



Ideje za učeničke radove iz astronomije:

Asteroidi

Stefan Cikota

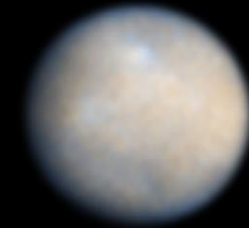
- Uvod
- Astrometrija
- Fotometrija
- Okultacije
- Distribucija dimenzija
- Udarne procesi
- Detekcija udara i udarna statistika
- Otkrivanje asteroida
- Bliski susreti

SUNČEV SUSTAV DANAS



SUNČEV SUSTAV DANAS

Patuljasti planeti



Ceres



Eris



Pluto



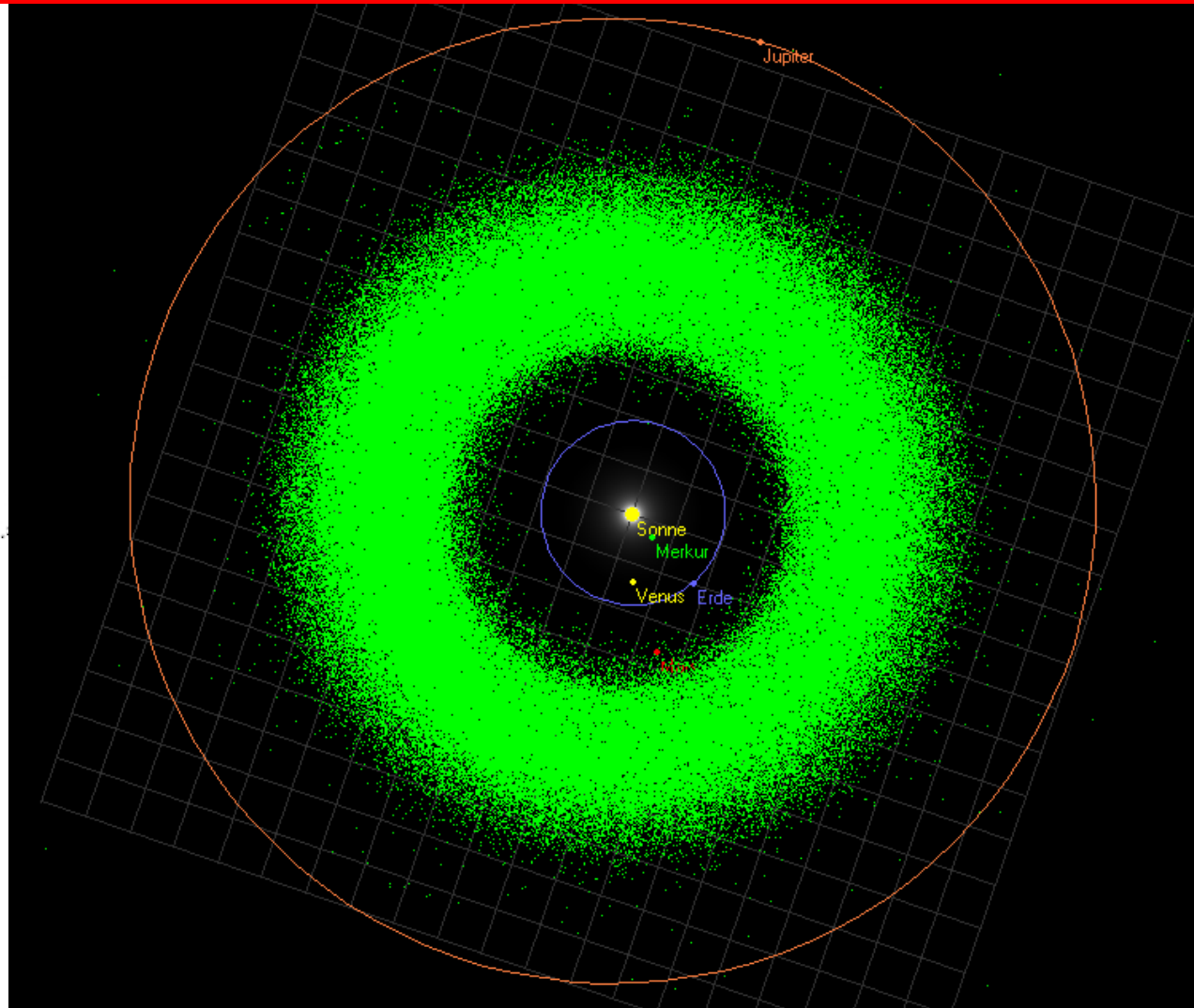
Makemake



Haumea

SUNČEV SUSTAV DANAS

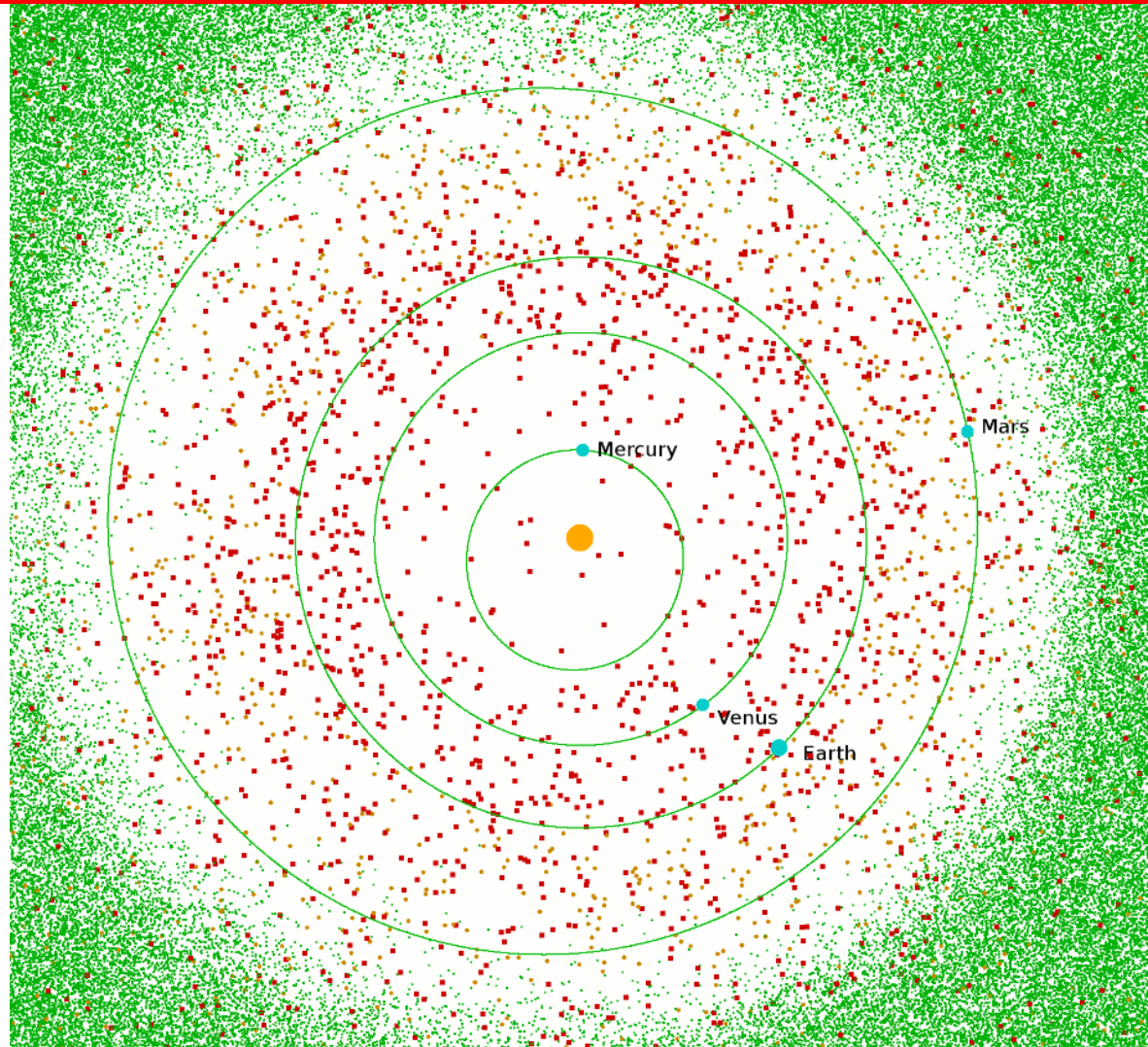
- 705'554 malih tijela Sunčeva sustava, od toga je 455'144 numerirano – veljača, 2017.
- Glavni asteroidni pojas (98,5% asteroida) i Kuiperov pojas sa ~ 1000 sa objekata (očekuje se ~70'000 objekata >100 km)



ZEMLJI BLISKI OBJEKTI

2. veljače 2017.:

- **13'680 “Zemlji Bliskih Objekata” ($0.983 < a < 1.3$)**
- **887 NEO-a > 1 km**
- **1667 potencijalno opasnih objekata (MOID 0.05, $> \sim 150$ m)**



- **Uzrast: OŠ/SŠ**
- **Potrebni instrumenti:**
 - **Fotoapararat + teleobjektiv (100-200 mm za sjajne objekte u opoziciji)**
 - **Teleskop: 500-4000 mm + fotoapararat/CCD**



ASTROMETRIJA

| Asteroid | Magnitude when brightest | Semi-major axis (AU) | Eccentricity of orbit | Diameter (km) | Year of discovery |
|---------------|--------------------------------|----------------------|--------------------------|------------------|----------------------|
| 99942 Apophis | 3.4* | 0.922 | 0.191 | 0.32 | 2004 |
| 4 Vesta | 5.20 | 2.361 | 0.089172 | 529 | 1807 |
| 2 Pallas | 6.49 | 2.773 | 0.230725 | 544 | 1802 |
| 1 Ceres | 6.65 | 2.766 | 0.079905 | 952 | 1801 |
| 7 Iris | 6.73 | 2.385 | 0.231422 | 200 | 1847 |
| 433 Eros | 6.8 | 1.458 | 0.222725 | 34 × 11 × 11 | 1898 |
| 6 Hebe | 7.5 | 2.425 | 0.201726 | 186 | 1847 |
| 3 Juno | 7.5 | 2.668 | 0.258194 | 233 | 1804 |
| 18 Melpomene | 7.5 | 2.296 | 0.218708 | 141 | 1852 |
| 15 Eunomia | 7.9 | 2.643 | 0.187181 | 268 | 1851 |
| 8 Flora | 7.9 | 2.202 | 0.156207 | 128 | 1847 |
| 324 Bamberga | 8.0 | 2.682 | 0.338252 | 229 | 1892 |
| 1036 Ganymed | 8.1 | 2.6657 | 0.533710 | 32 | 1924 |
| 9 Metis | 8.1 | 2.387 | 0.121441 | 190 | 1848 |
| 192 Nausikaa | 8.2 | 2.404 | 0.246216 | 103 | 1879 |
| 20 Massalia | 8.3 | 2.409 | 0.142880 | 145 | 1852 |

* Apophis will only achieve that brightness on April 13, 2029.^{[10][11]} It typically has an apparent magnitude of 20–22.

OŠ:

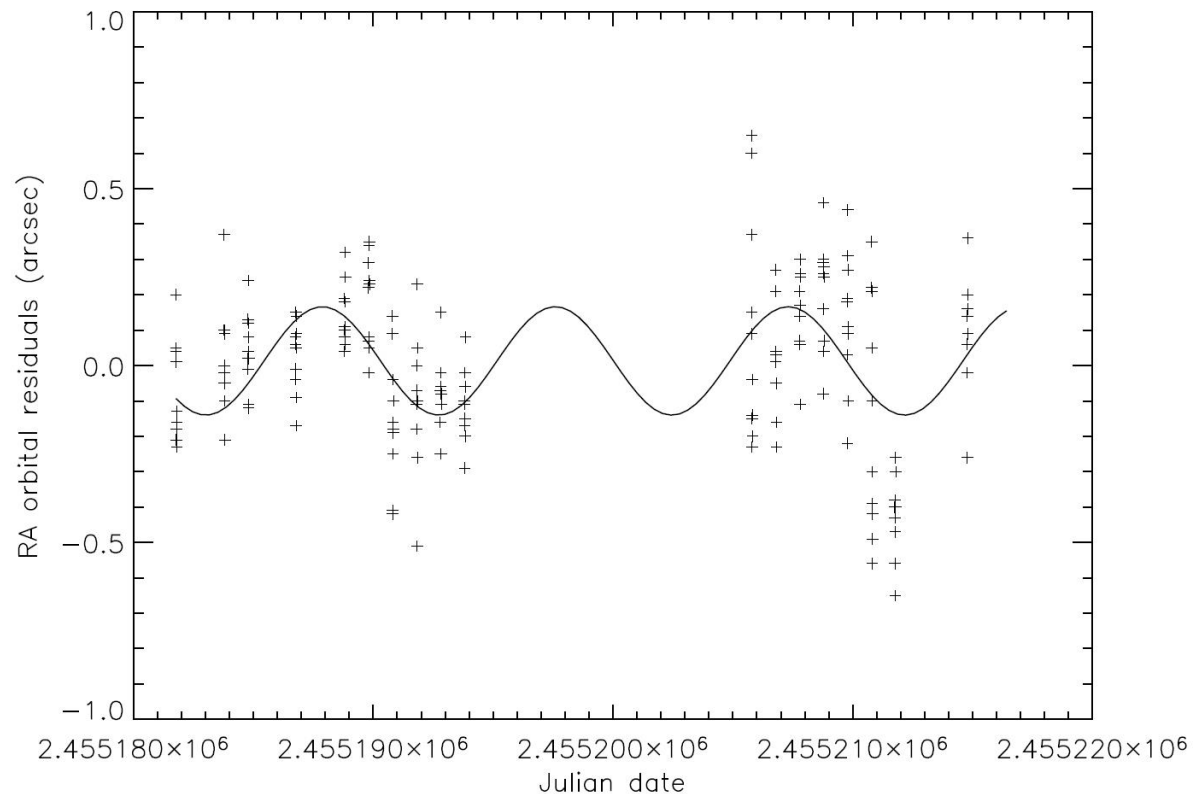
- snimati nebo fotoaparatom u razmacima po 1-2 dana
- prepoznati gibanje asteroida među zvijezdama
- određivati koordinate ucrtavajući u kartu neba
- pokušati procijeniti brzine gibanja

SŠ:

- snimati nebo fotoaparatom i boljim teleobjektivom/malim teleskopom, ili s CCD kamerom
- Precizna astrometrija pomoću MaximDL
- Mogućnost fitanja orbite i određivanja parametara orbite

U suradnji s zvjezdarnicama:

- već manjim teleskopima preciznost do 0.15 arcsec
- teleskopima klase 1-m preciznost u mas
- otkrivanje satelita i sl.



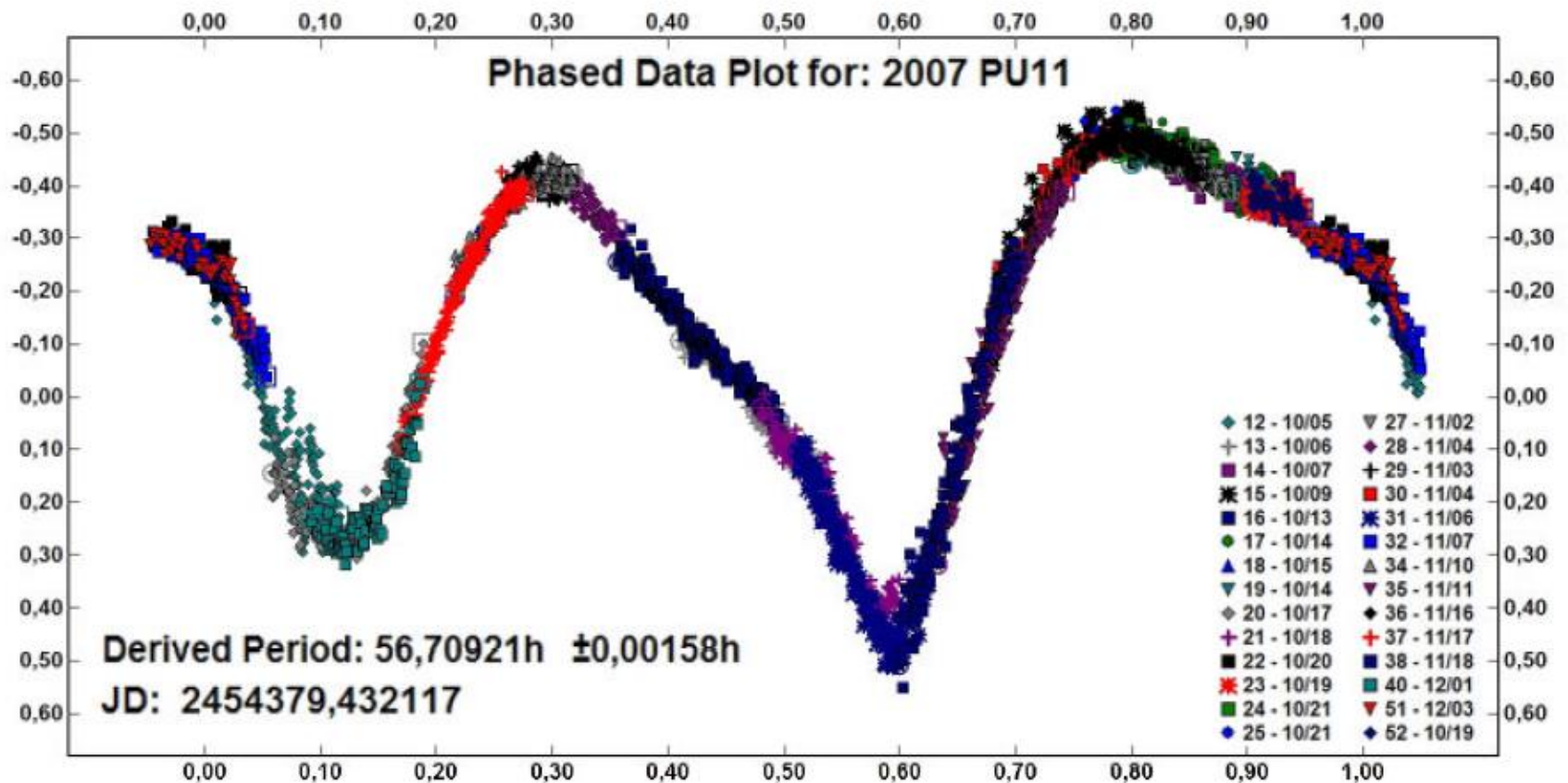
Slika: Odstupanje Orcusa od predviđenog položaja
prouzrokovano pomicanjem fotocentra

- **Uzrast: 7. & 8. r. OŠ, SŠ**
- **Potrebni instrumenti:**
 - Dobro nebo
 - Teleskop: 500-4000 mm + fotoapararat/CCD
 - Iznimka za bliske susrete: fotoapararat + teleobjektiv (300 mm)
 - Pristup profesionalnom teleskopu

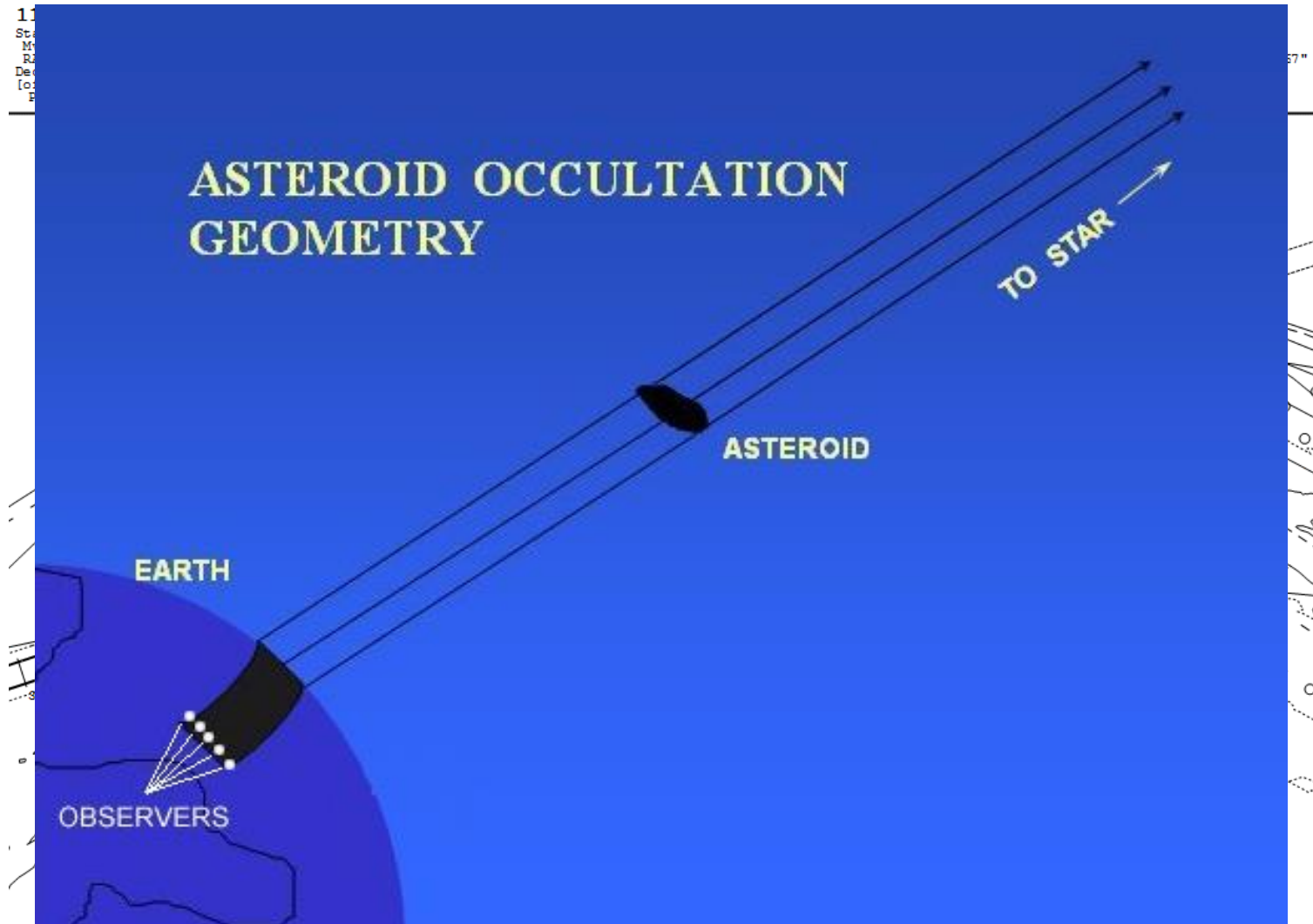
Postupanje:

- Uzastopno snimanje objekta kroz nekoliko noći (pratiti kvalitetu neba i SNR)
- Diferencijalna fotometrija pomoću MaximDL ili drugog sličnog software-a
- Potraga perioda rotacije (vizualno, pomoćnim softwareima, ili Lomb-periodogramom/Fourier transformacijom...)
- Zaključivanje o obliku

FOTOMETRIJA

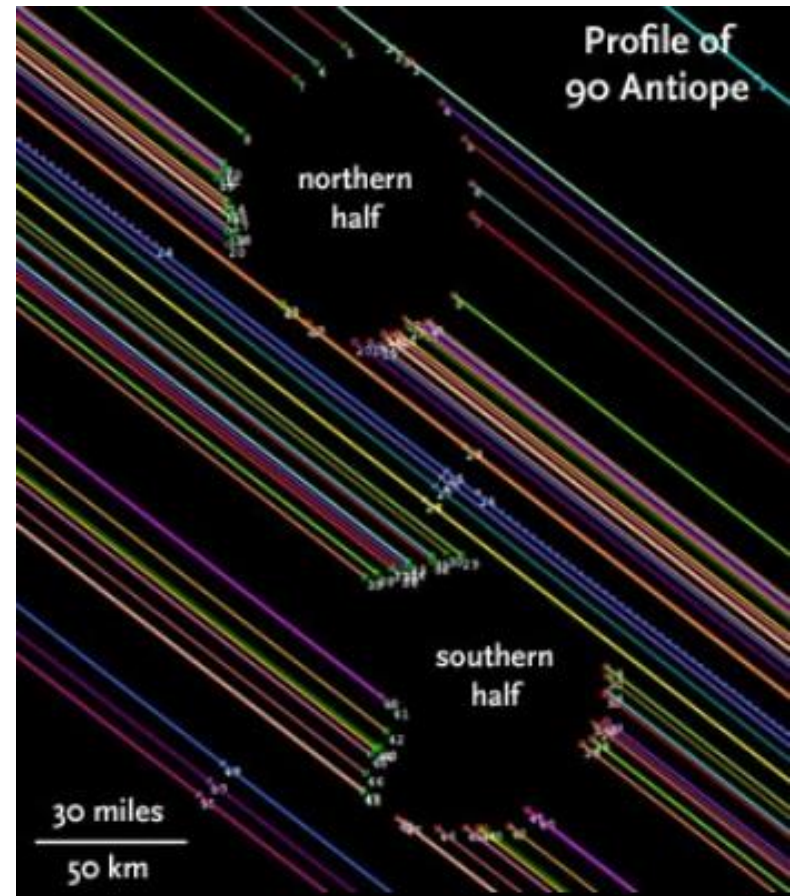
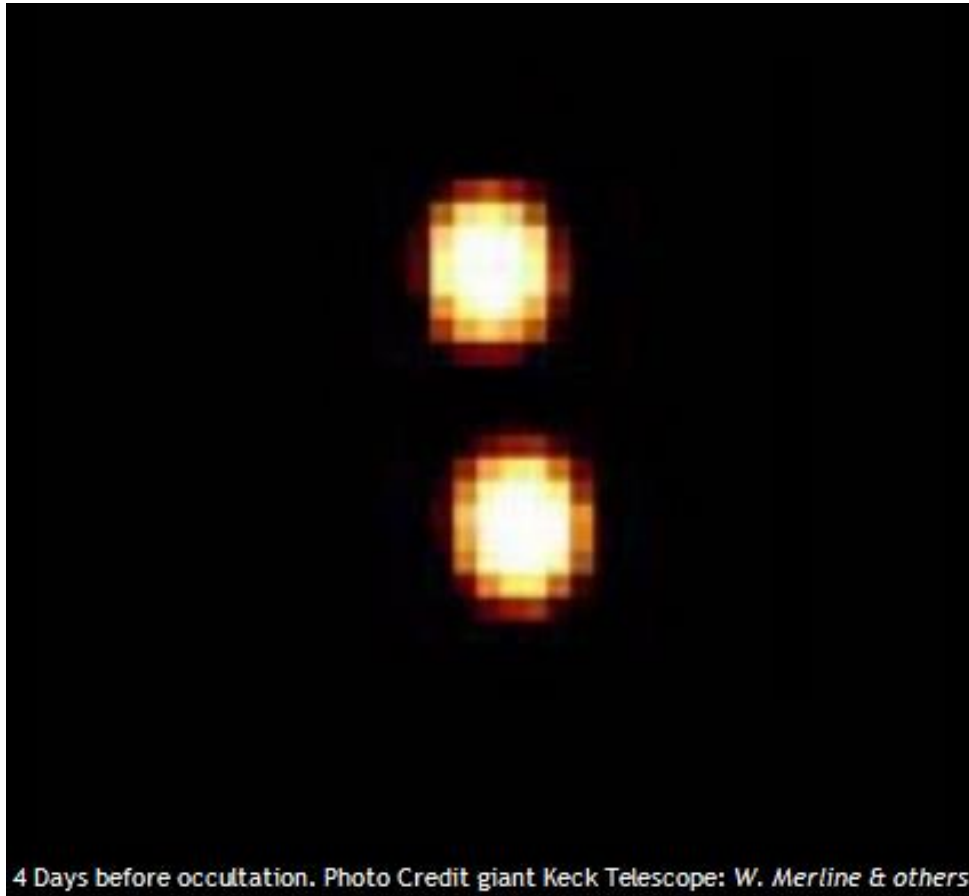


OKULTACIJE



- **Uzrast: 7. & 8. r. OŠ, SŠ**
- **Potrebni instrumenti:**
 - CCD video kamera/meteorska kamera
 - Teleobjektiv ili teleskop 100-4000 mm
 - Precizno očitavanje vremena (GPS modul ili radio prijemnik)

OKULTACIJE



euraster • net

a website for Asteroidal Occultation Observers in Europe

Plan your observation

Select current year events from the [Edwin Goffin list](#).

Look at [Steve Preston page](#) for accurate updates from high quality astrometric data.

Use [Occult Watcher](#) (by H. Pavlov) to automatically sort the predictions and announce your station.

Other links

[WinOccult](#) by Dave Herald
[OccuRec](#) by Hristo Pavlov
[Tangra3](#) by Hristo Pavlov
[Limovie](#) by Kazuhisa Miyashita
[IOTA/ES](#)
[more links](#)

European asteroidal occultation results

Best results

[TNO events 2016-2018](#)
(J. Lecacheux)

[Guide de l'observateur](#)
(in French)

2002/09/17
(345) [Tercidina event special page](#)

MAPS

you'll find sometimes in this directory path maps for special or coming events to plan your observation

New observers

You have to make a [report](#) of your negative or positive observation ([ex1](#), [ex2](#)).

Send it to :

- the Planoccult mailing list
(the simplest, see below to subscribe)

or

- frappa@euraster.net
[Gilles Regheere](#) (EAON)
and [Jan Manek](#) (IOTA)

Planoccult mailing list

It's a very good idea to join the [Planoccult mailing list](#), a central place to share informations, reports, results and be informed of updated predictions.

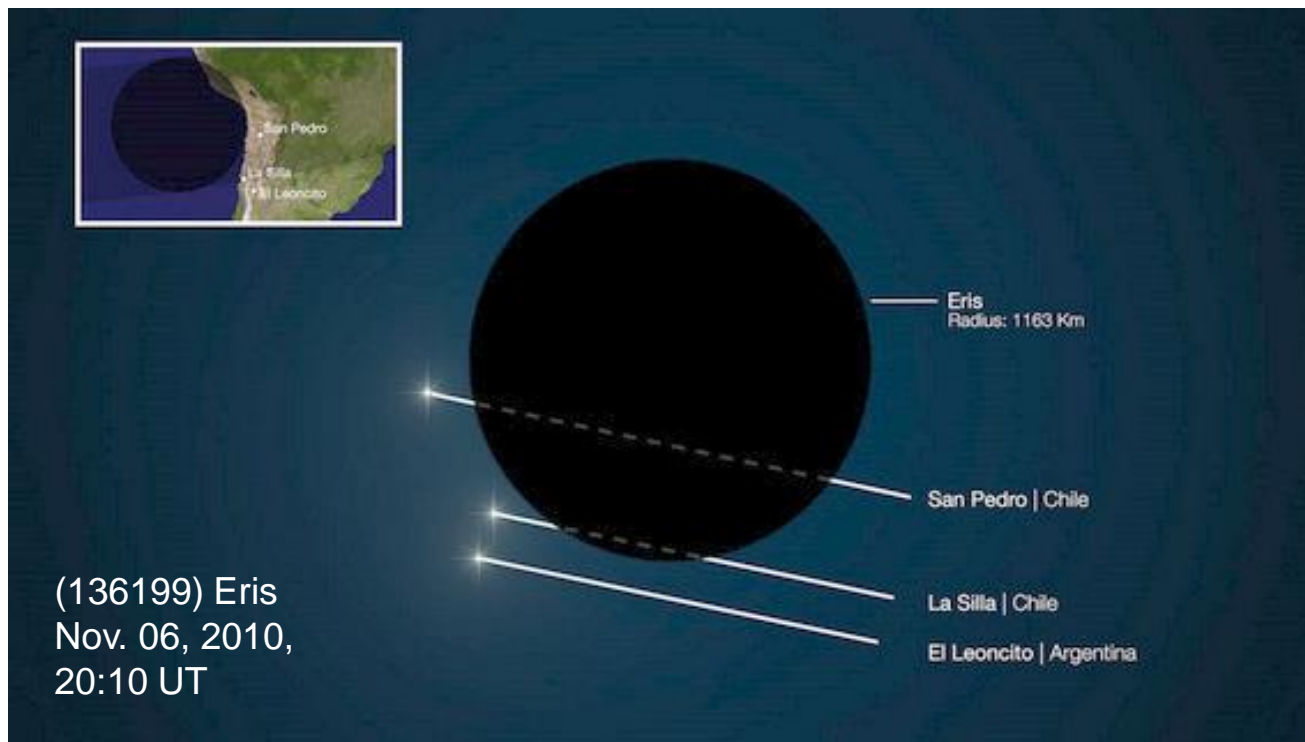
euraster.net is maintained by Eric Frappa - frappa@euraster.net
These pages are personal web pages

OKULTACIJE

=> Eris i Pluton gotovo identičnih polumjera:

$$R_{\text{ERIS}} = 1163 \pm 6 \text{ km}$$

$$R_{\text{PLUTO}} = 1153 \pm 10 \text{ km}$$

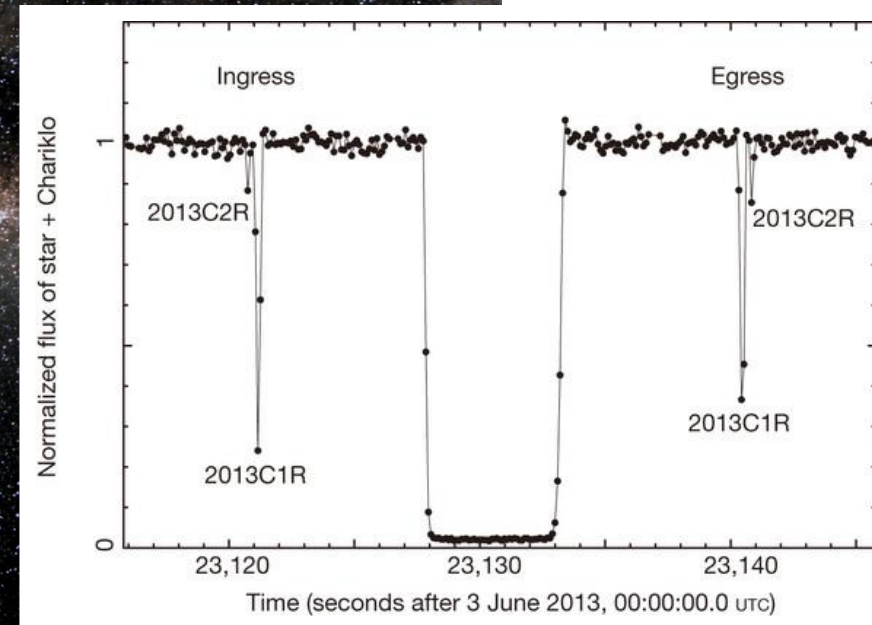
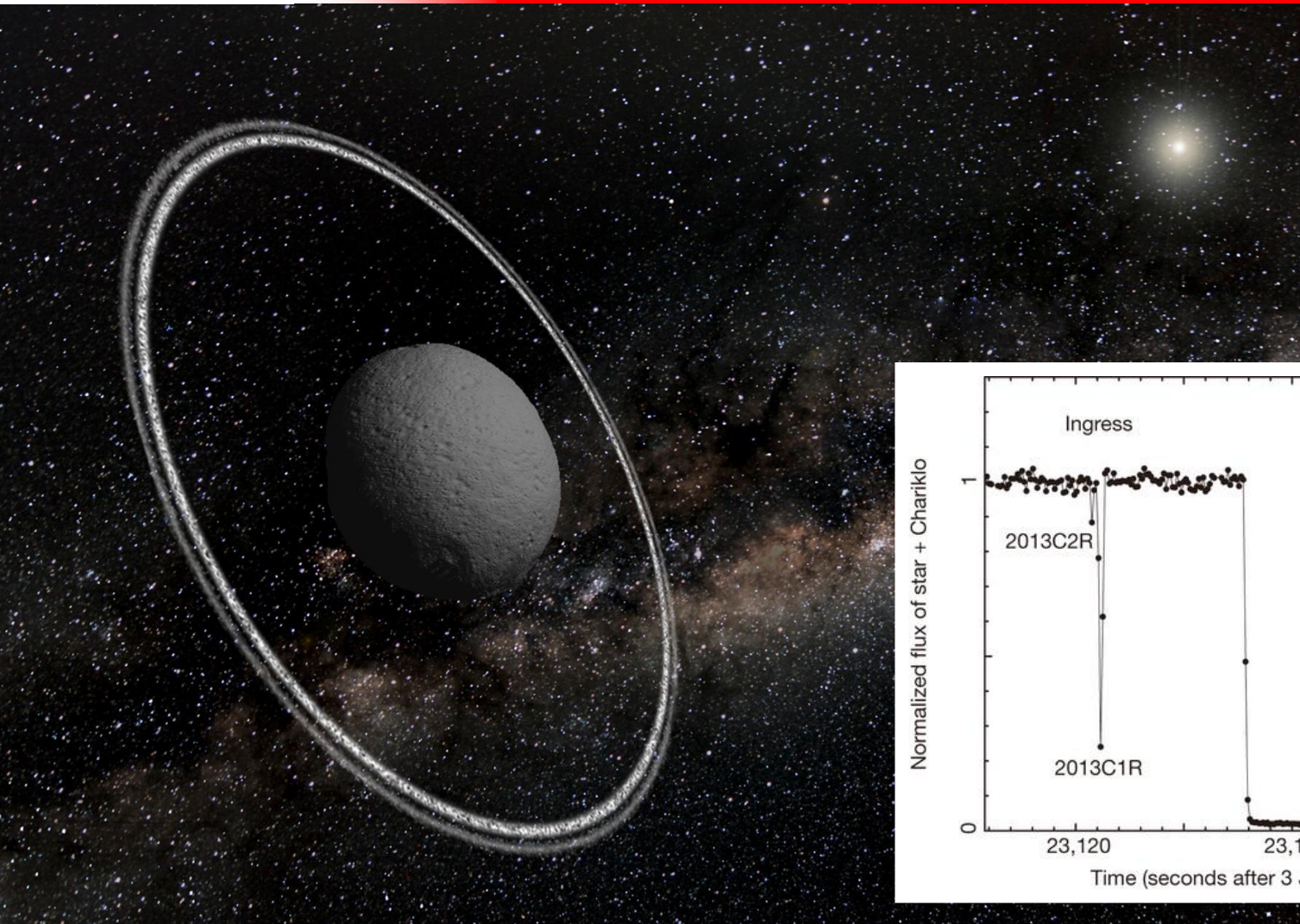


Occultation by
136199 Eris
San Pedro de
Atacama
Celestial Exploration
November 5th 2010

Promjer sličan
Plutonu, veći
albedo, 27%
masivniji

Albedo_{PLUTON} = ~0.58
Albedo_{ERIS} = ~0.96 (!)

OKULTACIJE

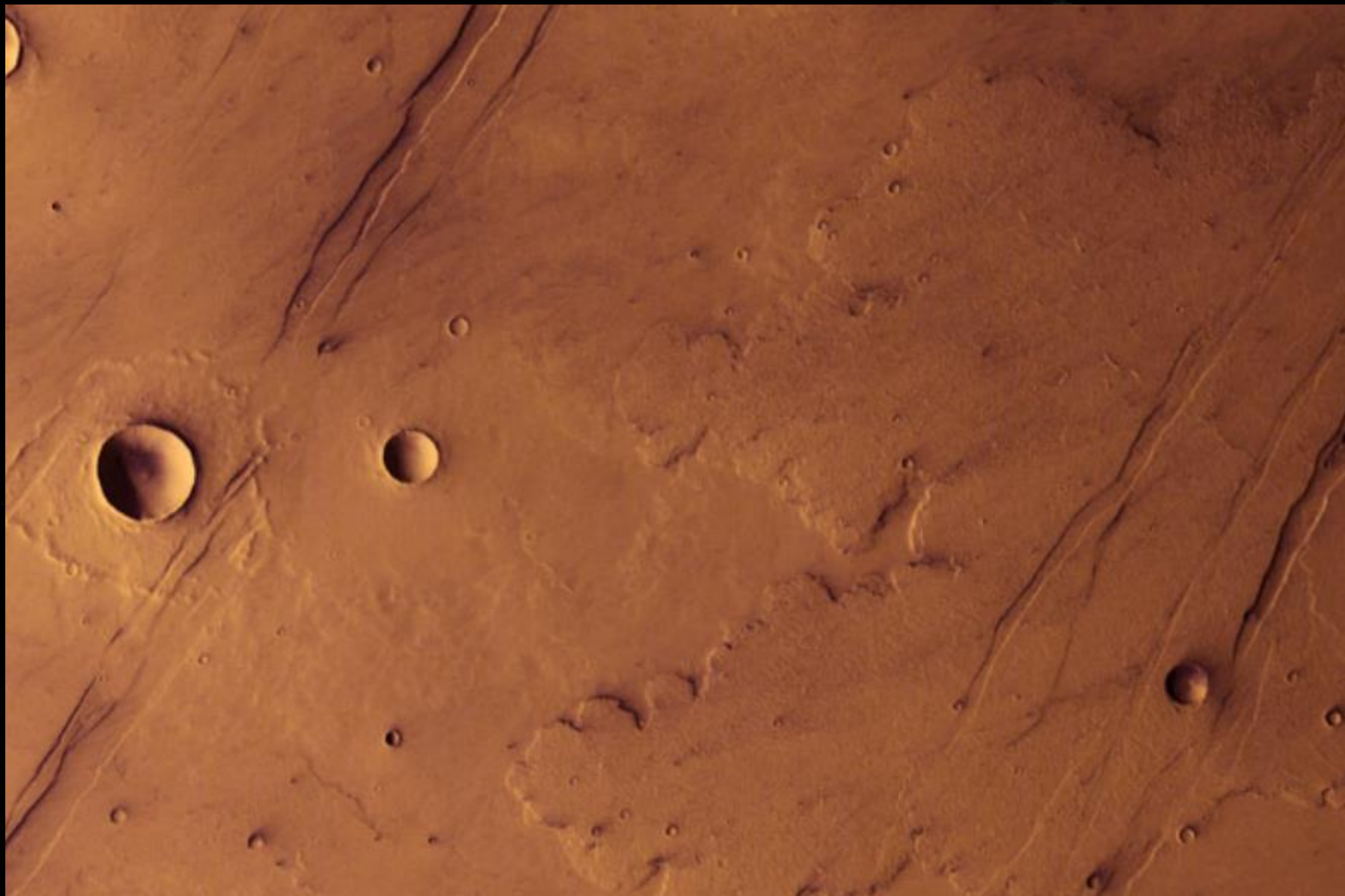


DISTRIBUCIJA DIMENZIJA

Uzrast: OŠ

**Izvor:
snimke
objekata iz
baza podataka
ili samostalno
snimaje**





Craters and Slumps on Me

Postupanje:

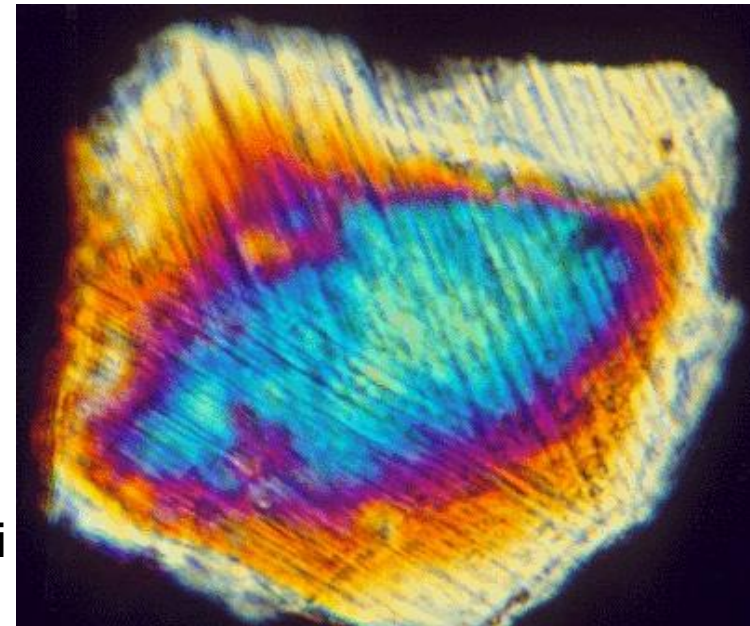
- Izrada histograma dimenzija kratera (br. kratera određenih dimenzija)
- Usporedba različitih dijelova Sunčeva Sustava (unutarnji Sunčev sustav – Merkur, Mjesec, asteroidni pojas; vanjski dijelovi Sunčeva sustava – prirodni sateliti Jupitera, Saturna, Urana, Neptuna..., Pluton)
- Usporedba objekata s atmosferom (Mjesec, Zemlja?)

UDARNI PROCESI



- Eugene M. Shoemaker (1928-1997)
- pronalazi kristalne silikatne strukture u kraterima nastalim testiranjem nuklearnog oružja u Nevadi
- pod mikroskopom “udarne lamele” nastaju pod silnim tlakom (udari ili nuklearno oružje)
- 1960. – Dokaz da je Barringerov krater udar asteroida (PhD)

Udarni
kvarc



OŠ/SŠ:

- Kreiranje kratera: bacanje kuglica s različitih visina (kinetička energija u odnosu na promjere nastalih kratera – ekstrapolacija na krater u SS), pucanje iz zračne puške, prave malokalibarske puške ili sl.

SŠ:

- Geologija/kemija/astronomija: Proučavanje udarnih lamela, kvarcnog stakla i sl.

DETEKCIJA UDARA I UDARNA STATISTIKA

- Znanstvena zajednica skeptična je prema Shoemakerovim tezama
- 1973. godine započinje sistematsku potragu za malim tijelima Sunčeva sustava (18" astrograf, Palomar Obs.)
- Otkriva 30 kometa i 800 asteroida



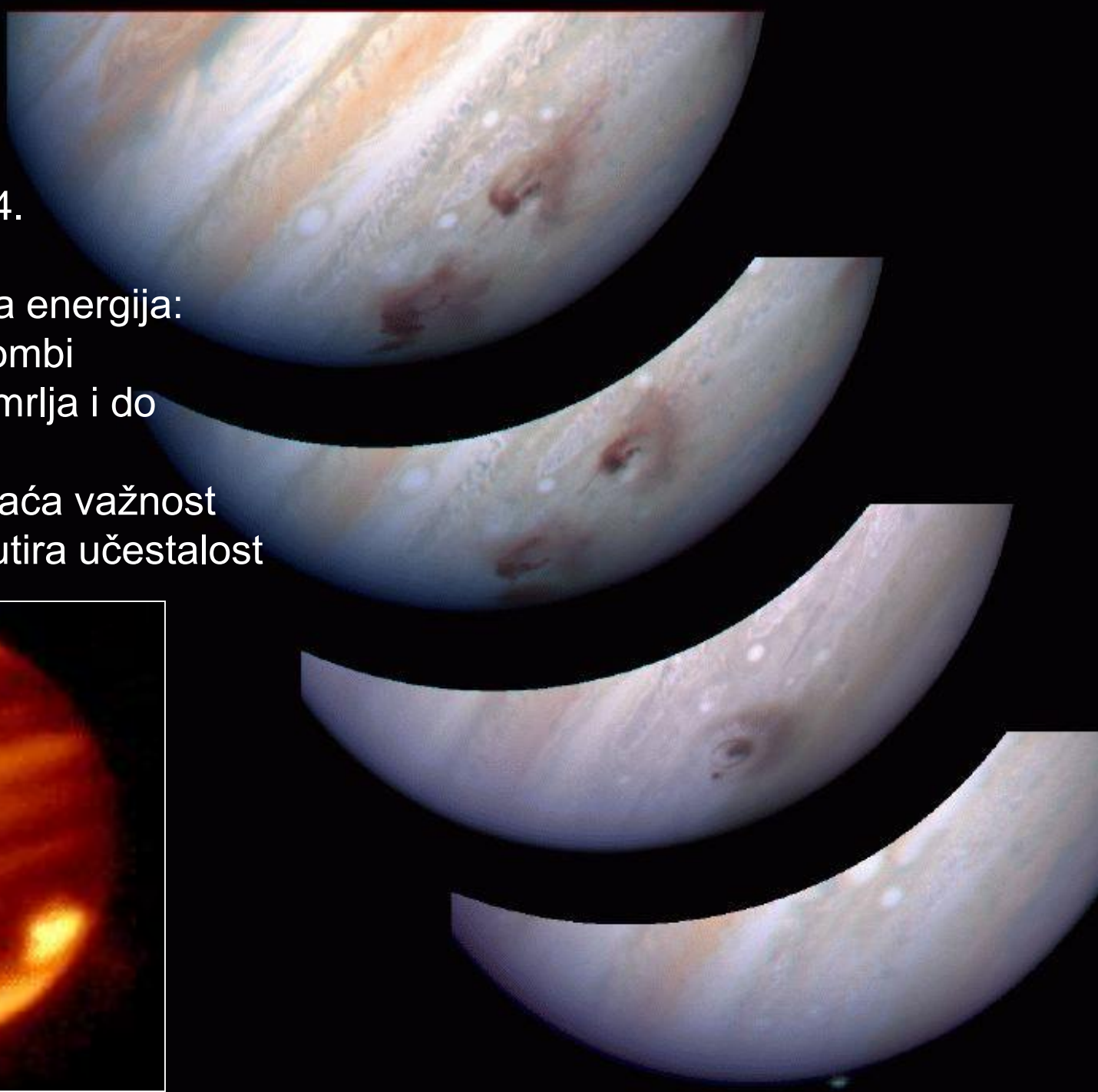
Eugene & Carolyn
Shoemaker

D/1993 F2 (Shoemaker-Levy 9)

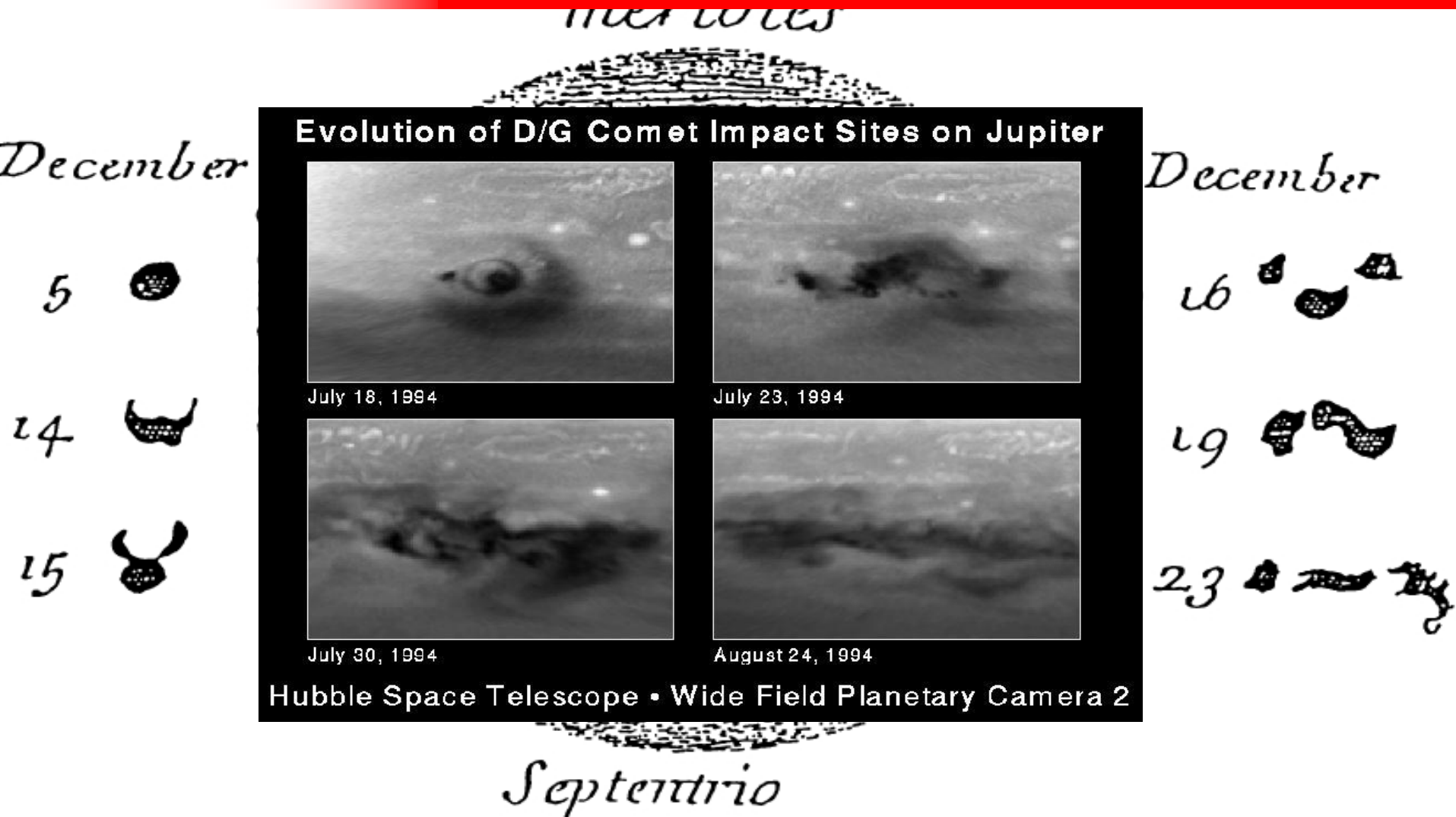
- otkriven 24.03.1993., već raskomadan
- Shuichi Nakano - komet će udariti u Jupiter



- Udar između
16. i 22. lipnja 1994.
- brzina 60 km/s
ukupna oslobođena energija:
50 mil. Hirošima bombi
- promjeri udarnih mrlja i do
26000 km
- zn. zajednica shvaća važnost
problematike, diskutira učestalost



Važnost starih zapisa: CASSINIJEVI CRTEŽI IZ 1690.



WESLEYJEV UDAR

- promjer mrlje ~4500 km
- objekt ~300-500 m

Jupiter ■ July 23, 2009
Hubble Space Telescope
Wide Field Camera 3



NASA, ESA, H. Hammel (Space Science Institute), and the Jupiter Impact Team

Vatrene kugle u Jupiterovoj atmosferi

- 05. ožujka 1979. godine, Voyager 1 u potrazi za munjama u Jupiterovoj atmosferi
- Meteor u trajanju 1.77 sekundi, masa ~11 kg, promjer ~14 cm (sa Zemlje nije vidljivo)

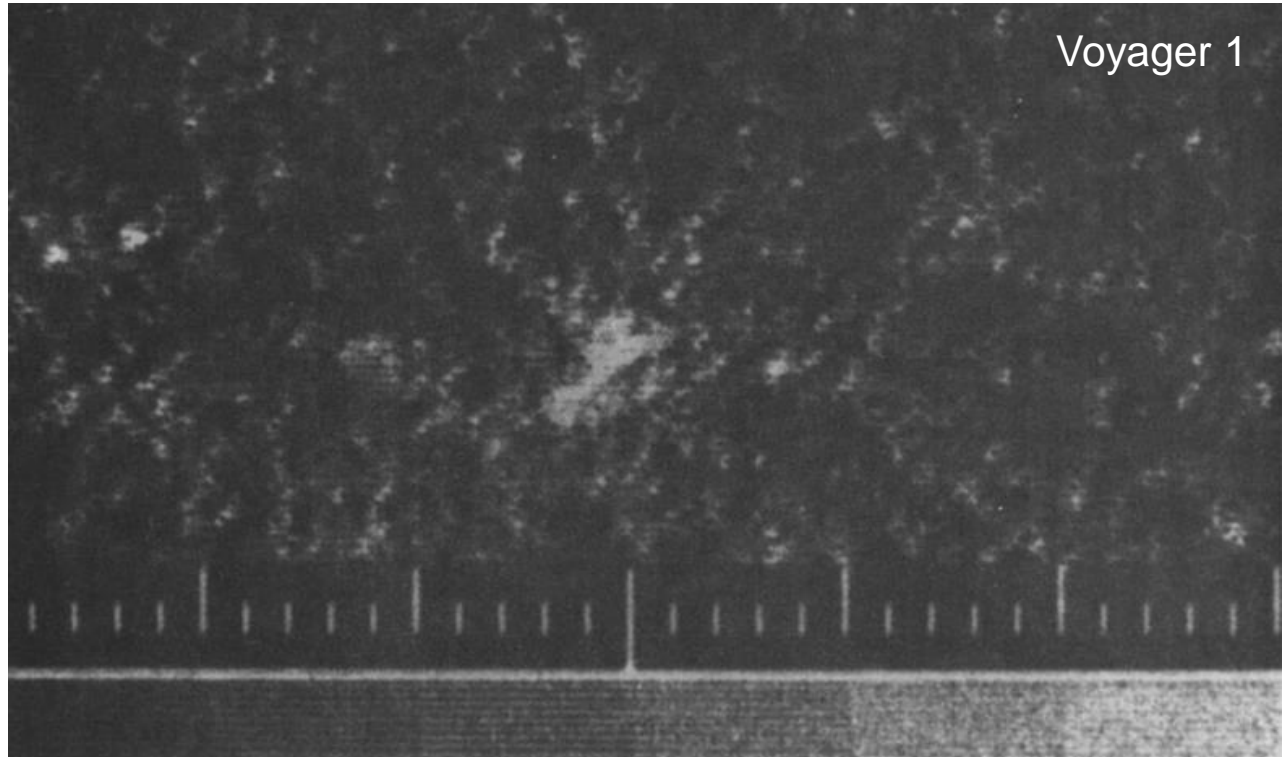
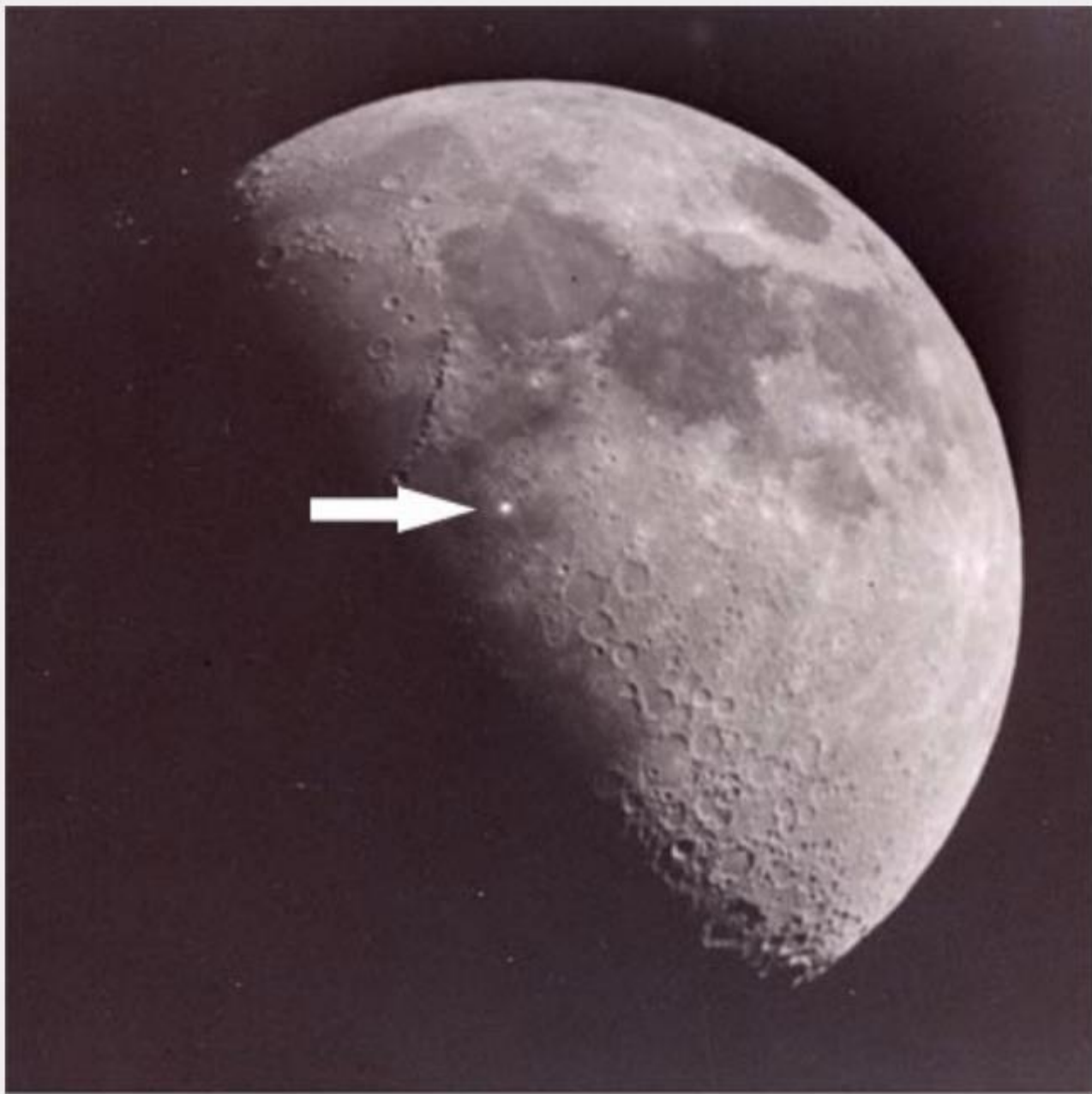


Fig. 1. Enlarged image of the fireball. The image carried the count of FDS 16396.30 and the number PICNO 1427J1+000. Details are given in the text.

Vatrene kugle u Jupiterovoj atmosferi

- 03. lipnja 2010.,
Anthony Wesley (AU)
+ Christopher Go
(Filipini), ~2 sec,
8-13 m, 4400 K
- 20. kolovoza 2010.
Masayuki Tachikawa
(Japan), 2 sec, ~10 m
- nema “ožiljaka”
- takvi udari vrlo česti,
~svakih 6 dana





*Example of a lunar flash, photographed in 1953. Credit: Leon Stuart/
Columbia University Department of Astronomy*

OŠ/SŠ:

- Snimanje Mjeseca ili Jupitera s ciljem detekcije udara

Instrumenti: $D > 0.2 \text{ m}$ + osjetljiva CCD video kamera

Software: dostupni online ili se lako programiraju

SŠ:

- Prikupljanje svih poznatih promatranih sudara iz literature – izrada udarne statistike u odnosu na dimenzije objekata

BLISKI SUSRETI?

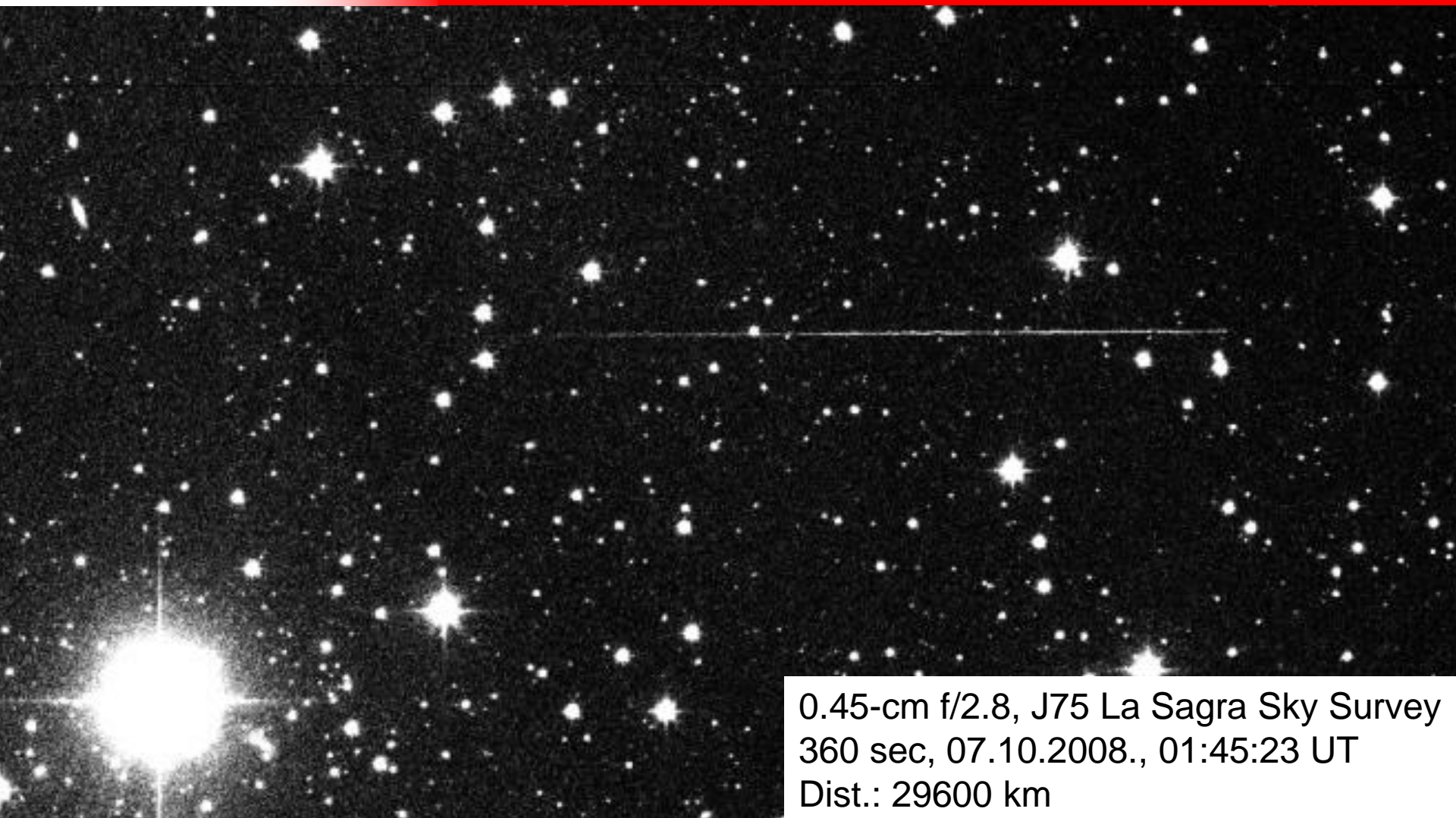
On July 6, 2017 there were **1803** potentially hazardous asteroids.

Recent & Upcoming Earth-asteroid encounters:

| Asteroid | Date(UT) | Miss Distance | Velocity (km/s) | Diameter (m) |
|----------------------------|-------------|---------------|-----------------|--------------|
| 2017 MB3 | 2017-Jun-30 | 5 LD | 6.5 | 31 |
| 2017 MC1 | 2017-Jun-30 | 2.5 LD | 11.6 | 44 |
| 2017 NB | 2017-Jul-02 | 3.5 LD | 10 | 38 |
| 2017 MC3 | 2017-Jul-02 | 6.5 LD | 13.2 | 57 |
| 2017 MO8 | 2017-Jul-03 | 4.1 LD | 10.9 | 22 |
| 2017 ME4 | 2017-Jul-03 | 5.4 LD | 6.8 | 20 |
| 2017 MB5 | 2017-Jul-05 | 19 LD | 9.5 | 113 |
| 2017 MQ7 | 2017-Jul-06 | 17.6 LD | 10.9 | 84 |
| 2017 MA5 | 2017-Jul-06 | 14.9 LD | 7.9 | 28 |
| 2017 MP7 | 2017-Jul-08 | 11 LD | 8.2 | 29 |
| 2017 MC4 | 2017-Jul-11 | 7.6 LD | 20.7 | 150 |
| 2017 NH | 2017-Jul-12 | 16.6 LD | 7.8 | 158 |
| 2017 MR8 | 2017-Jul-15 | 3.3 LD | 6.9 | 35 |
| 2007 MB4 | 2017-Jul-16 | 14.5 LD | 9.6 | 107 |
| 2017 BS5 | 2017-Jul-23 | 3.1 LD | 5.8 | 54 |
| 2014 OA339 | 2017-Aug-13 | 12.3 LD | 10 | 47 |
| 3122 | 2017-Sep-01 | 18.5 LD | 13.5 | 5376 |

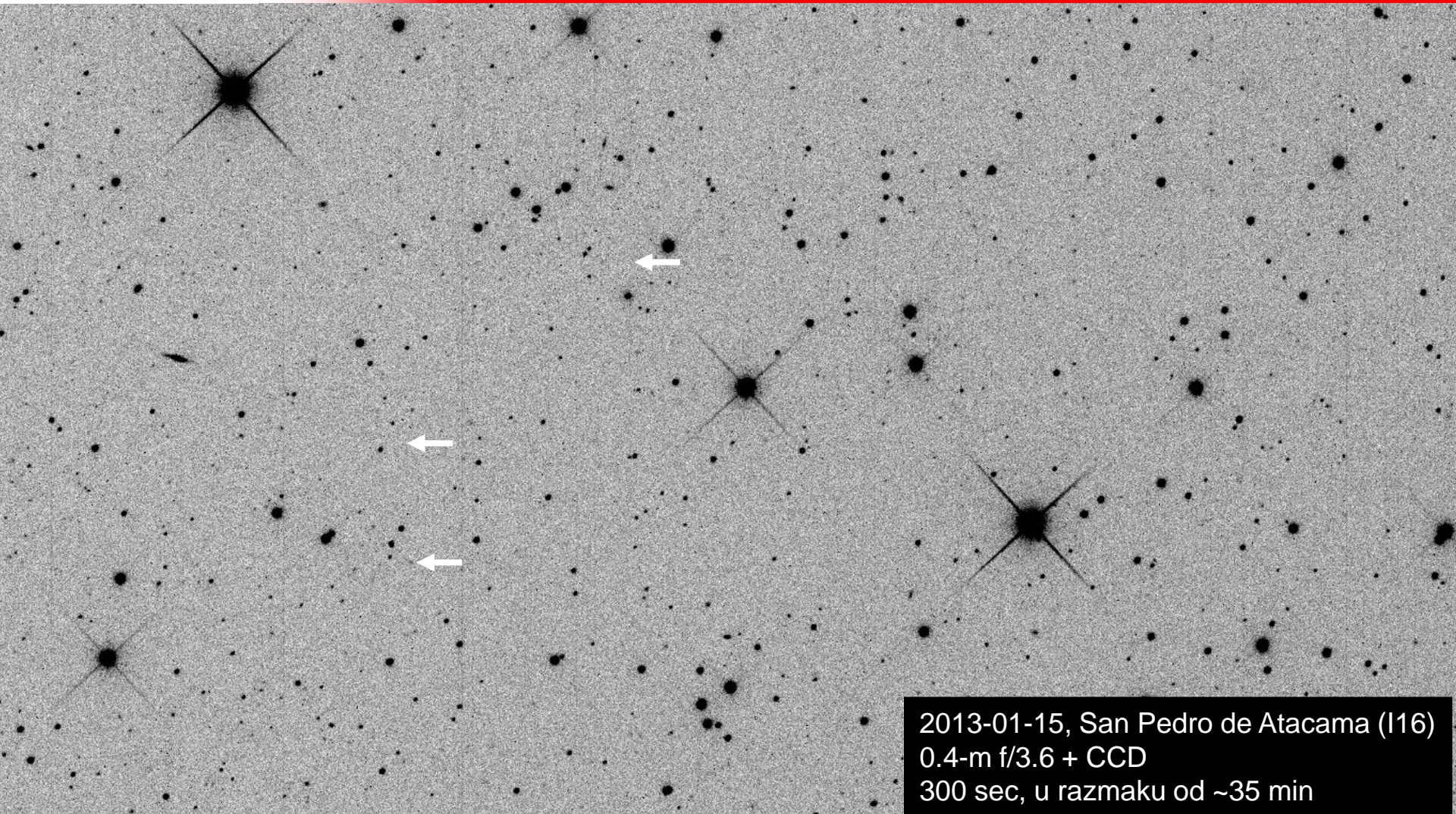
Notes: LD means "Lunar Distance." 1 LD = 384,401 km, the distance between Earth and the Moon. 1 LD also equals 0.00256 AU. MAG is the visual magnitude of the asteroid on the date of closest approach.

2008 TC₃

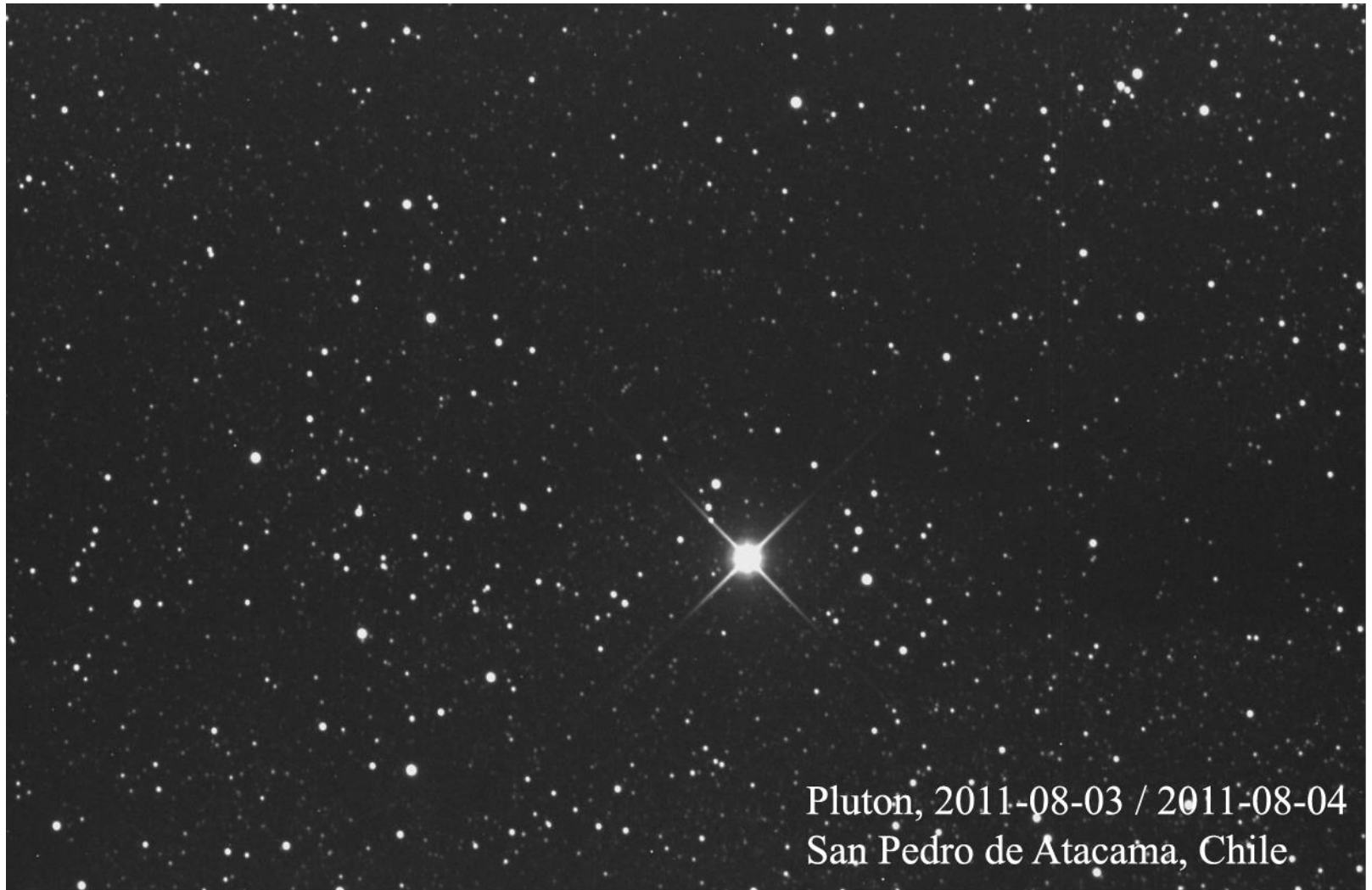


0.45-cm f/2.8, J75 La Sagra Sky Survey
360 sec, 07.10.2008., 01:45:23 UT
Dist.: 29600 km

OTKRIVANJE ASTEROIDA



OTKRIVANJE ASTEROIDA



Pluton, 2011-08-03 / 2011-08-04
San Pedro de Atacama, Chile.

SŠ:

- Pristup profesionalnoj opremi
- U HR: Zvezdarnica Tičan
- Dugotrajni projekt, ne samo za natjecanje
- Upute na upit

POOR
PLUTO



Hvala na pažnji! Pitanja?

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