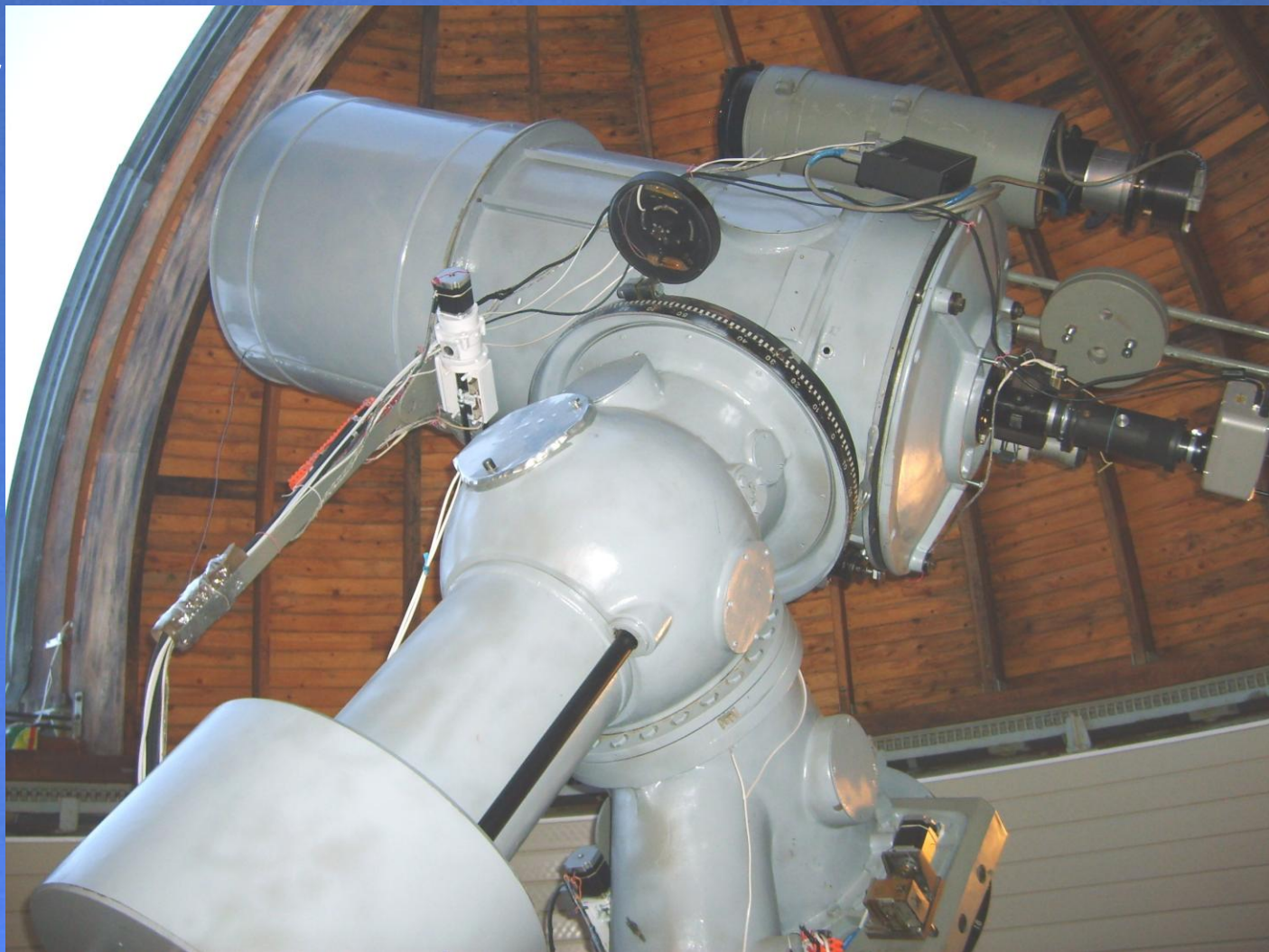
at Mountain astronomical station of Pulkovo observatory
(Northern Caucasus near Kislovodsk, $h = 2100$ m) C20

Maksutov – Cassegrain
system +
extra lens corrector

$D = 500$ mm
 $F = 4100$ mm

CCD-camera
SBIG STL 1001E
 1024×1024 pix.
 24×24 μm
 $\text{FoV} \approx 21' \times 21'$

BVRI filters



APEX-II – CCD-frame processing software

- Calibration – fitting, synthesis and application of darks and flats
- Sky background smoothing
- Object detection using threshold algorithm
- Deblending
- Object center detection using PSF method
 - Special algorithm for tracks measurement
- Flux measurement using aperture or PSF methods
- Noise rejection
- Identification of measured objects with reference catalogues (USNO-A2, USNO-B1, TYCHO-2, HIPPARCOS, UCAC-4, 2MASS, user's catalogues)
- Astrometric reduction using several methods
- Identification of unknown objects using EPOS module (asteroid and comet searching)
- Creation of report in standard format (e.g. MPC format)

EPOS

(Ephemeris Program for Objects of Solar System)
software for celestial-mechanics computations and visualization



The software is available at:

<http://www.epos.gao.spb.ru/personal/neo/ENG/ESUPP/main.html>

**ZA-320M and MTM-500M telescopes
take part in GAIA-FUN-SSO
training observational campaigns
since 2010**

(99942) Apophis

(December 2012 – March 2013)

515 astrometric positions (664 ?)
with average accuracy

0".07 -- 0".36 for right ascension

0".07 -- 0".48 for declination

Color indices

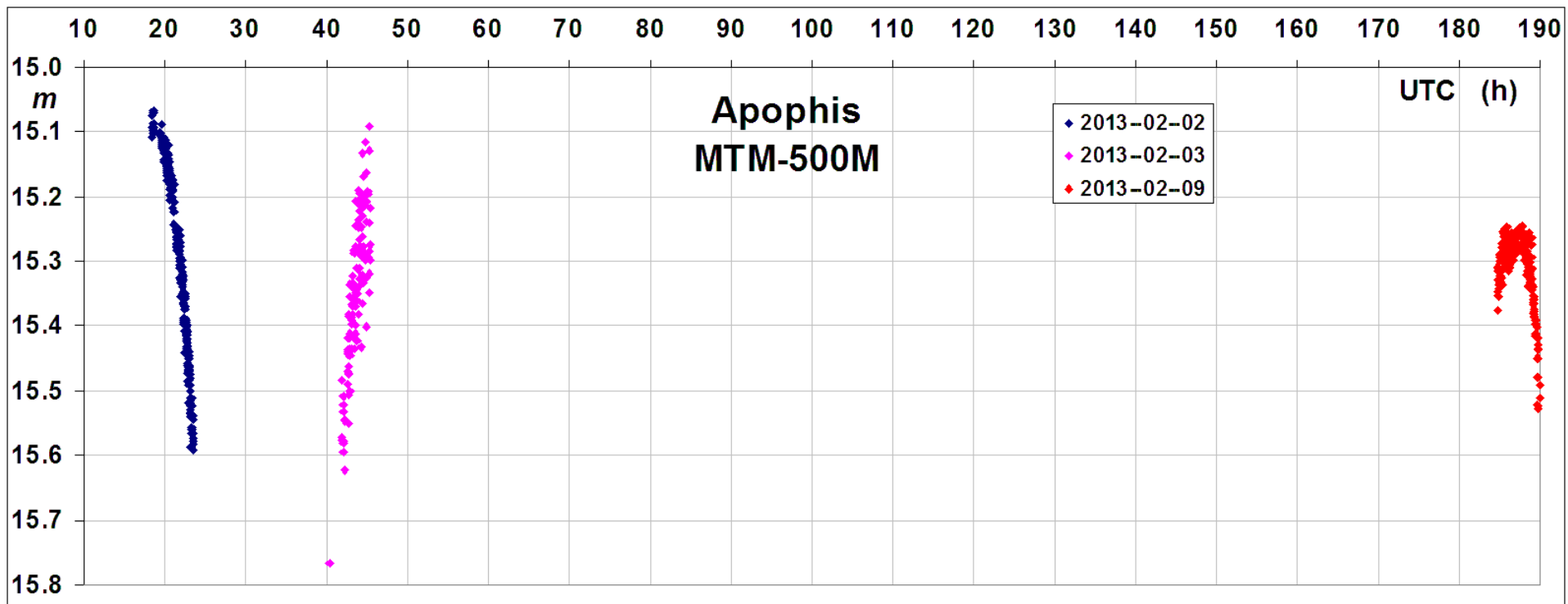
$$B-V = 0.81^m \pm 0.06^m$$

$$V-R = 0.42^m \pm 0.06^m$$

$$R-I = 0.28^m \pm 0.07^m$$

(99942) Apophis

(December 2012 – March 2013)



(367943) Duende = 2012 DA14

Close approach (27700 km) to the Earth
on 15-th of February 2013

436 astrometric positions
with average accuracy

0".43 for right ascension

0".26 for declination

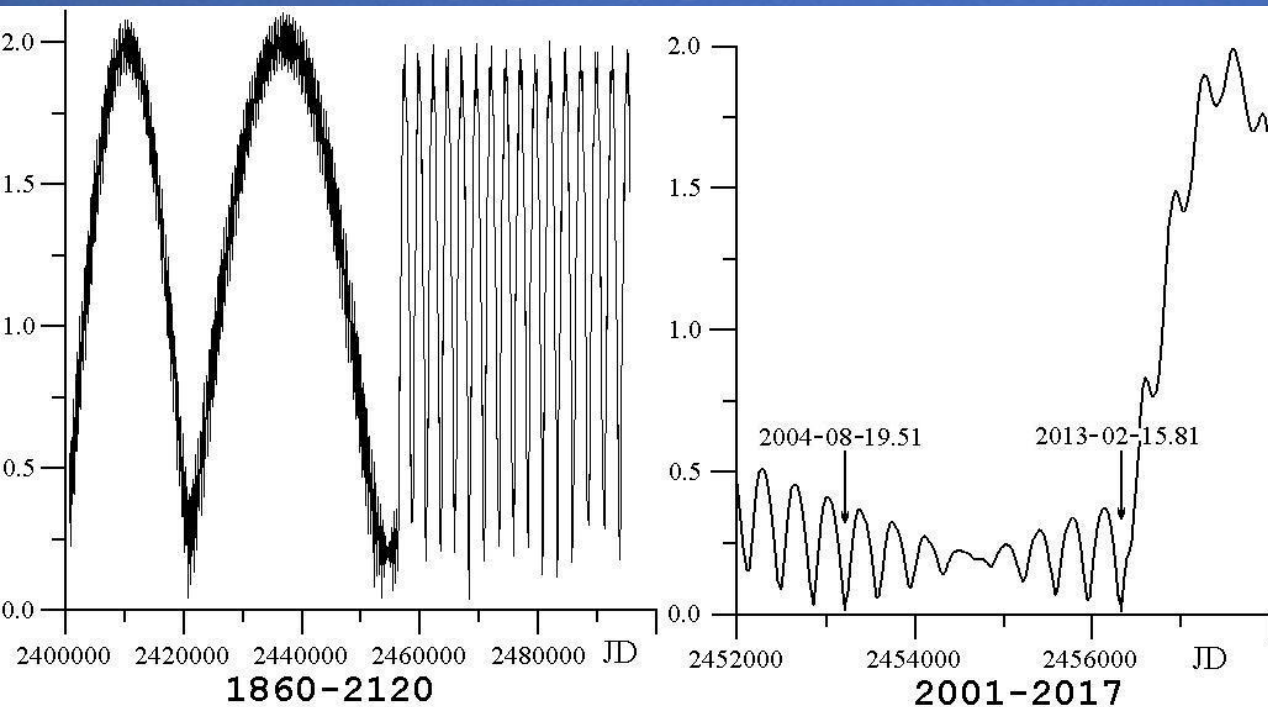
Color indices

$$B-V = 0.86^m \pm 0.15^m$$

$$V-R = 0.39^m \pm 0.04^m$$

$$R-I = 0.36^m \pm 0.03^m$$

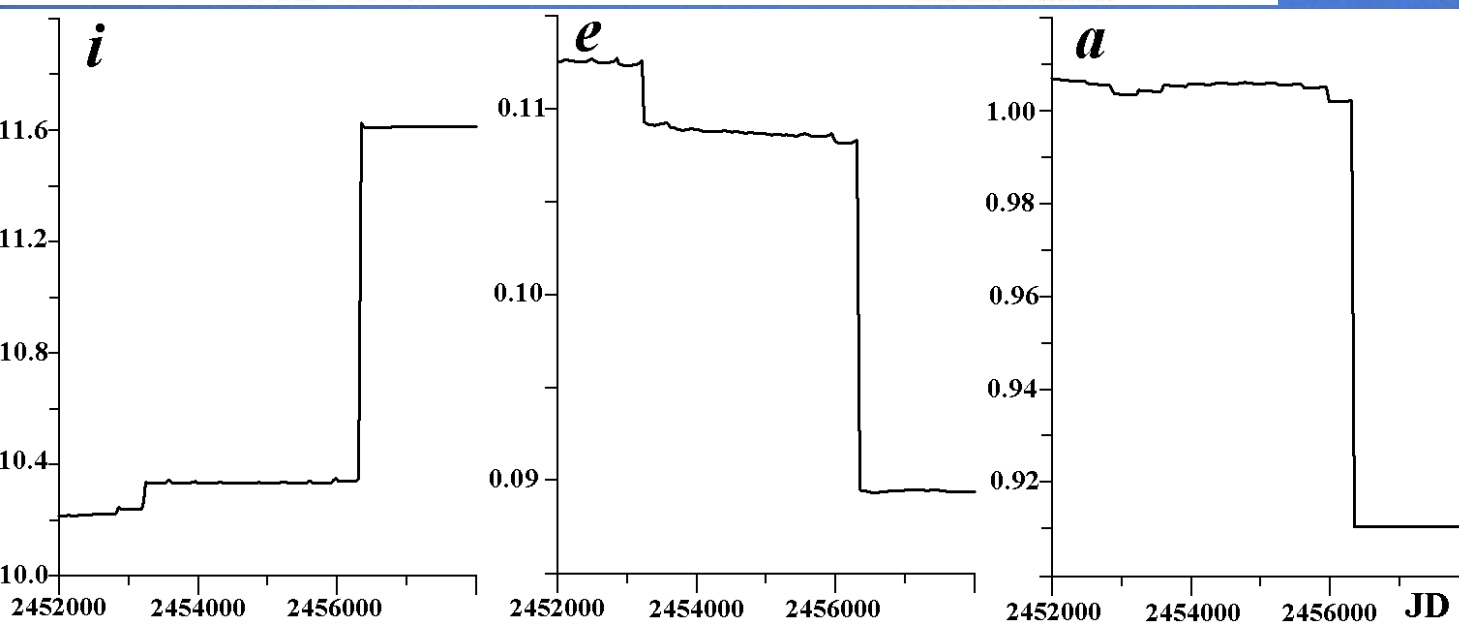
Duende orbital evolution



(EPOS calculations)

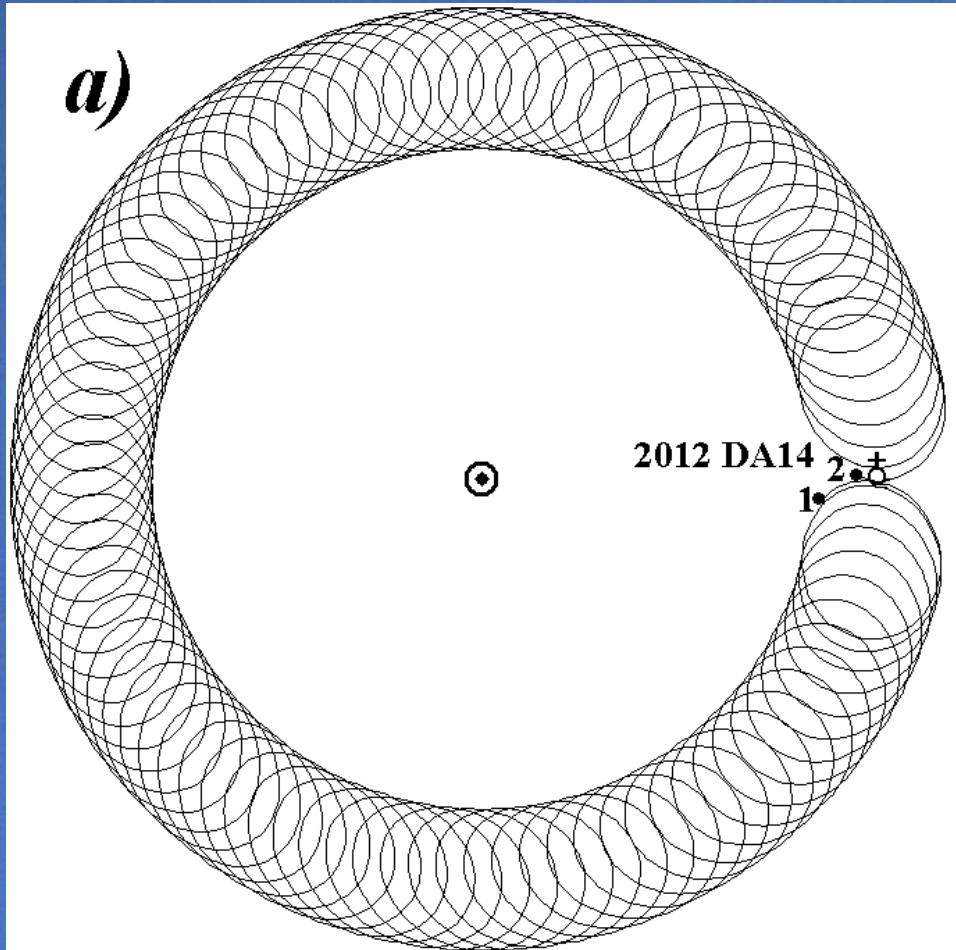
1:1 resonance
with the Earth

Change of
geocentric distance
in 1860 – 2120
and 2001 – 2017

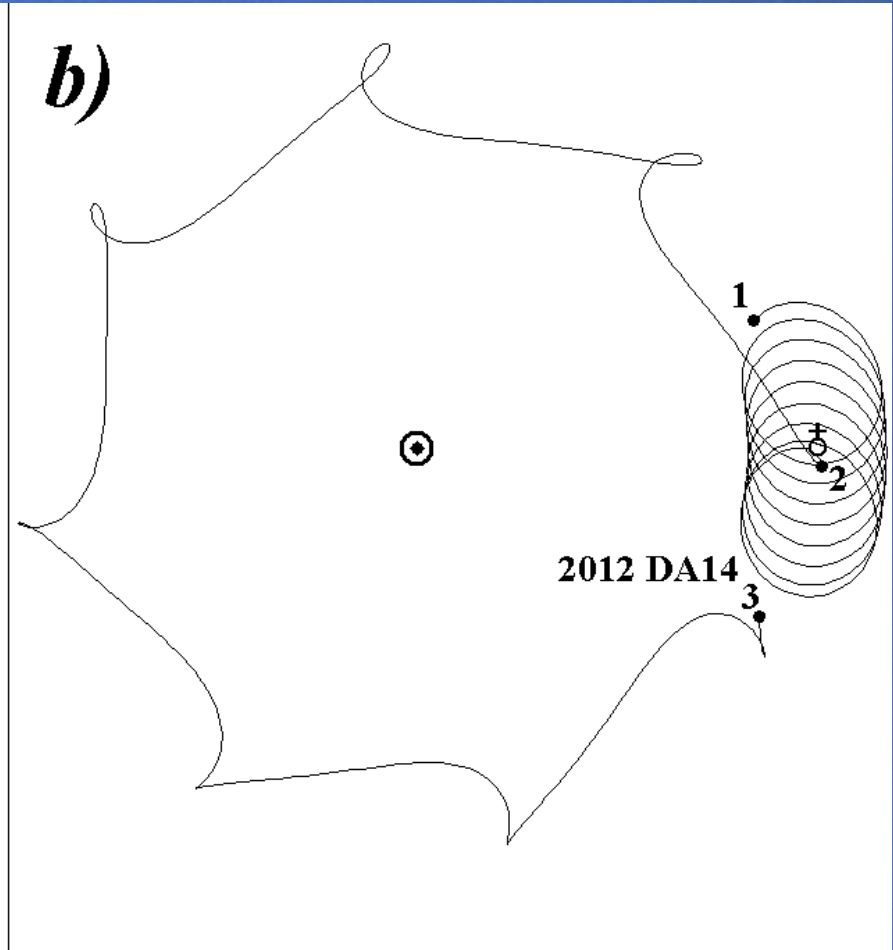


Change of 3
orbital elements
in 2001 – 2017

Duende orbital evolution (EPOS calculations)

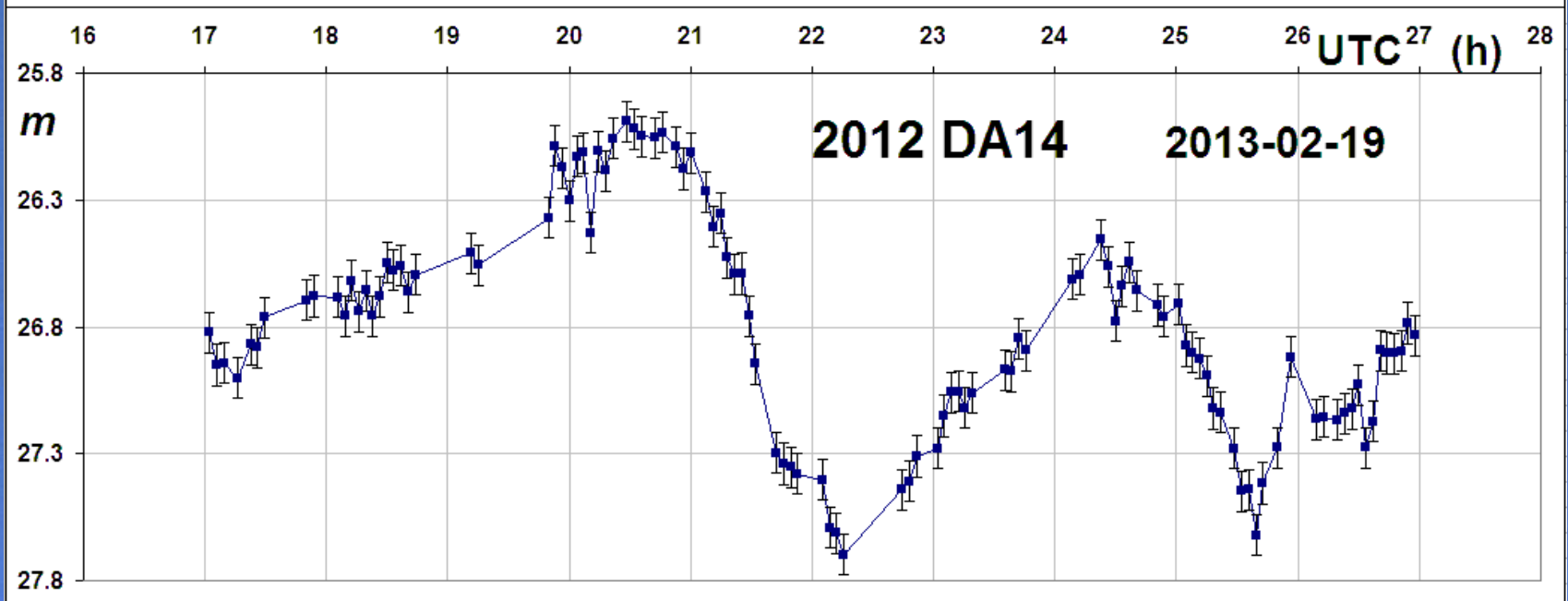
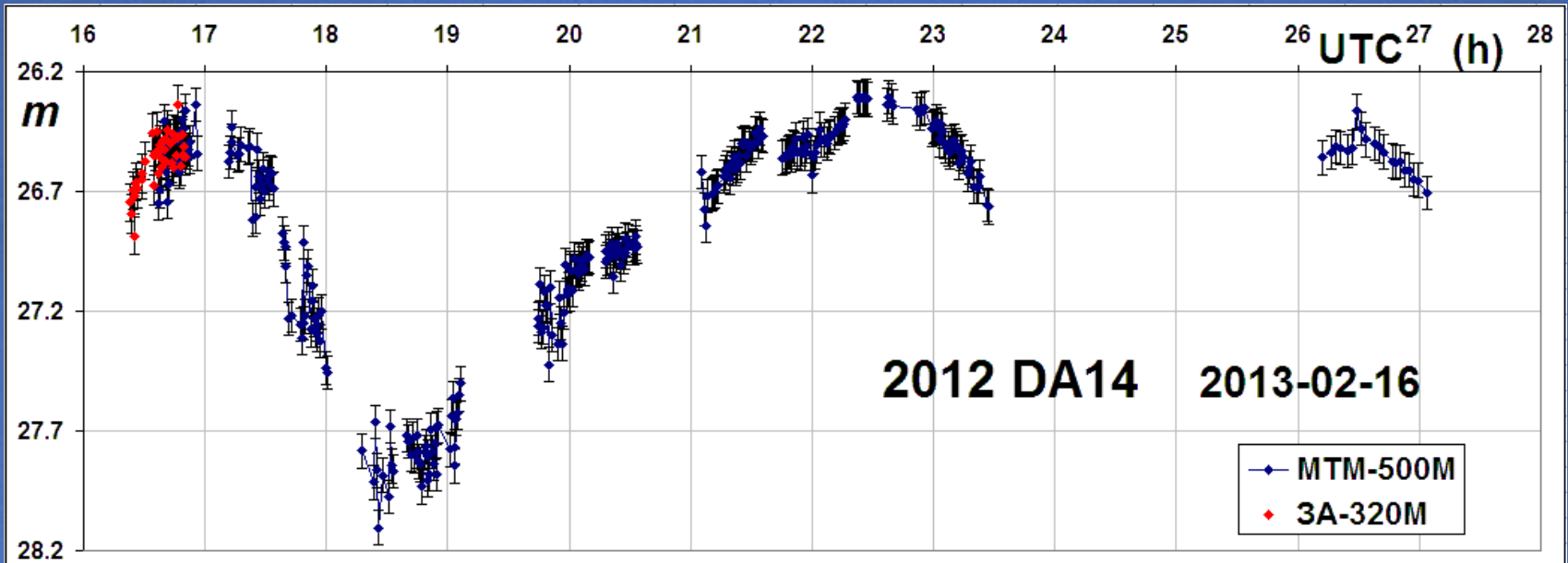


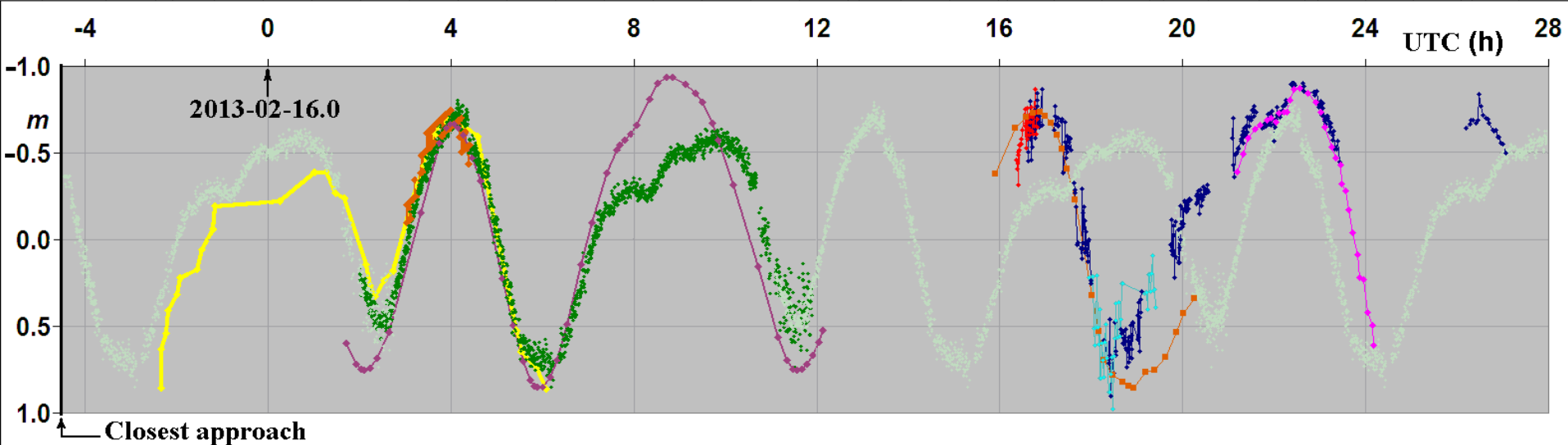
Horseshoe-shaped orbit



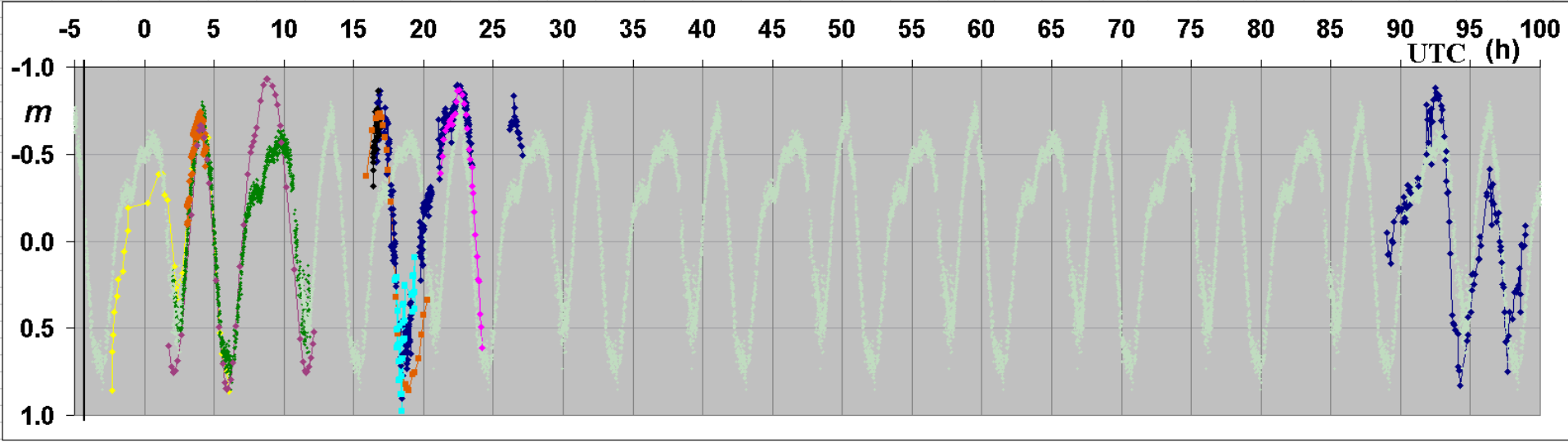
1-2 – quasi-satellite
or circulatory orbit
2-3 – circulatory orbit
after 2013-02-15

Duende light-curves



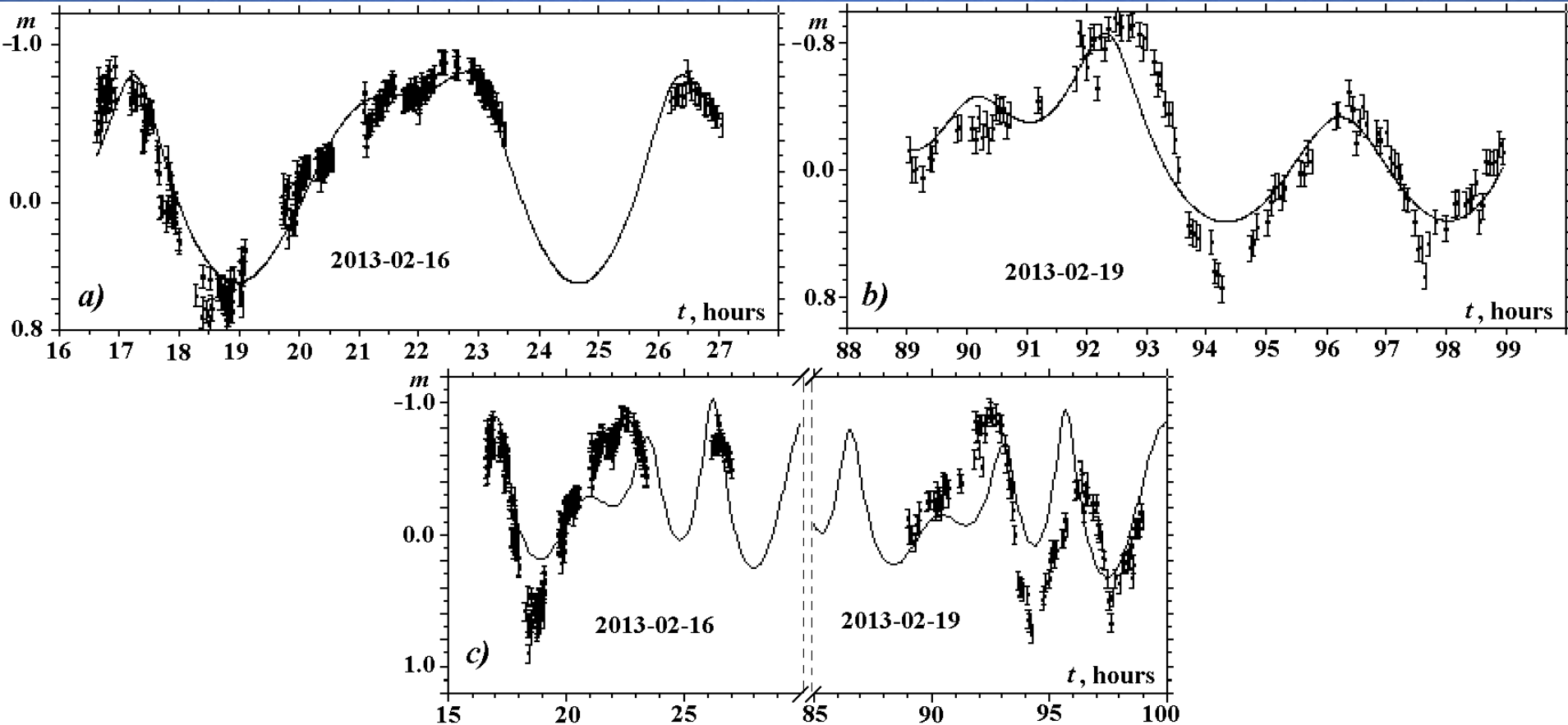


- ◆ *de Leon J. et al.*, *Astronomy & Astrophysics*, 2013, vol. 555, id. L2.
“La Hita” observatory, Spain, 15-16 febr. (Graphical data)
- ◆ *Gary B.* <http://brucegary.net/2012DA14>
Arizona, USA, 16 febr. (Digital data) ◆ $P = 9.22^h$
- ◆ MPC (MPS 456432)
NAO Rozhen, Smolyan, Bulgaria, 16 febr. (Digital data)
- ◆ *Elenin L., Molotov I.*, *The Minor Planet Bulletin*, 2013, vol. 40, no. 4, p. 187-188.
New-Mexico, USA, 16 febr. (Graphical data)
- ◆ **ZA-320M**
Pulkovo, Russia, 16 febr.
- ◆ **MTM-500M**
Northern Caucasus, Russia, 16-17 febr.
- ◆ *Teraï T. et al.*, *Astronomy & Astrophysics*, 2013, vol. 559, A106.
Saitama Univ. observatory, Japan, 16 febr. (Graphical data)
- ◆ MPC (MPS 456433)
Galati observatory, Romania, 16 febr. (Digital data)
- ◆ *Birtwhistle P.* <http://peter-j95.blogspot.ru/2013/02/partial-lightcurve-for-2012-da14.html>
England, 16-17 febr. (Graphical data)



◆ MTM-500M (19-20 febr.)
Northern Caucasus, Russia

Preliminary results of modeling of **Duende** rotation



Semi-axis of body ellipsoid – 4:2:1,
semi-axis of “photometrical” ellipsoid – 10:2:1
⇒ heterogeneous albedo and/or non-ellipsoidal form

Rotation of rotational axis (tumbling)

2013 TV135

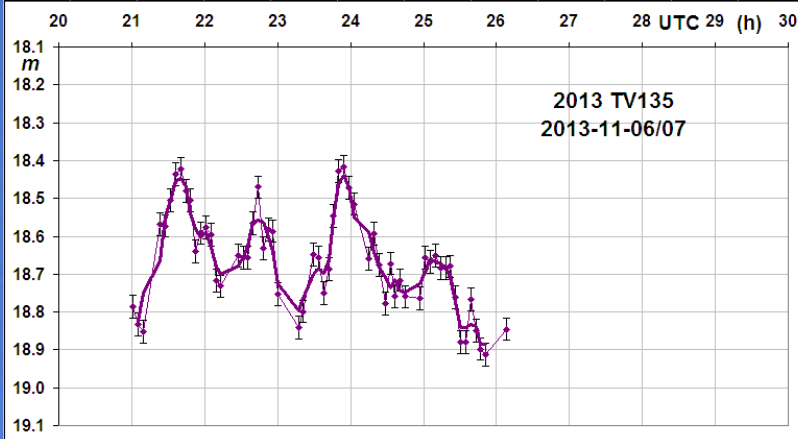
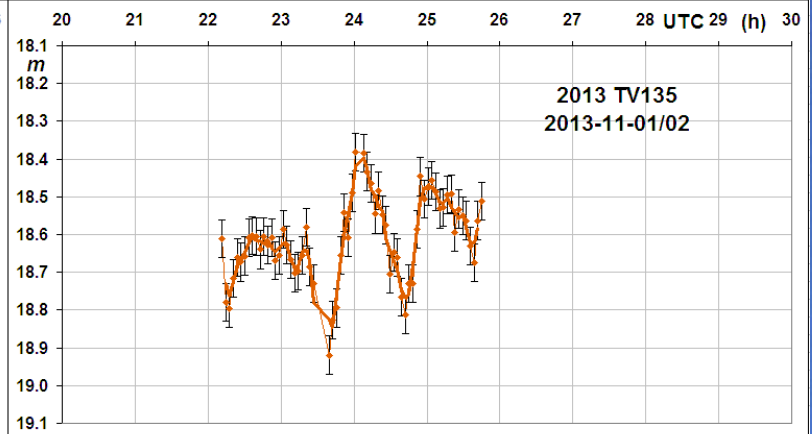
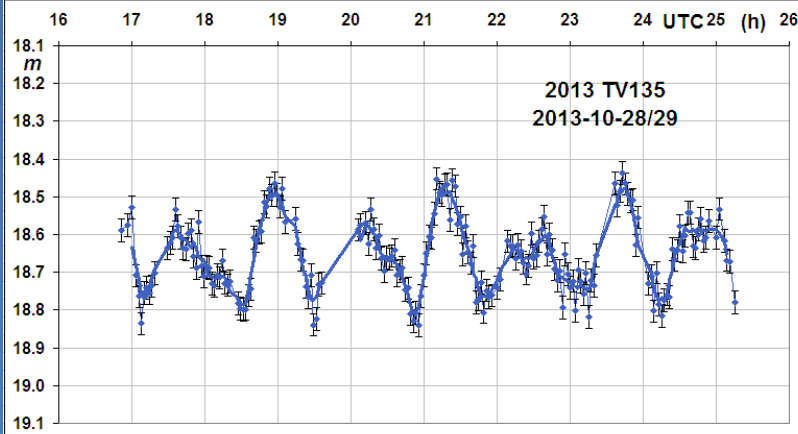
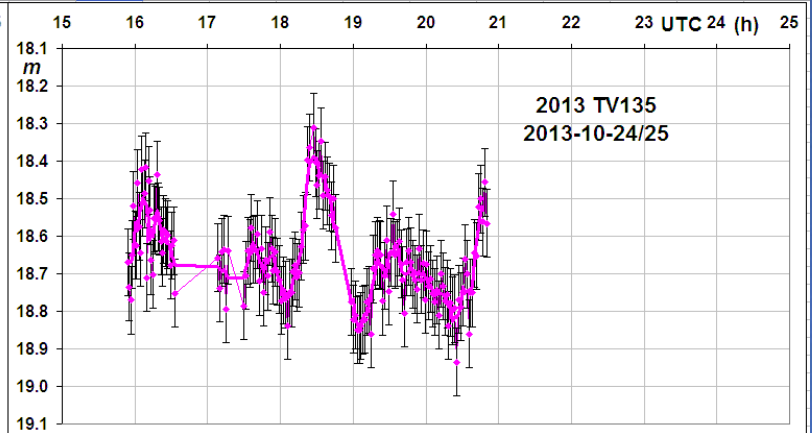
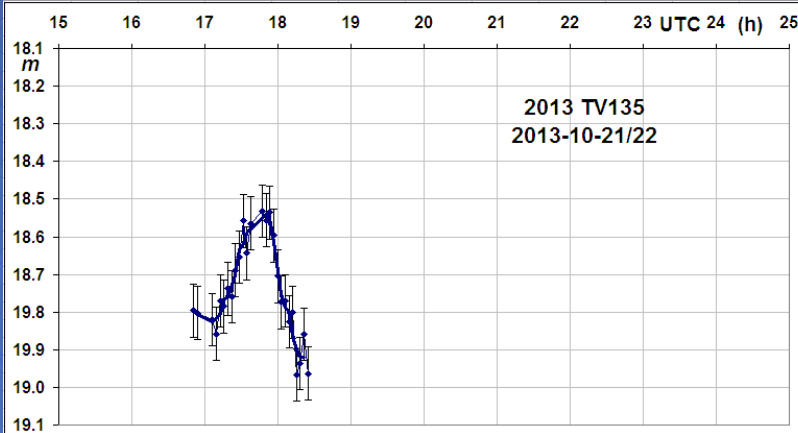
Approach to the Earth (0.045 a.u.)
on 2013-09-17

**335 astrometric positions
with average accuracy**

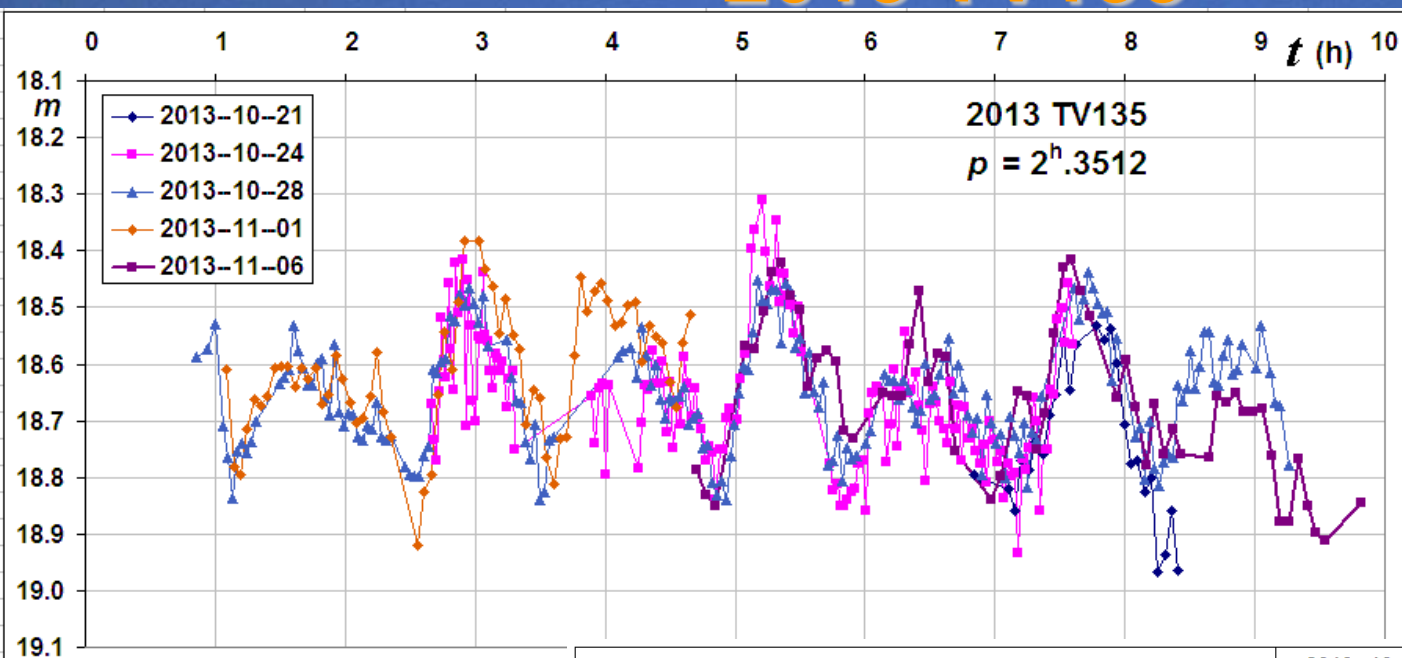
0".28 for right ascension

0".28 for declination

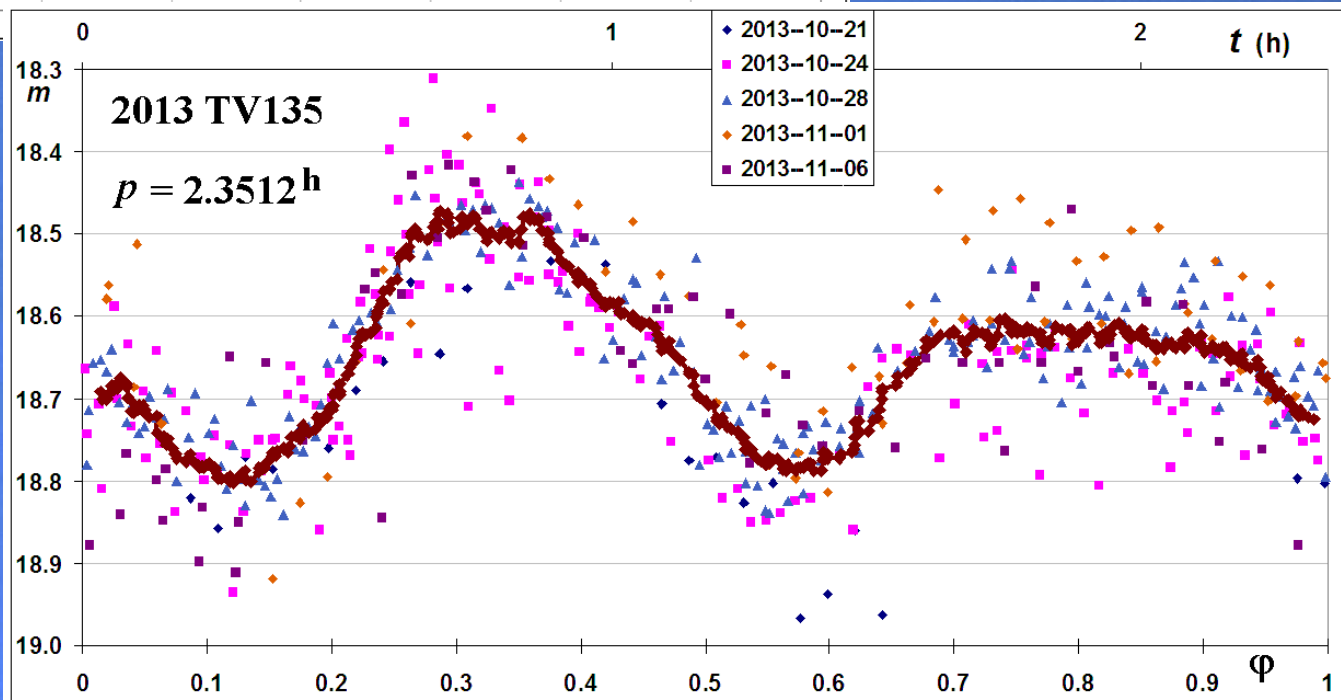
2013 TV135



2013 TV135



$$p = 2.3512^h \pm 0.0004^h$$



2014 HQ124

Close approach (0.0086 a.u.) on 2014-06-08.

- Campaign of Lohrman observatory (Dresden) for triangulation (synchronous observations)

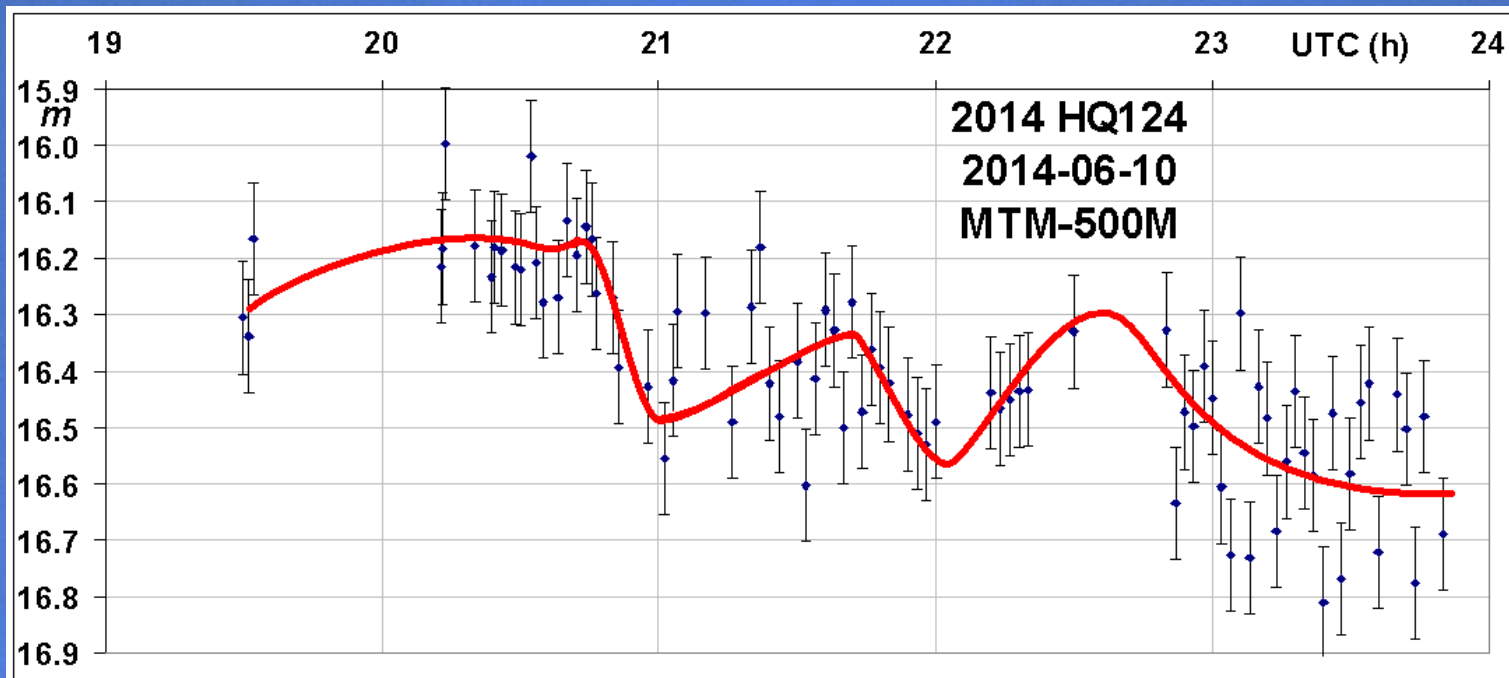
84 astrometric positions with average accuracy

0".19 for right ascension

0".26 for declination

including 18 positions

at appointed time moments for triangulation



AZT-16

Cerro El Roble, Chile

($h = 2220$ m)

Double-meniscus
Maksutov system

$D = 1.0$ m (mirror)

$D = 0.7$ m (meniscus)

$F = 2.06$ m

Astrometric

FoV $\approx 5^\circ \times 5^\circ$

CCD-camera

SBIG STX-16803

4096×4096 pix.

9×9 μm

FoV $\approx 1^\circ \times 1^\circ$

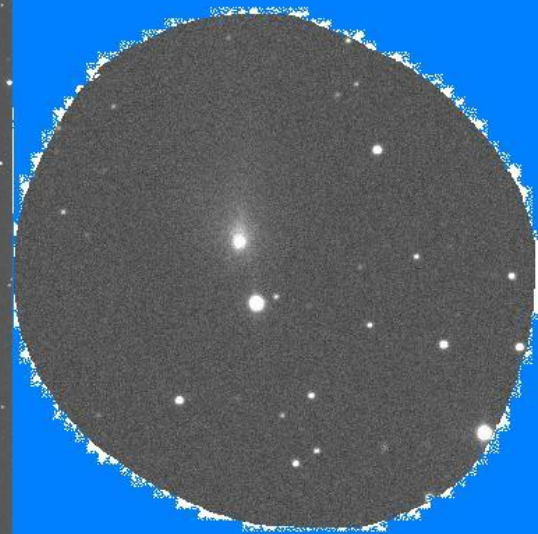
Up to 22^m



AZT-16



Comet LONEOS
AZT-16
2013-04-18
04:31:21.29 UTC



**Thank you
for your attention!**

