Astrometric and Photometric Applications for the Study of Outer Solar System Bodies

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Summary

- Context of the Outer Solar System;
- Goals:
  - Study of PSFs for Extended Objects; Digital Coronography;
  - Orbits of Irregular Satellites;
  - Stellar Occultation by TNOs, Centaurs and Irregular Satellites.

Outer Solar System Study

- Who are the Outer Solar System Objects?
  - Giant Planets
  - Satellites (Regular and Irregular)
  - Centaurs
  - TNOs
- Why study the Outer Solar System Objects?
  - Remnants of the primordial Solar System
  - Formation and Evolution of the Solar System

Outer Solar System Study

- Few objects visited by spacecraft.
- Ground-based observations:
  - Classic observations;
  - Stellar occultations;
  - Mutual phenomena;

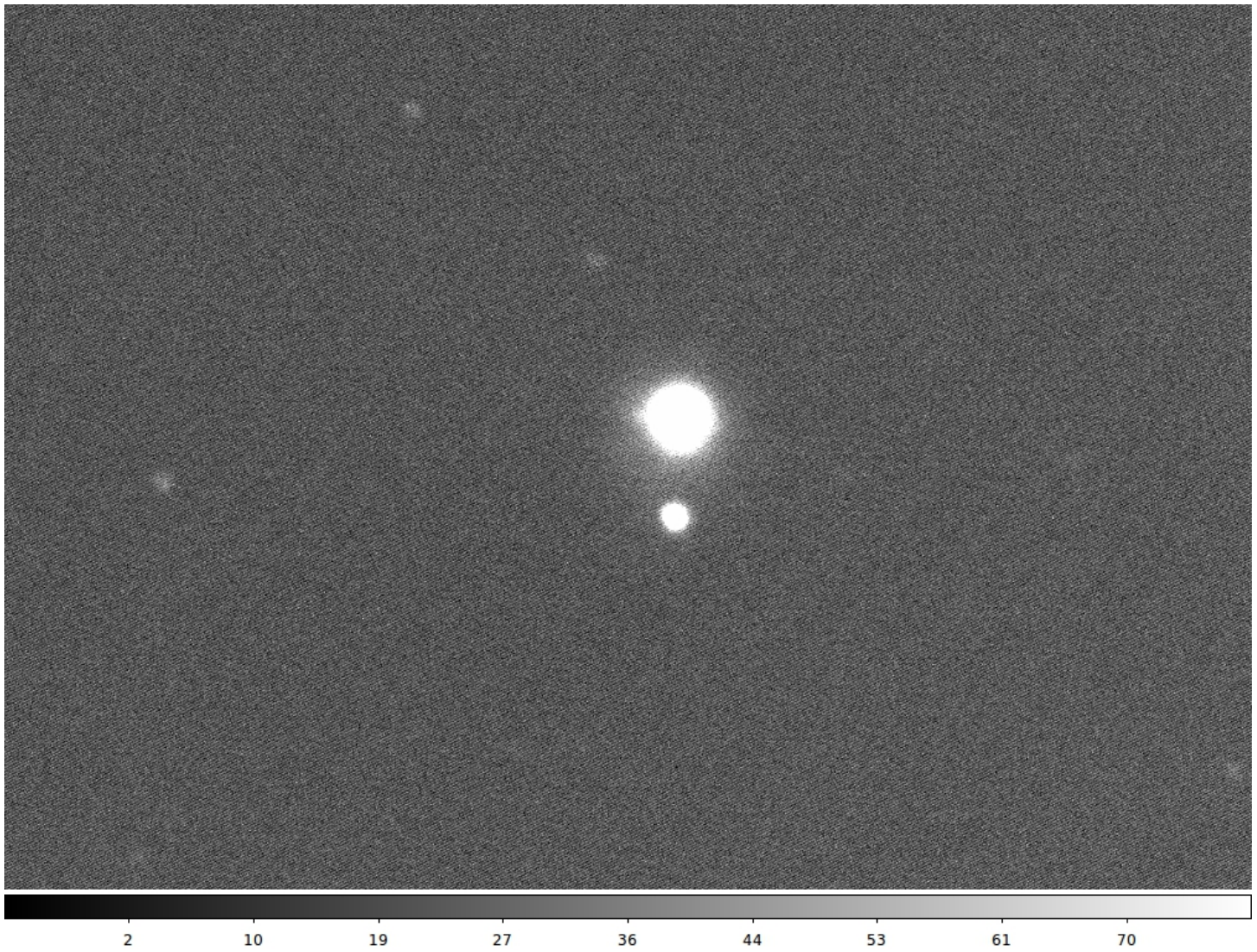
Goals

- Use astrometric and photometric techniques to study the Outer Solar System.
  - Study of PSFs for Extended Objects: Neptune; Digital Coronography: Triton;
  - Orbits of Irregular Satellites: mainly Jupiter; Saturn, Uranus and Neptune;
  - Prediction and observation of stellar occultations by Irregular Satellites, TNOs and Centaurs: Prediction, Observation, photometric Analysis, Physical Parameters (Shape, Size, Albedo, Atmosphere, Rings, Satellites, etc.)

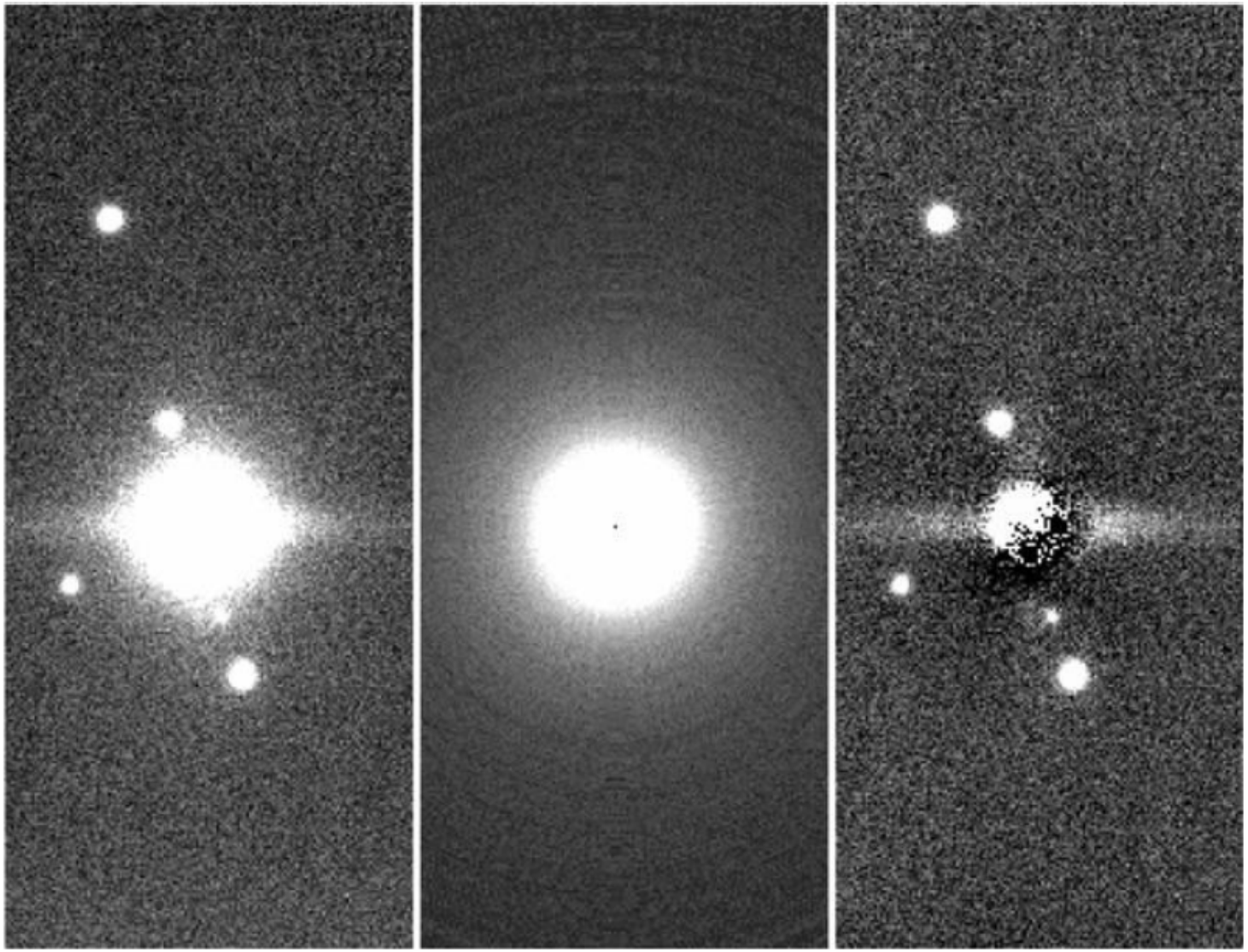
Astrometry of Extended Objects

- OPD and OHP databases;
- We estimate more than 8000 images for Neptune and Triton;
- Angular Diameter of Neptune ~ 2.2 arcsec;
- Systematic Error in the ephemeris of Uranus and Pluto (Pinho,2012 and Rossi,2012)

Astrometry of Extended Objects



Astrometry of Extended Objects



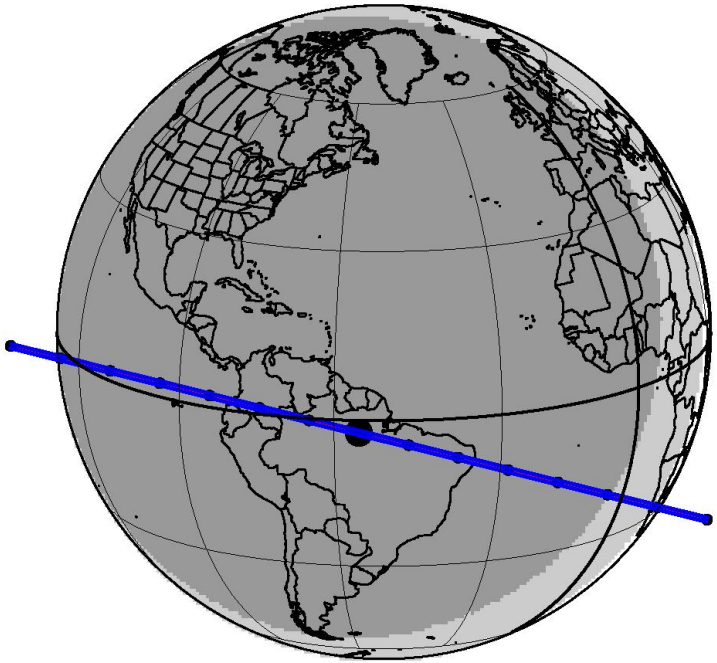
Pinho et. al, 2012

Irregular Satellites

- Astrometry of Irregular Satellites of Giant Planets using PRAIA;
- 3 Databases (OPD, OHP and ESO) with observations between 1992 and 2014;
- More than 6000 positions found for 18 satellites (Jupiter: 12, Saturn: 4, Uranus: 1 and Neptune: 1);
- Paper in process.

Irregular Satellites

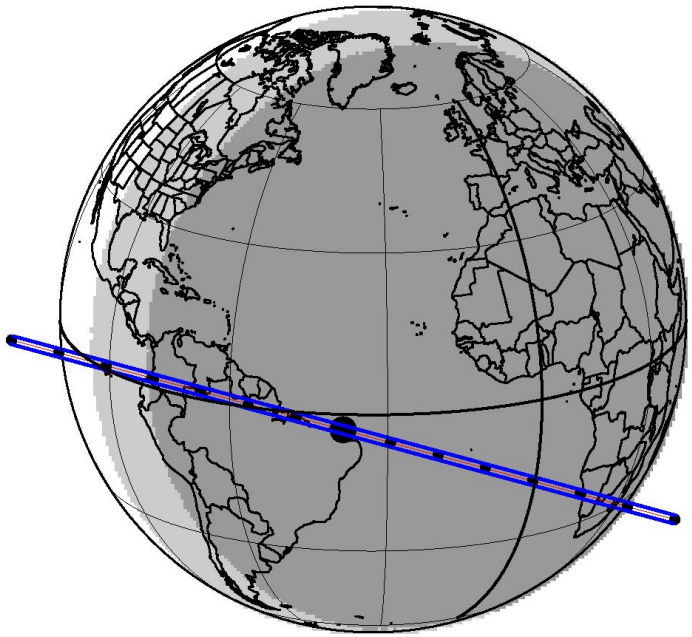
−Elara− dots each 1000km or 50.03s <> offsets (mas) 0.0 0.0



d	m	year	h:m:s UT	ra	dec	J2000_candidate	C/A	P/A	vel	Delta	R*	I
25	01	2015	04 36 08.0	09 27 59.9290	+15 44 42.777		0.648	194.00	−19.99	4.31	16.3	−(

Credits: Rio

−Himalia− dots each 1000km or 91.41s <> offsets (mas) 0.0 (



d	m	year	h:m:s UT	ra	dec	J2000_candidate	C/A	P/A	vel	Delta	R*
03	03	2015	00 39 25.0	09 10 38.6352	+17 45 26.467		0.714	195.15	−10.94	4.50	14.1

Credits: R

Stellar Occultations

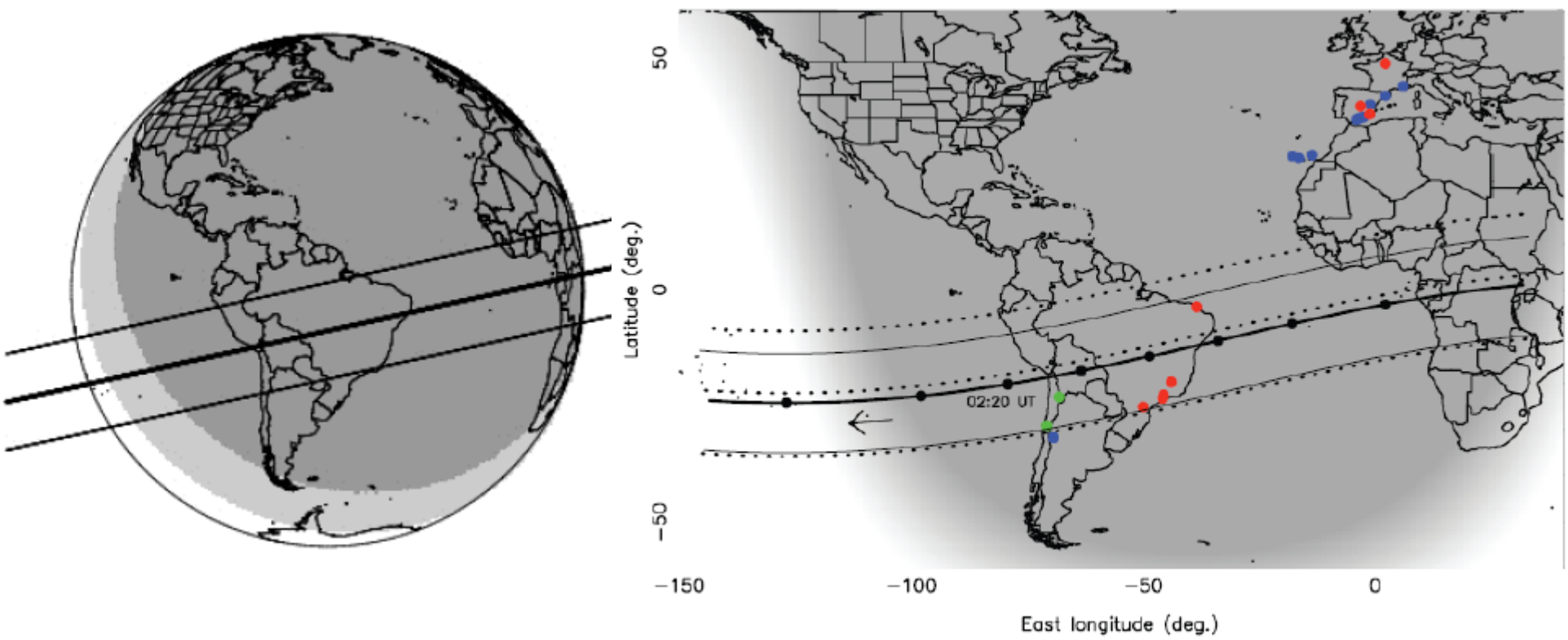
Stellar Occultations

- Prediction
  - Small correction of the position close to the event;
  - Frequent observation and numerical integration of the orbits. (NIMA, Josselin Desmars)
  - Astrometric Chord

Astrometric Chord

- Differential astrometry of object and star in the same field of view (FOV);
- Cromatic Refraction is modeled in this method;
- Sucess in the prediction of a occultation by Eris in November 6, 2010.

Astrometric Chord



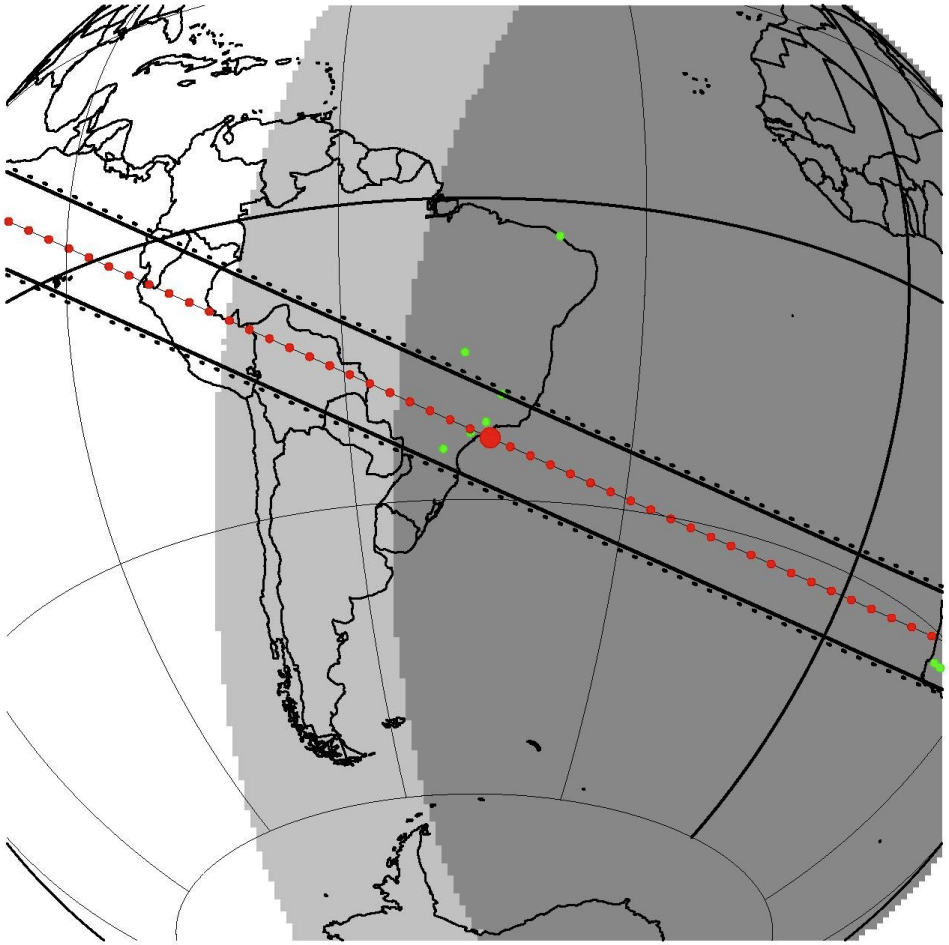
Astrometric Chord

- Other events to study
  - Triton in March, 2008, Namibia
  - Varuna in January, 2011, Japan

Stellar Occultation: Ceres

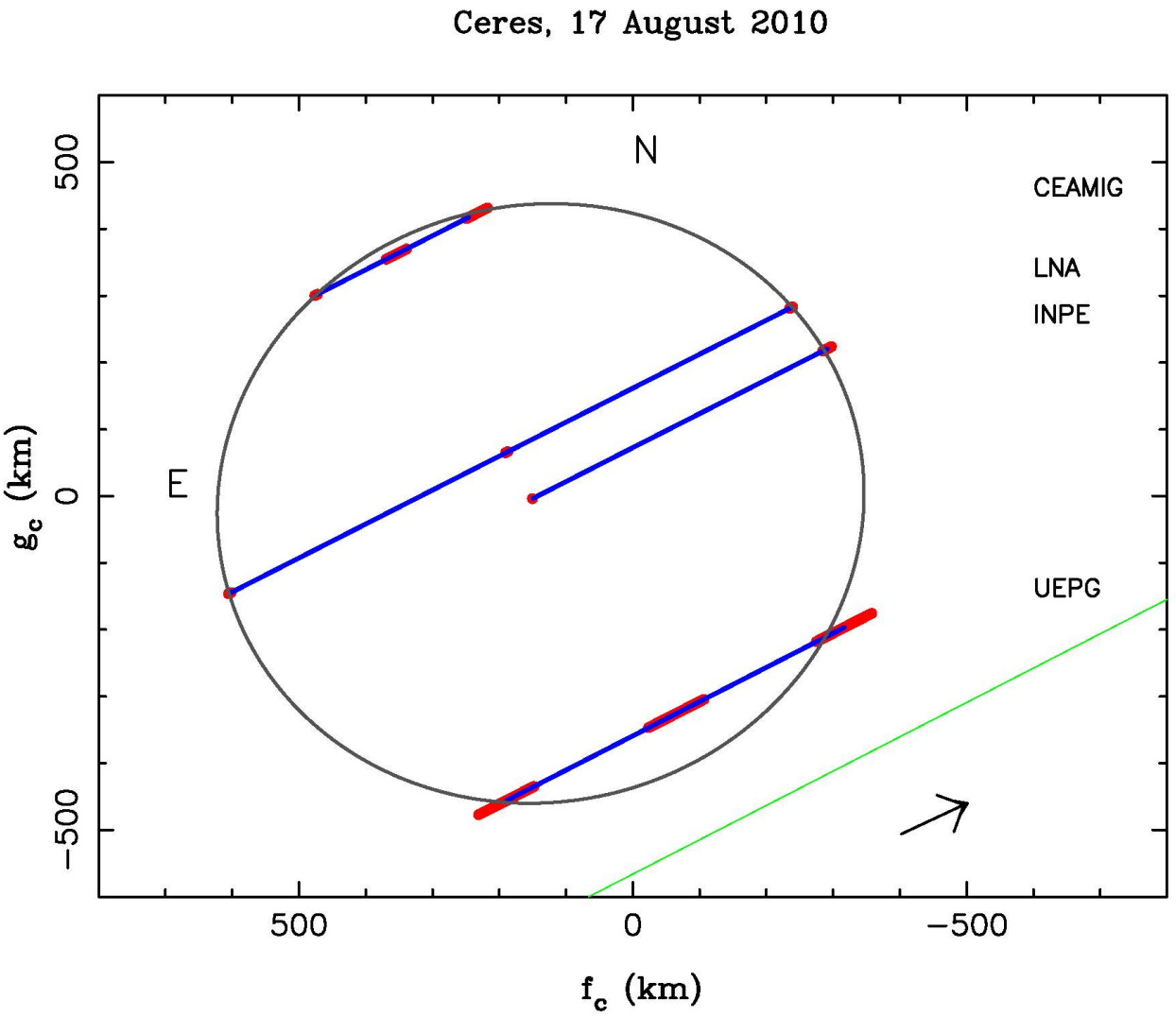
Ceres

Ceres: offset No/DE405 06/08/10, star UCAC3 Offset (mas): 0.0 0.0



d	m	year	h:m:s	UT	ra___dec___J2000_candidate	C/A	P/A	vel	Delta	R*	K*	long
17	08	2010	22 40 55.		17 18 29.0080 −27 26 38.890	0.248	24.19	3.92	2.29	9.9	7.4	−47.

Ceres


Ceres, 17 August 2010
N
E
CEAMIG
LNA
INPE
UEPG
500
0
−500
g_c (km)
500
0
−500
f_c (km)

Ceres

- Our Work
- Equatorial Radius:
  - 486 ± 3 Km
- Oblateness:
  - 0.08 ± 0.03

- Drummond et. al(2014)
- Equatorial Radius:
  - 483 ± 7 Km
- Oblateness.
  - 0.08 ± 0.02

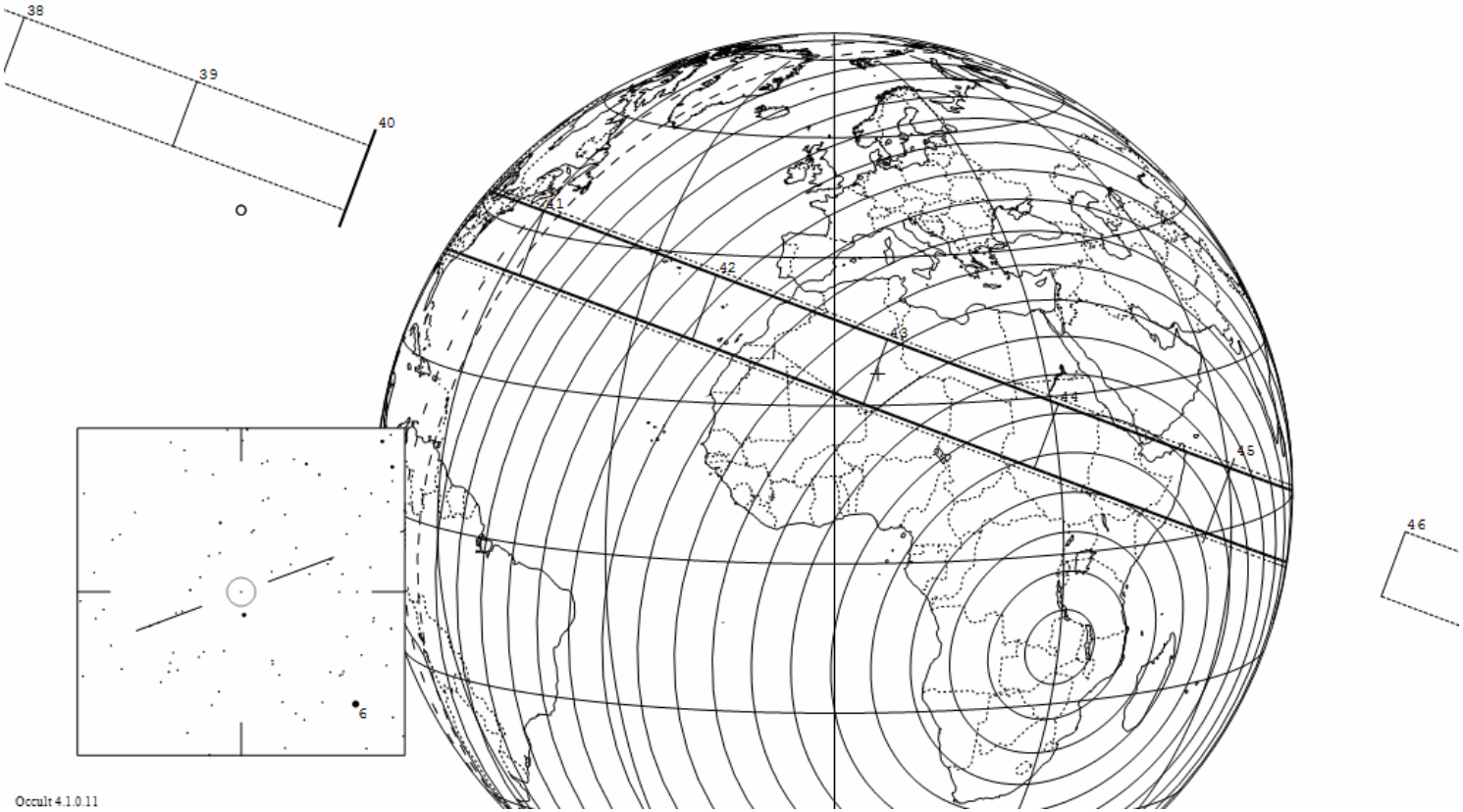
Ceres

1 Ceres occults TYC 0865-00911-1 on 2013 Oct 25 from 9h 40m to 9h 46m UT

Star:
Mv = 10.0 Mp = 10.4 Mr = 9.8
RA = 11 57 52.7635 (J2000)
Dec = 9 7 49.836 ...
[of Date: 11 58 35, 9 3 14]
Prediction of 2013 Sep 8.0

Max Duration = 22.5 secs
Mag Drop = 0.31 (0.26r)
Sun : Dist = 37 deg
Moon: Dist = 72 deg
: illum = 65 %
E 0.028"x 0.027" in PA 1

Asteroid:
Mag = 8.8
Dia = 960km, 0.403"
Parallax = 2.677"
Hourly dRA = 4.085s
dDec =-22.56"



Occult 4.1.0.11

Thank You