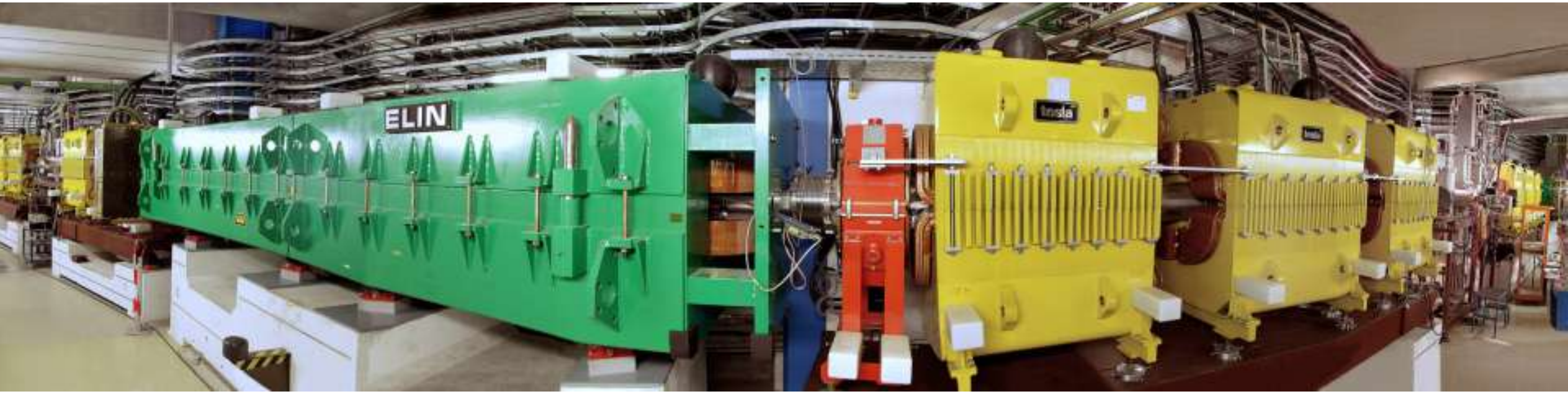
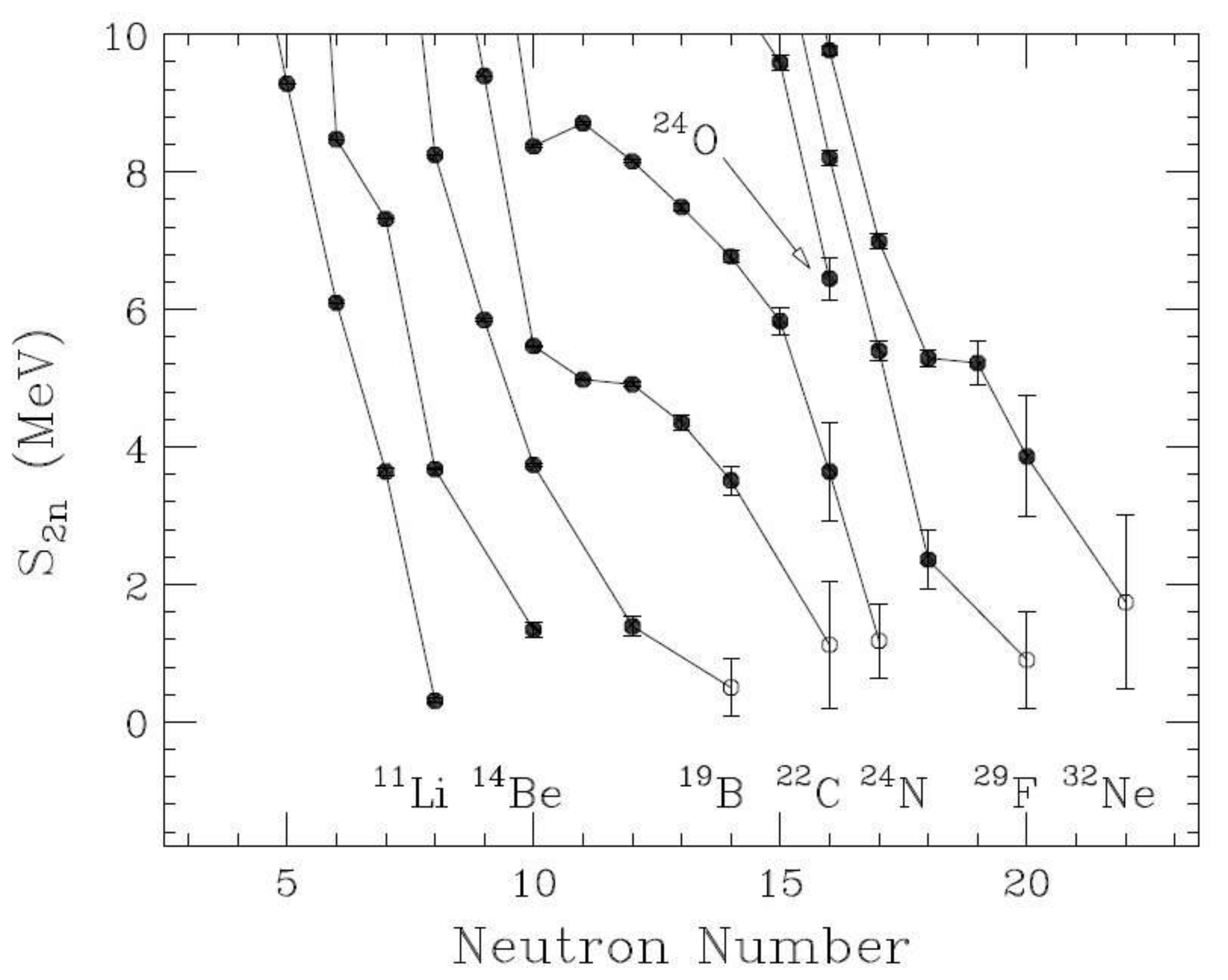
GROUND BASED STUDIES OF ASTEROIDS

Michael Fauerbach, Ph.D.
Florida Gulf Coast University


ELIN
tesla
tesla

Search for ^{26}O



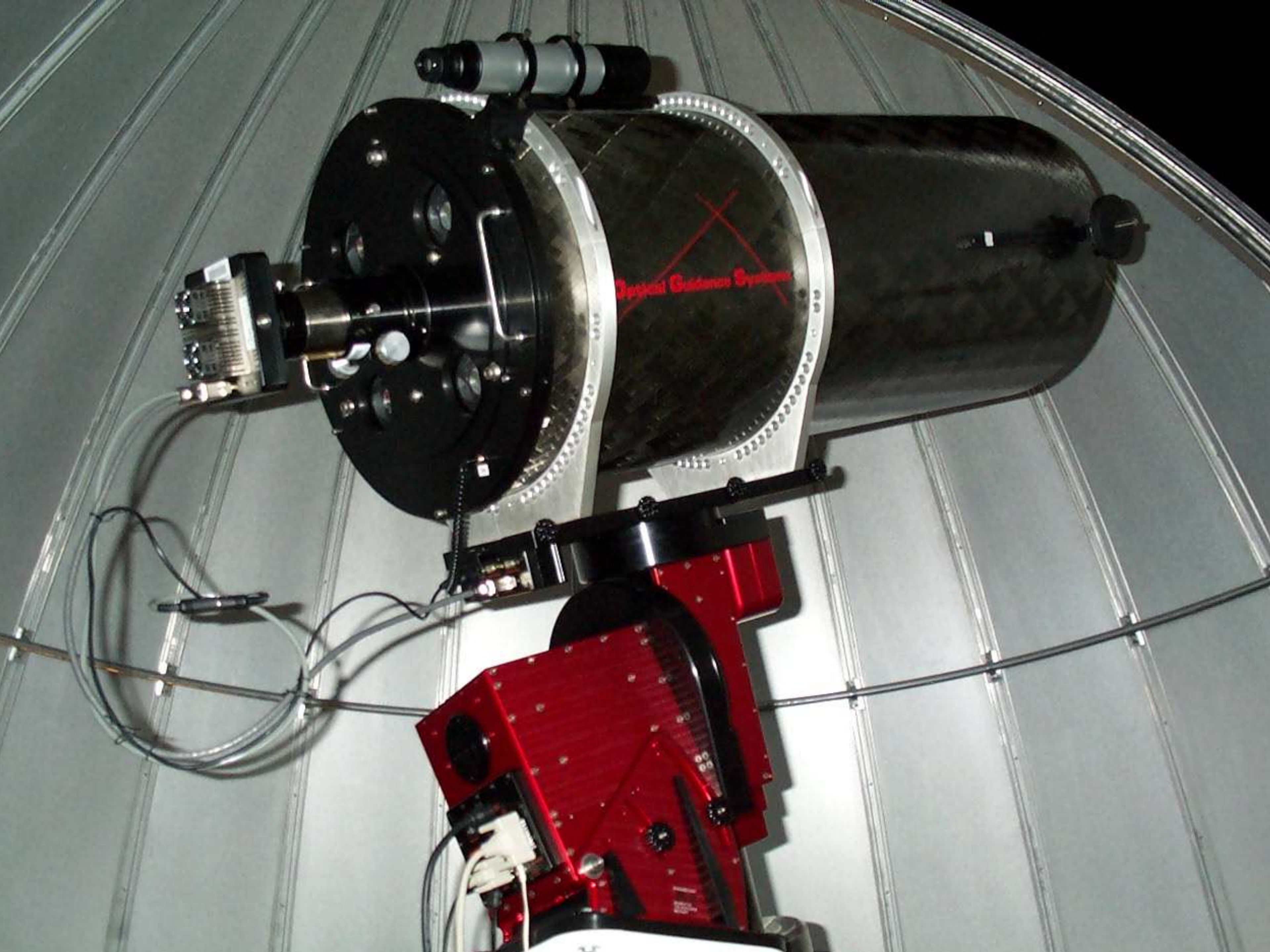
- FGCU opened in 1997
- 10th member in SUS
- fastest growing University in USA

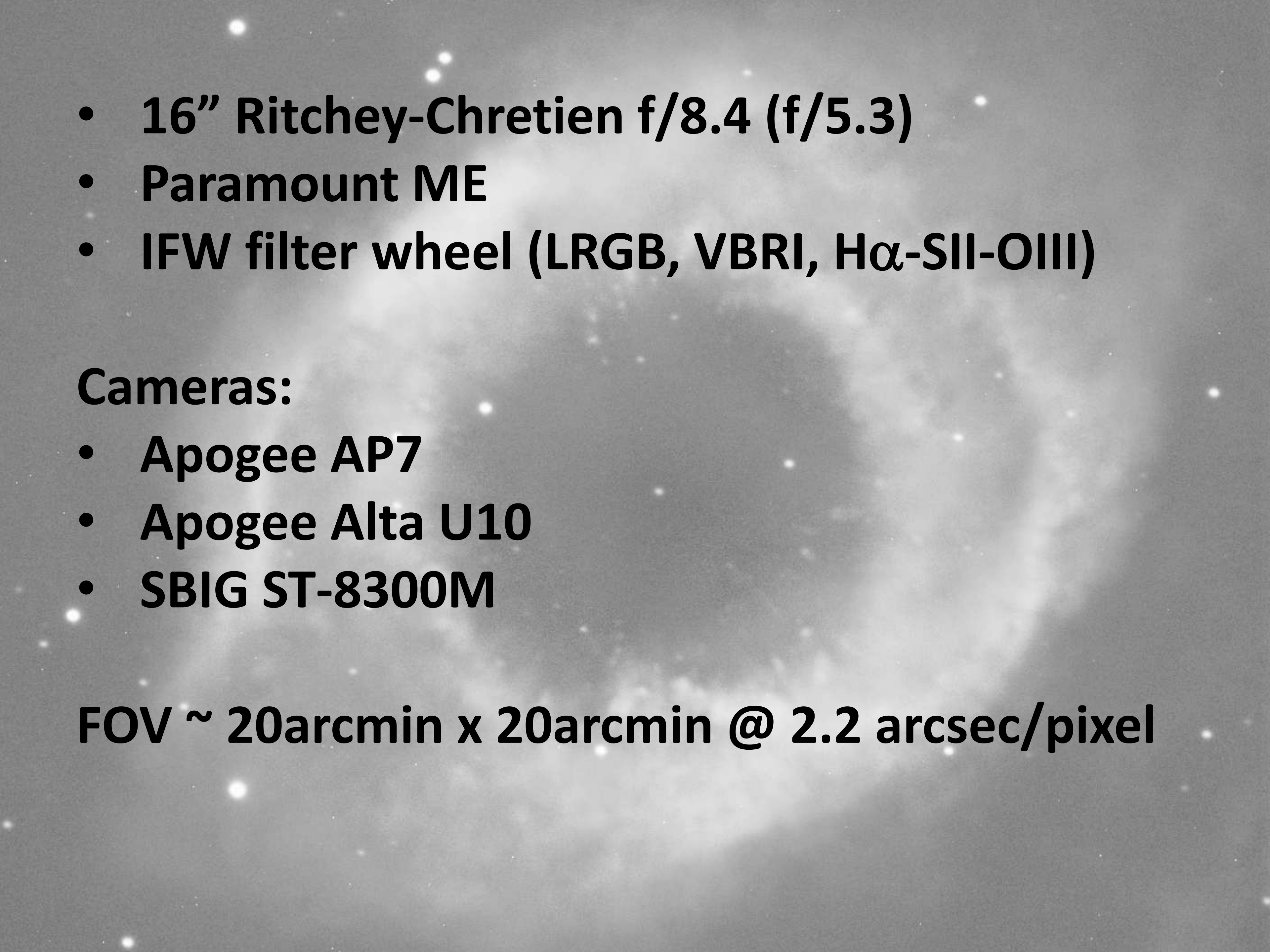
FLORIDA
GULF COAST
UNIVERSITY

FGCU


FGCU
FORT MYERS
(DUNK CITY)
NOW
YOU
KNOW


Evelyn L. Egan
Astronomical
Observatory


Optical Guidance Systems



- 16” Ritchey-Chretien f/8.4 (f/5.3)
- Paramount ME
- IFW filter wheel (LRGB, VBRI, Hα-SII-OIII)

Cameras:

- Apogee AP7
- Apogee Alta U10
- SBIG ST-8300M

FOV ~ 20arcmin x 20arcmin @ 2.2 arcsec/pixel

Research Focus:

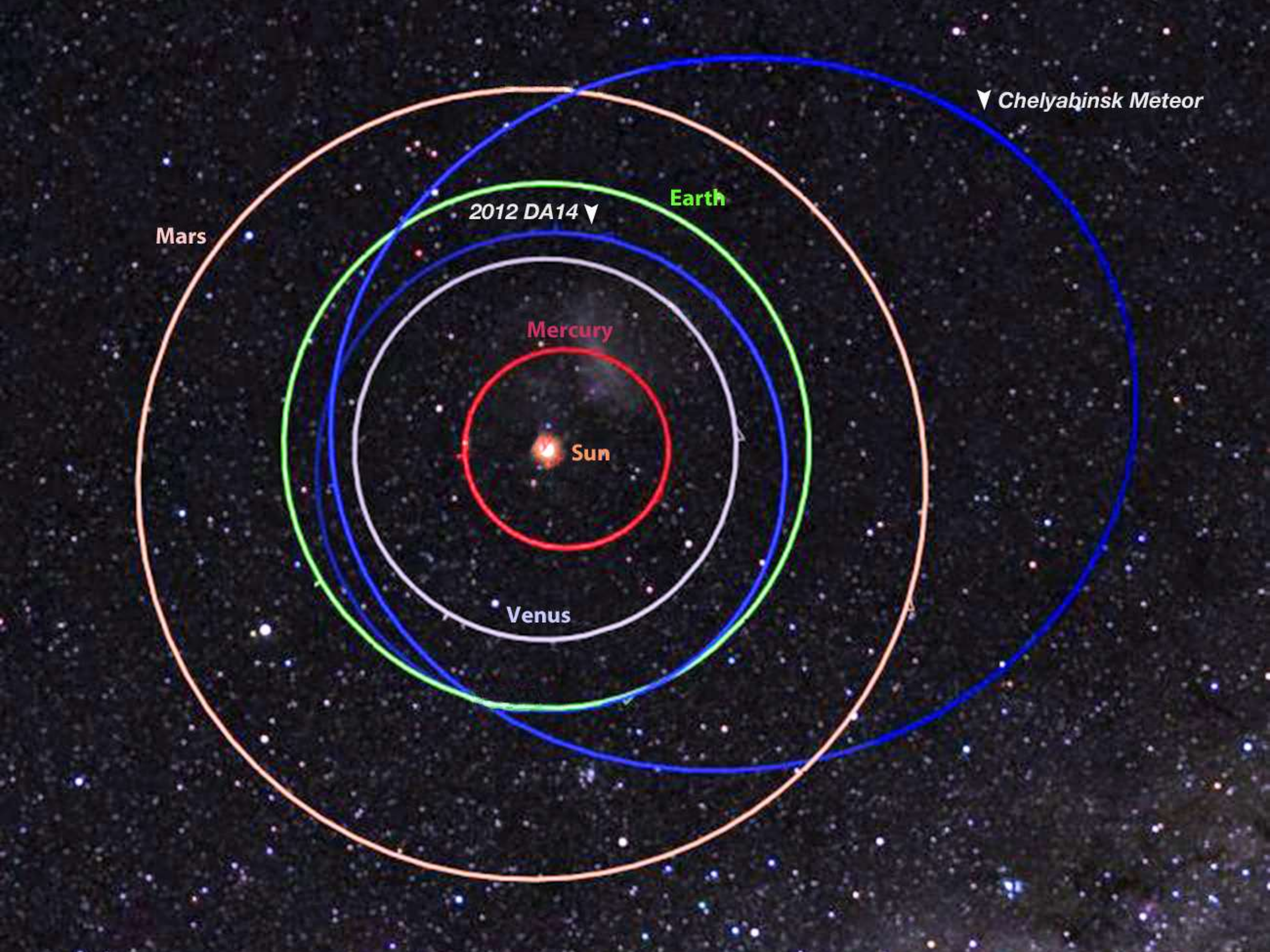
Asteroids

Why Asteroids?

- Easy to excite students and general public
- Scientific interesting results with limited time available
- Important to NASA's future
- Important for survival of humans

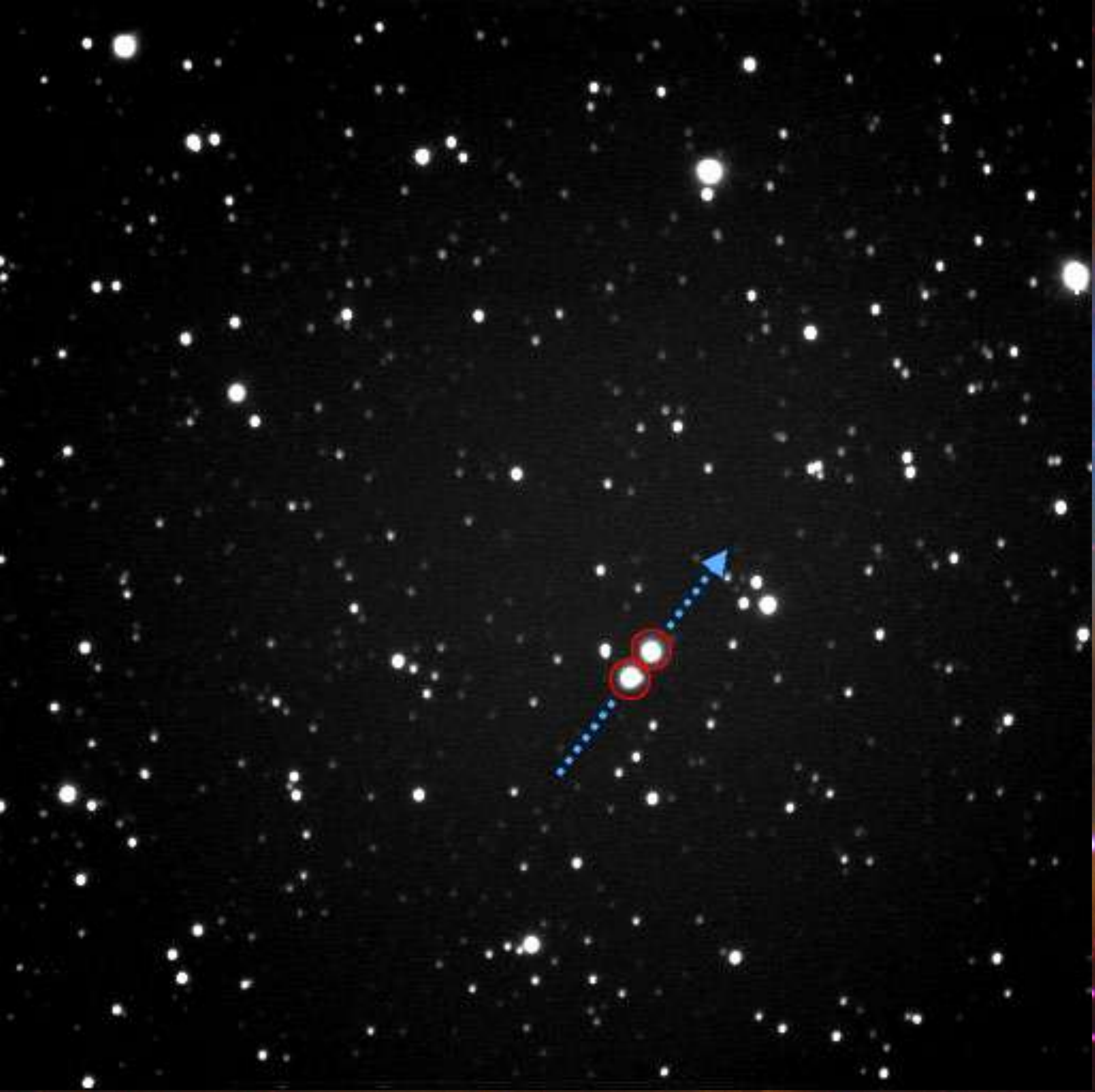
Chelyabinsk meteor, February 15, 2013

<20m, air burst equivalent to 440kilotons of TNT


Chelyabinsk Meteor
Earth
2012 DA14
Mars
Mercury
Sun
Venus

Airburst estimates for a stony asteroid with a diameter ranging from 30m to 85m http://impact.ese.ic.ac.uk/ImpactEffects/

Diameter	Kinetic energy at atmospheric entry	Airburst energy	Airburst altitude	Average frequency
30 m (98 ft)	708 kt	530 kt	16.1 km (53,000 ft)	185 years
50 m (160 ft)	3.3 Mt	2.9 Mt	8.5 km (28,000 ft)	764 years
70 m (230 ft)	9 Mt	8.5 Mt	3.4 km (11,000 ft)	1900 years
85 m (279 ft)	16.1 Mt	15.6 Mt	0.435 km (1,430 ft)	3300 years



511 Davida

2-30sec exp.

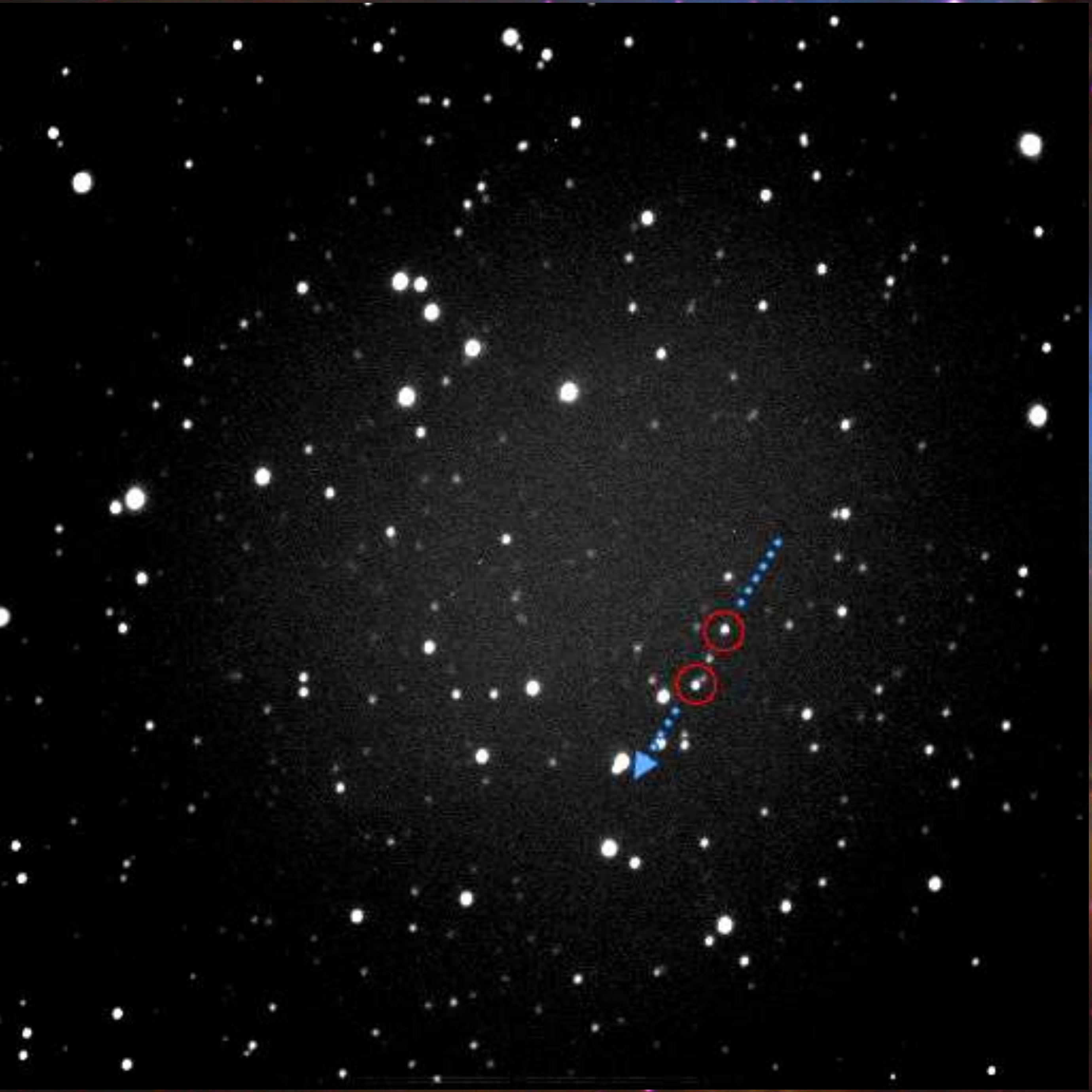
1h45min between exp.

Large (320km)

Main Belt Asteroid

Distance to Earth

1.91 A.U.



1999GJ4

2-20sec exp.

6minutes

between exp.

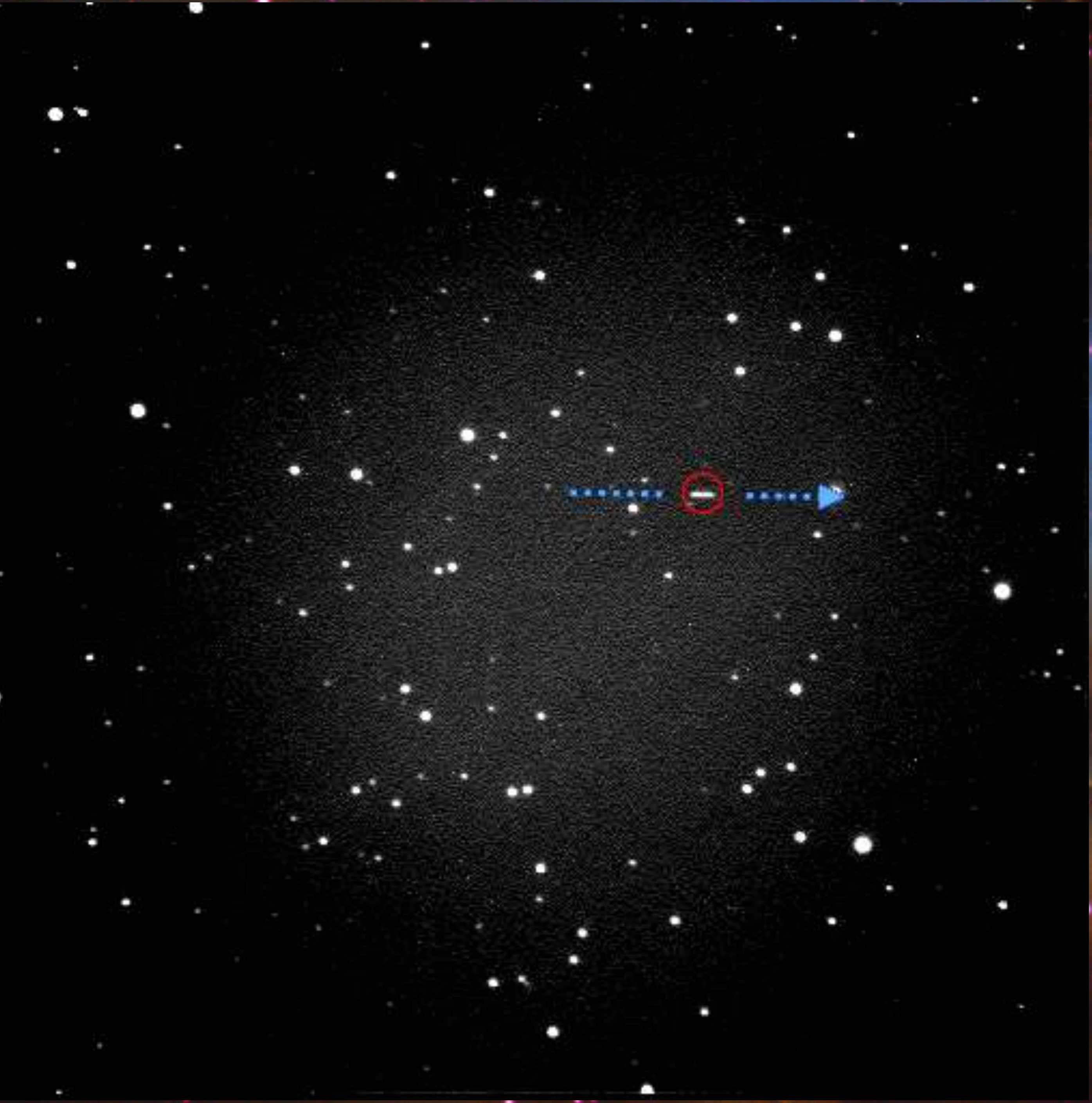
Near Earth Asteroid

(Apollo)

Size: 3-6km

Distance to Earth

1.29 A.U.



2003FG

1minute exp.

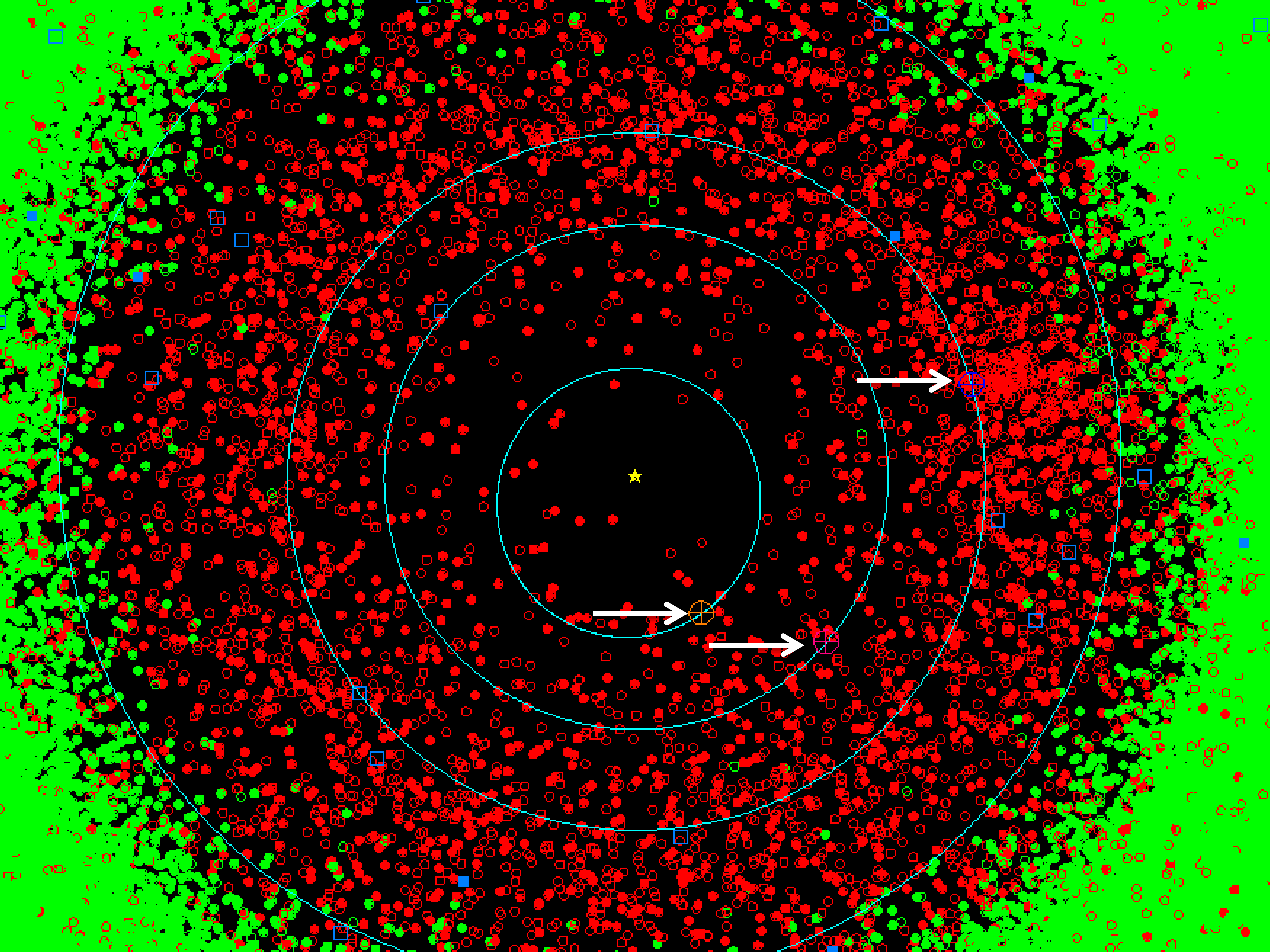
PHA

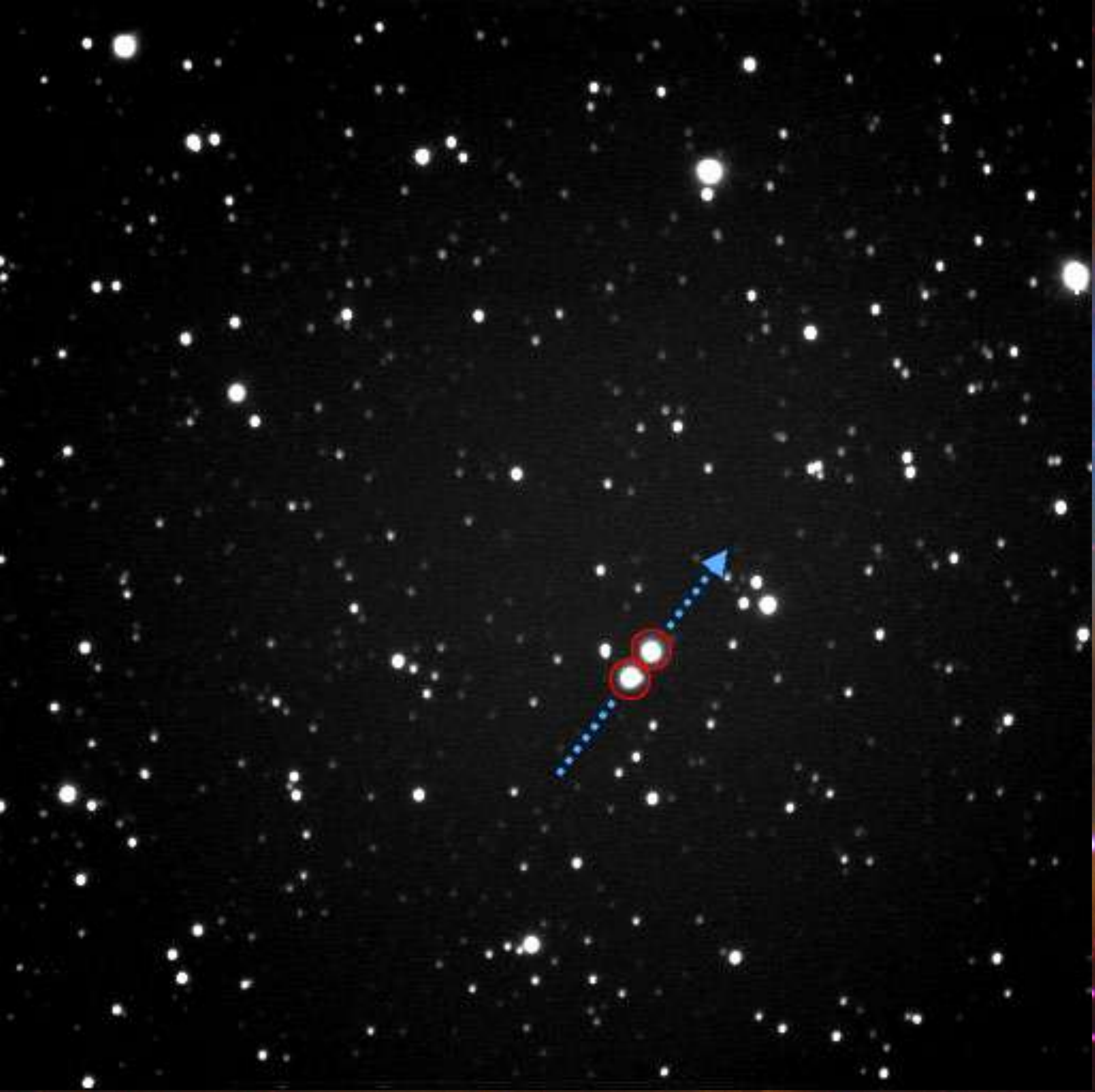
(>150m, <0.05AU)

Size: 430-970m

Distance to Earth

0.07 A.U.





Slow motion of distant objects makes discovery of TNOs more complex

1h45min between exp.

Distance to Earth

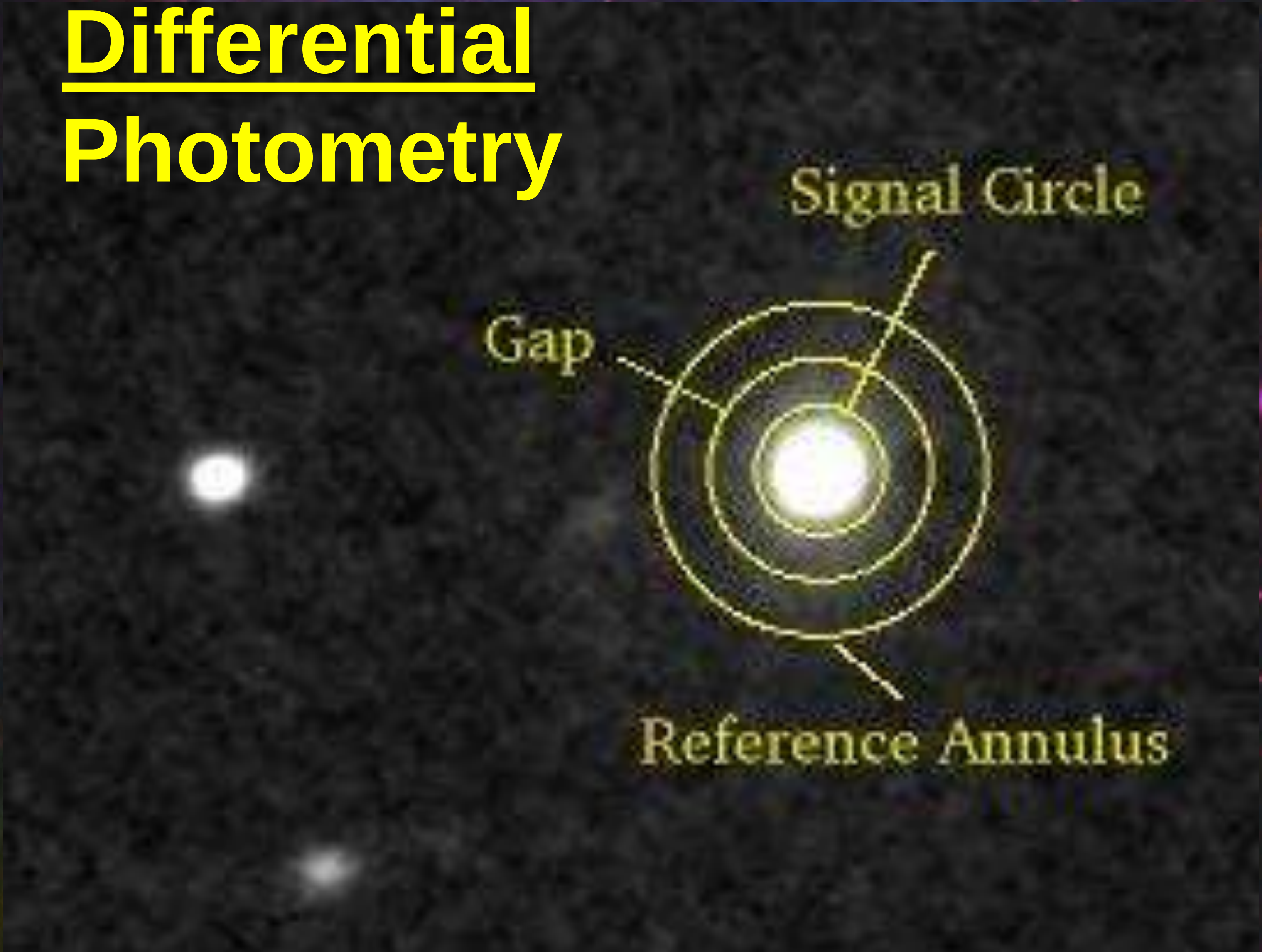
1.91 A.U.

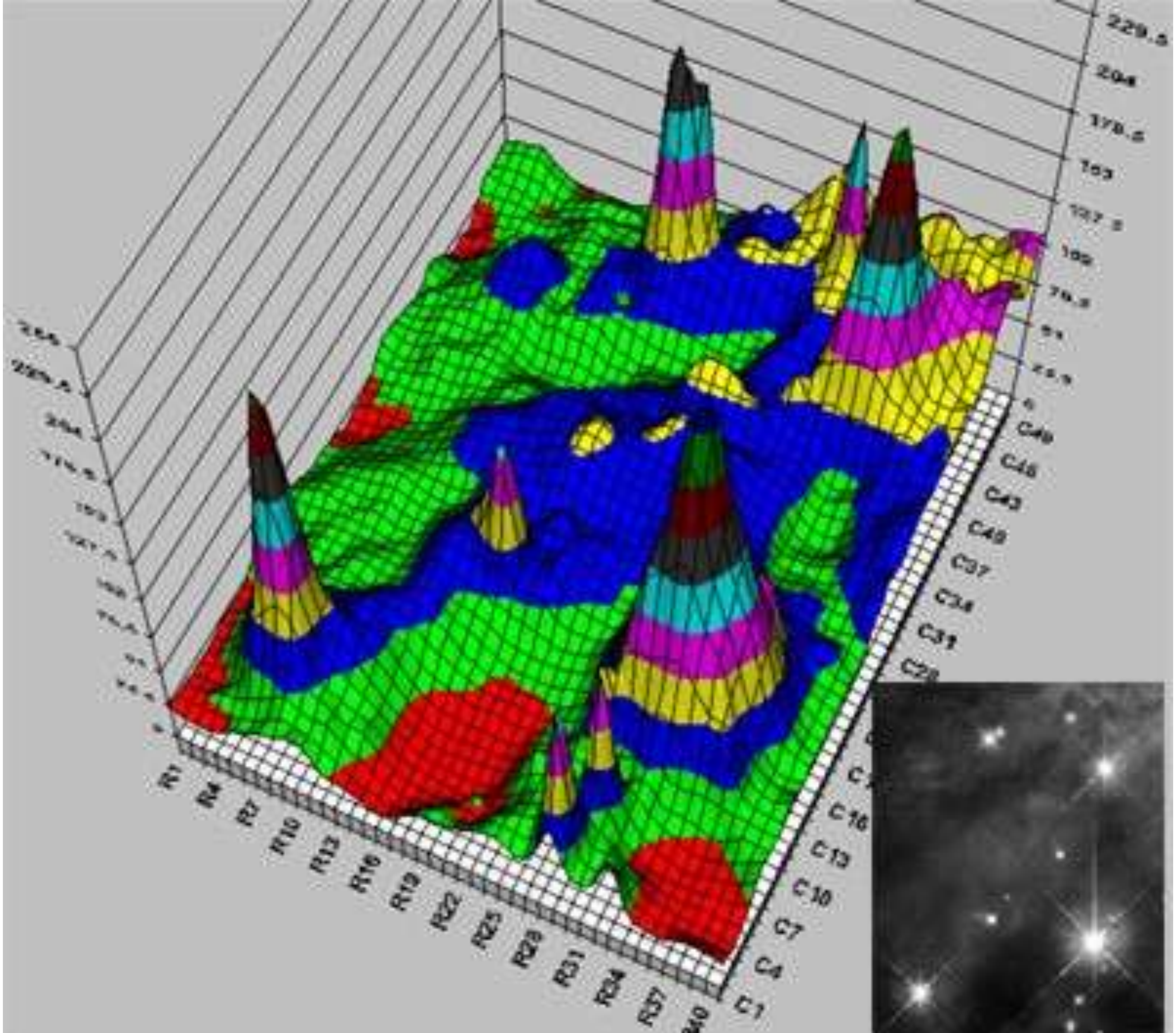
Is it worth doing?

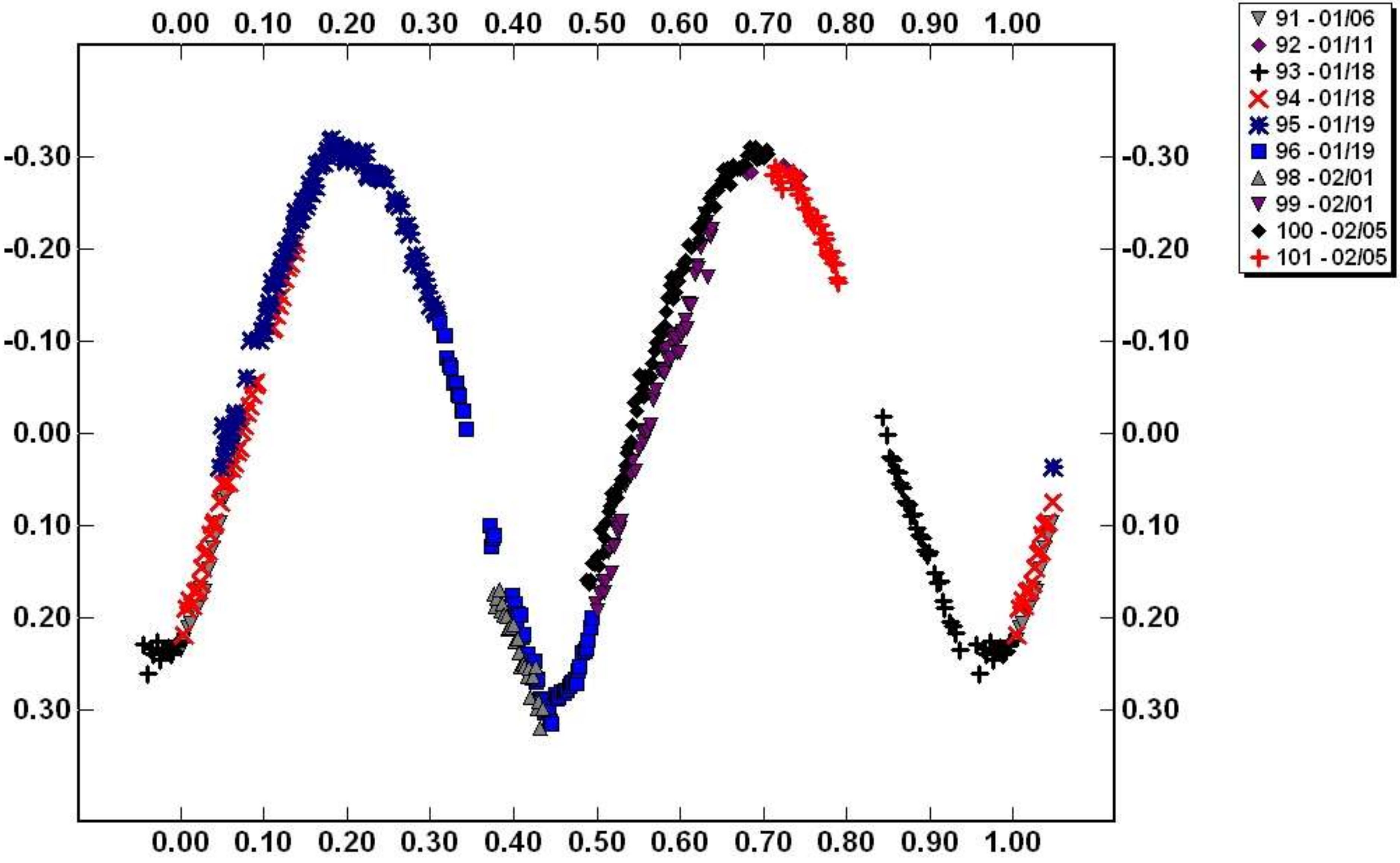
Yes, absolutely	No absolutely not
Lots of planning, lots of work, but it provides useful and immediate results.	Lots of work, and department chair did not consider it scholarship.

Differential

- Photometry



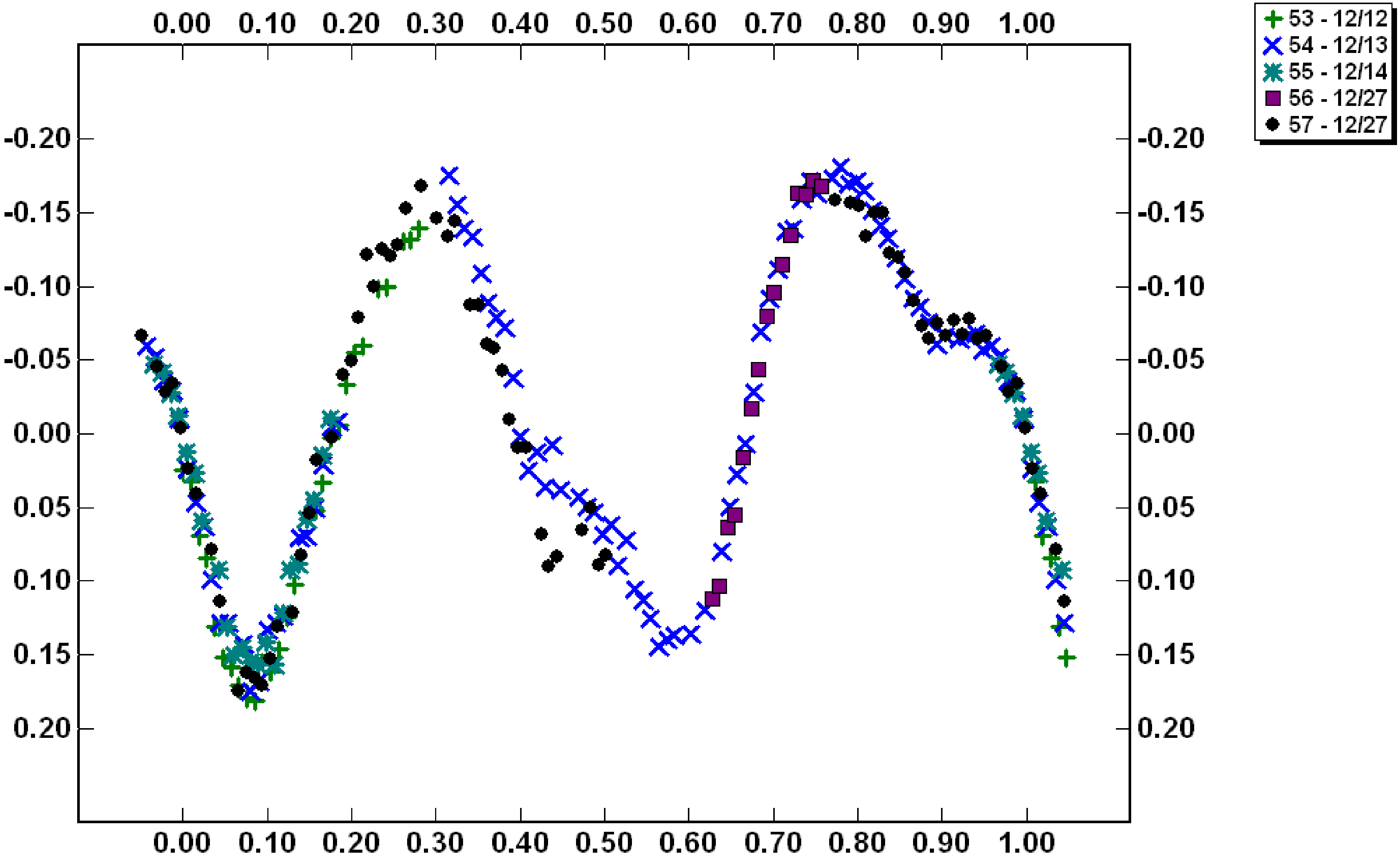

255
229.5
204
178.5
153
127.5
102
76.5
51
25.5
0
229.5
204
178.5
153
127.5
102
76.5
51
25.5
0
R1
R4
R7
R10
R13
R16
R19
R22
R25
R28
R31
R34
R37
R40
C1
C4
C7
C10
C13
C16
C28
C31
C34
C37
C40
C43
C46
C49



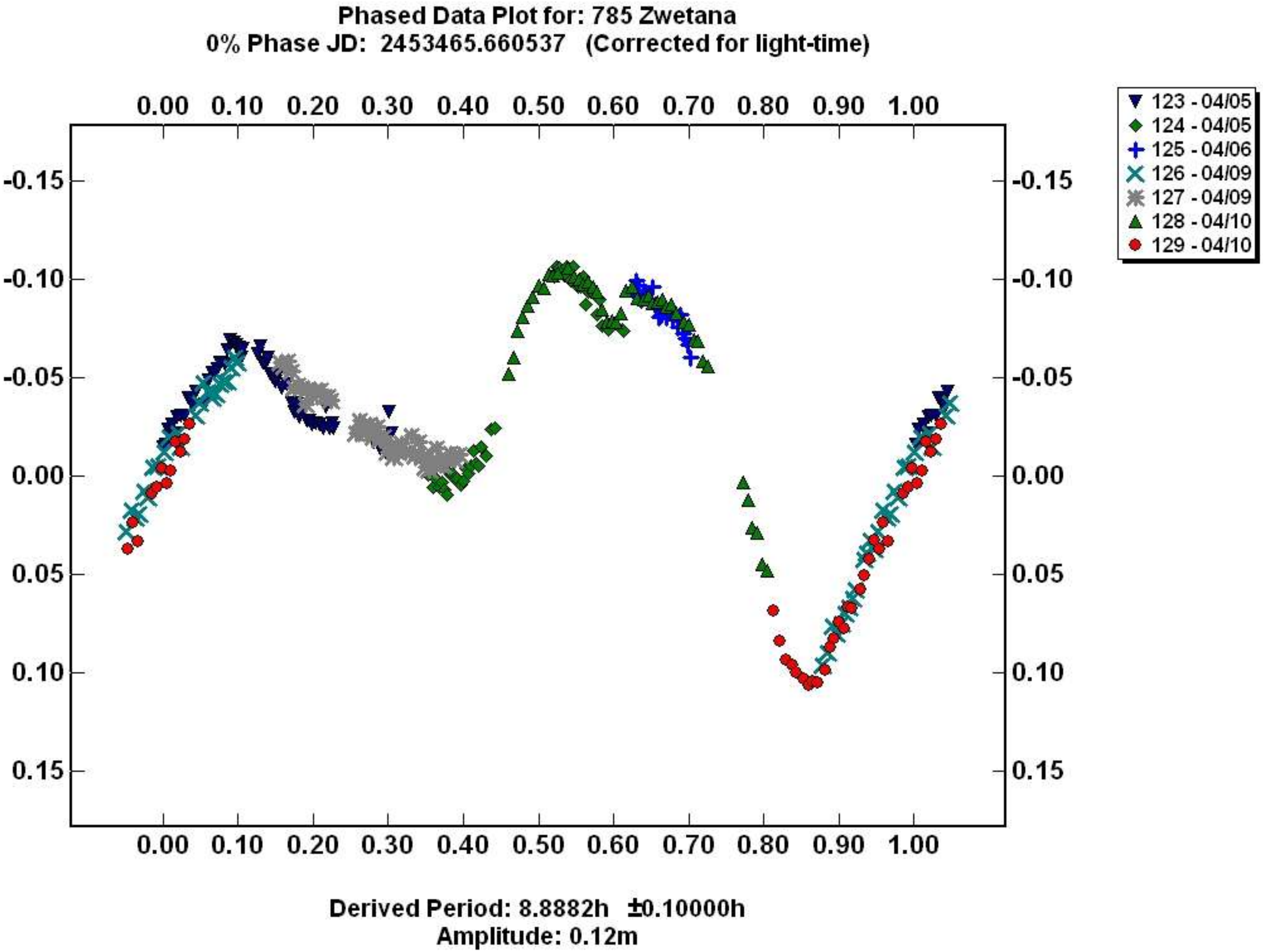
Phased Data Plot for: 1963 Bezovec
0% Phase JD: 2453376.728194 (Corrected for light-time)

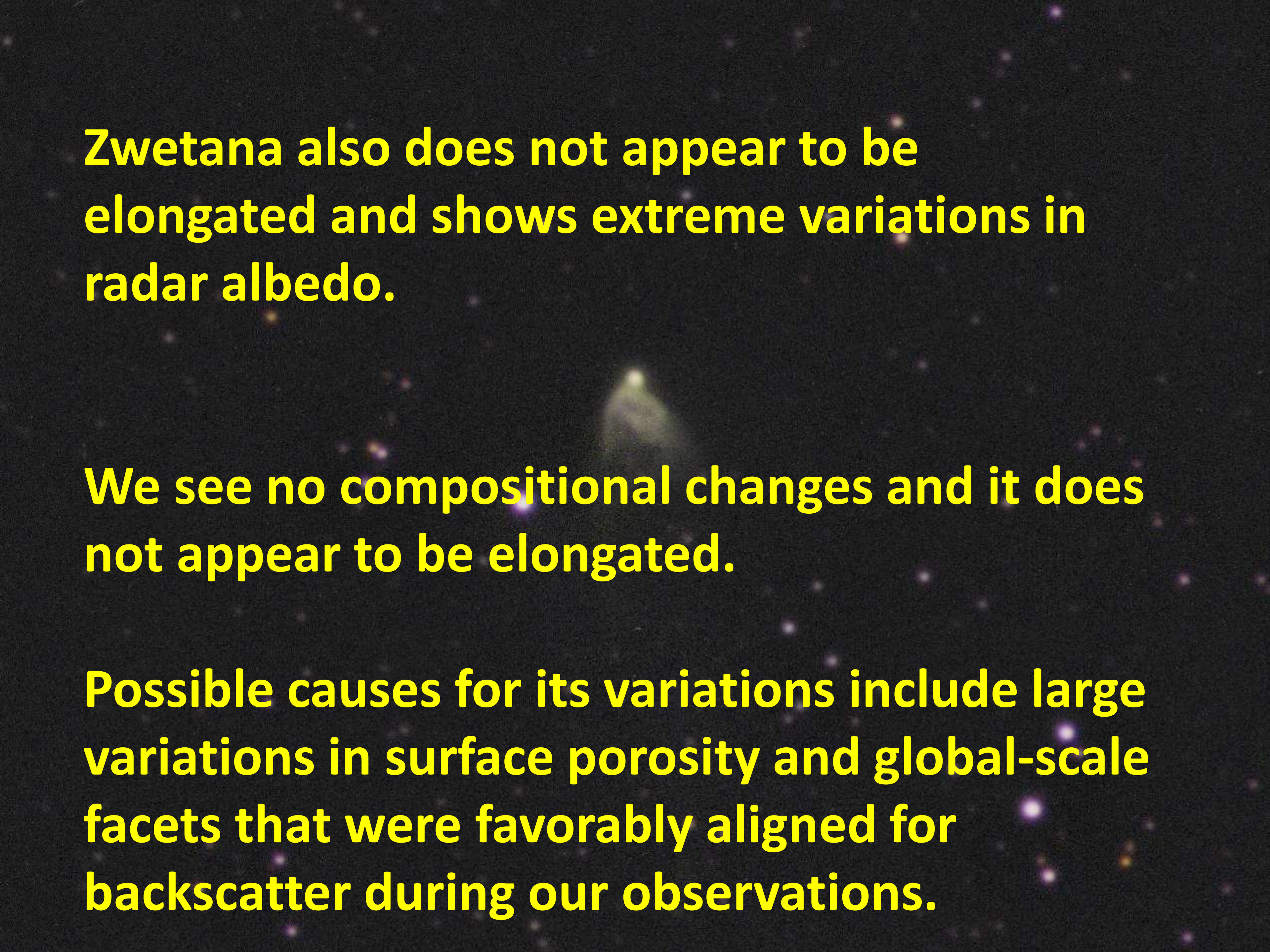
Derived Period: 18.1600h ±0.00010h
Amplitude: 0.55m

Phased Data Plot for: 125 Liberatrix
0% Phase JD: 2453352.487997 (Corrected for light-time)



Derived Period: 3.9683h ±0.00020h
Amplitude: 0.28m


Phased Data Plot for: 785 Zwetana
0% Phase JD: 2453465.660537 (Corrected for light-time)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
123 - 04/05
124 - 04/05
125 - 04/06
126 - 04/09
127 - 04/09
128 - 04/10
129 - 04/10
Derived Period: 8.8882h ±0.10000h
Amplitude: 0.12m



Zwetana also does not appear to be elongated and shows extreme variations in radar albedo.

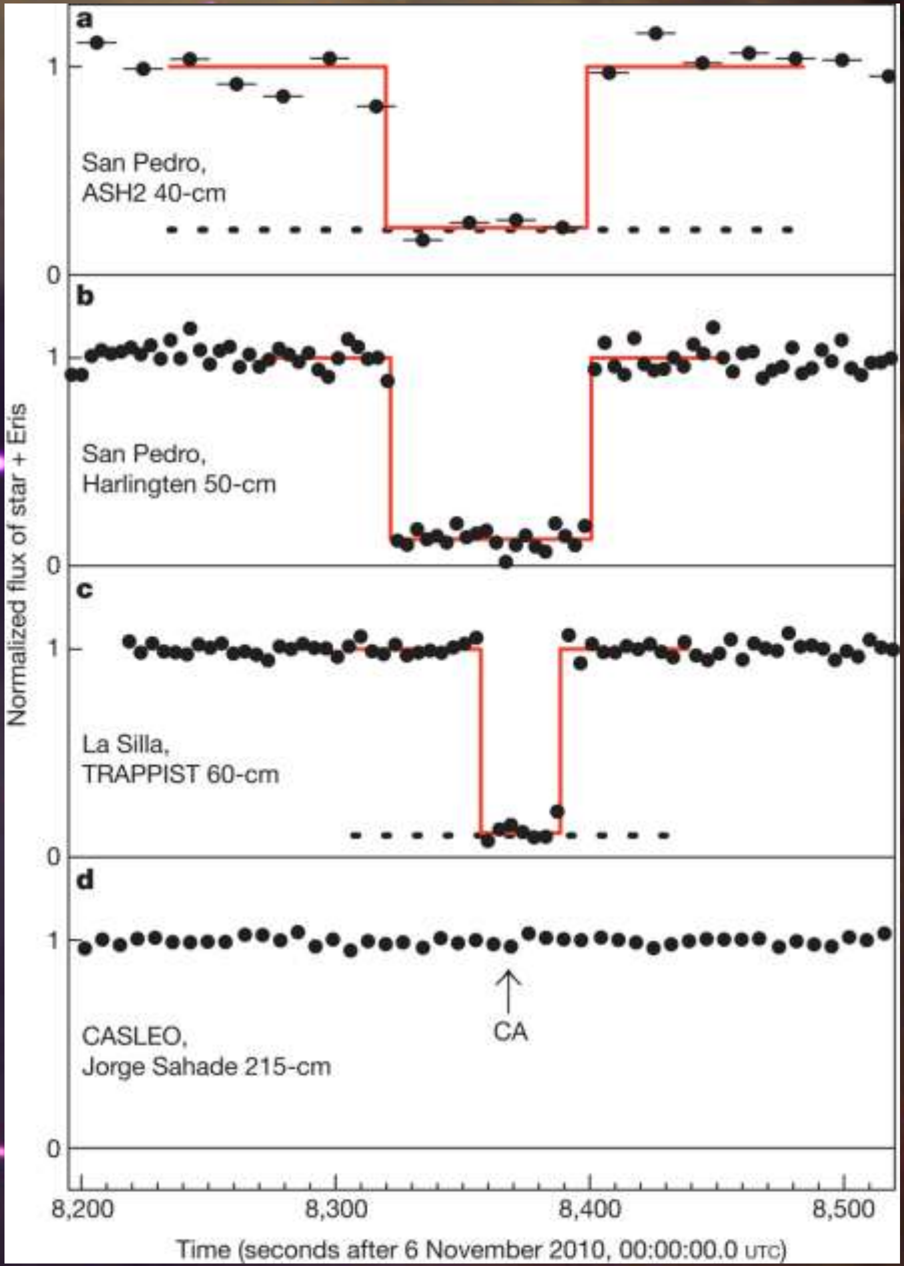
We see no compositional changes and it does not appear to be elongated.

Possible causes for its variations include large variations in surface porosity and global-scale facets that were favorably aligned for backscatter during our observations.

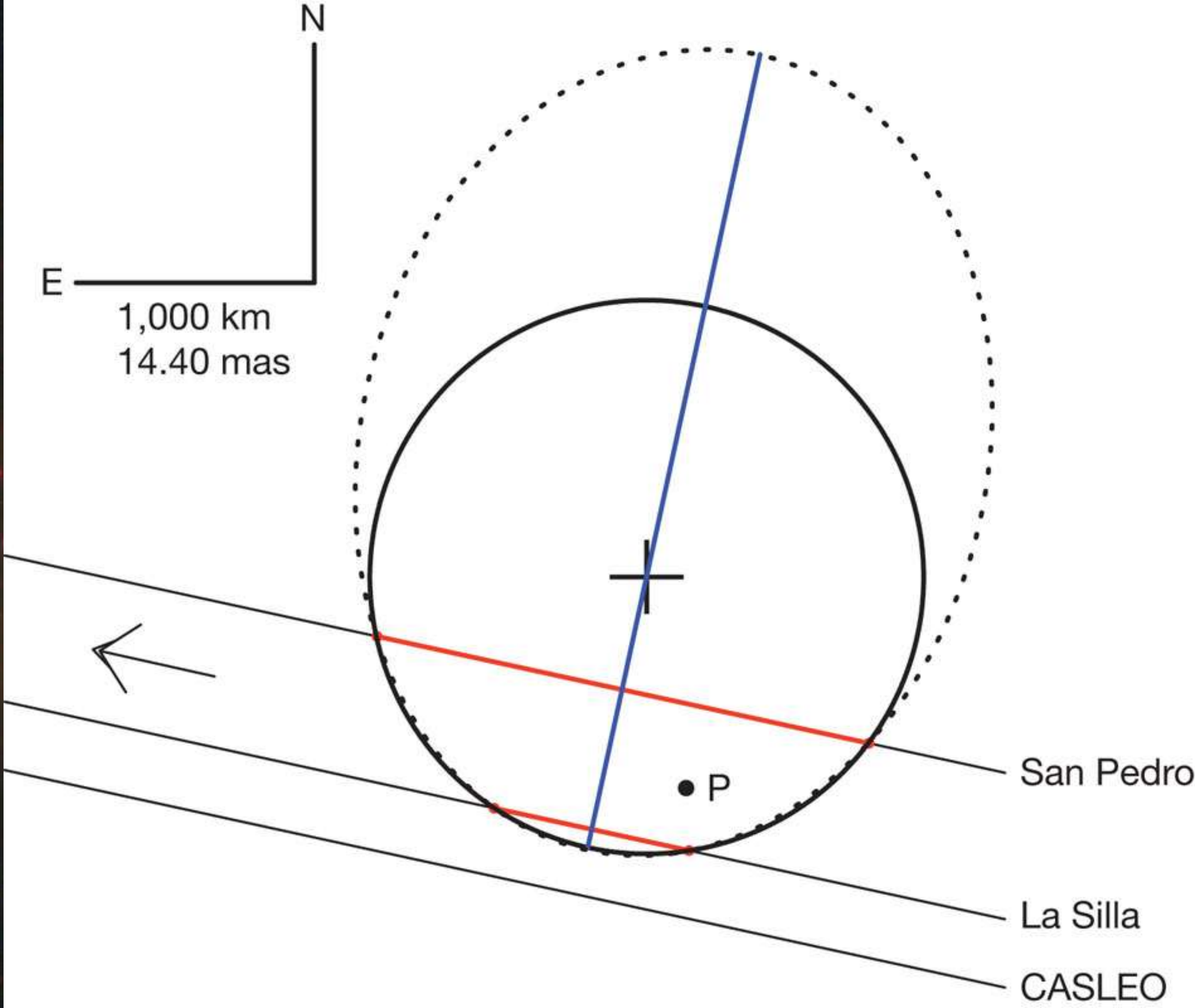
How can we find out about the shape of an asteroid?

- Spacecraft flyby
- (Doppler) Radar observations
- Stellar occultation (2D only)
- Lightcurve inversion
- KOALA (Knitted Occultation, Adaptive optics, and Lightcurve Analysis)

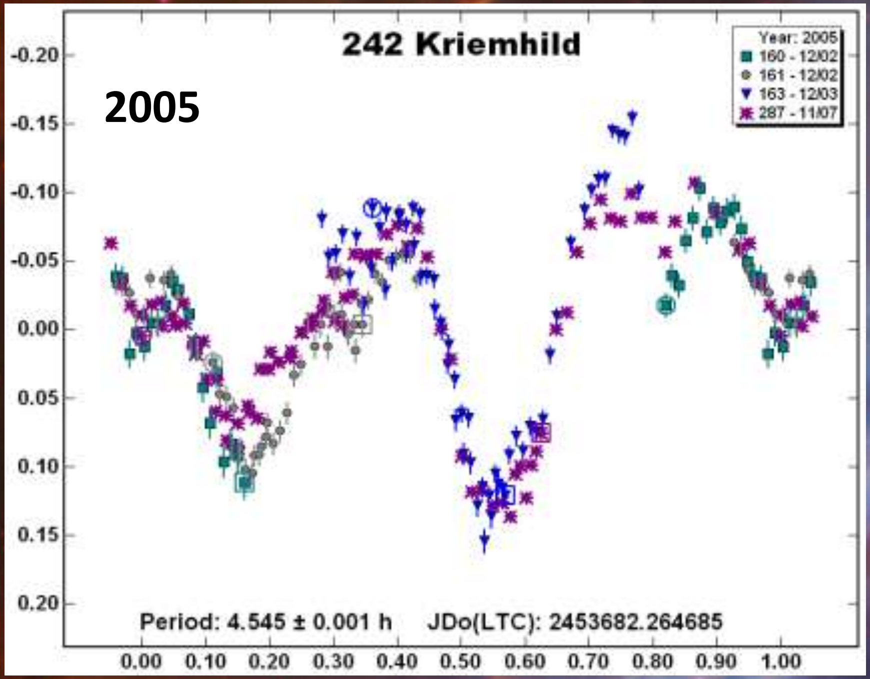
Eris occultation light curves



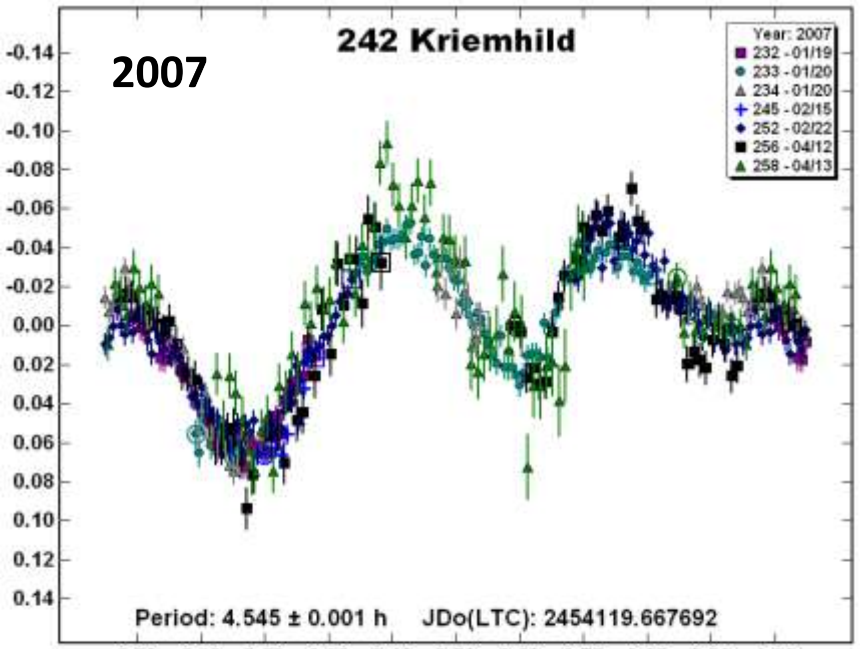
Measuring Eris' size

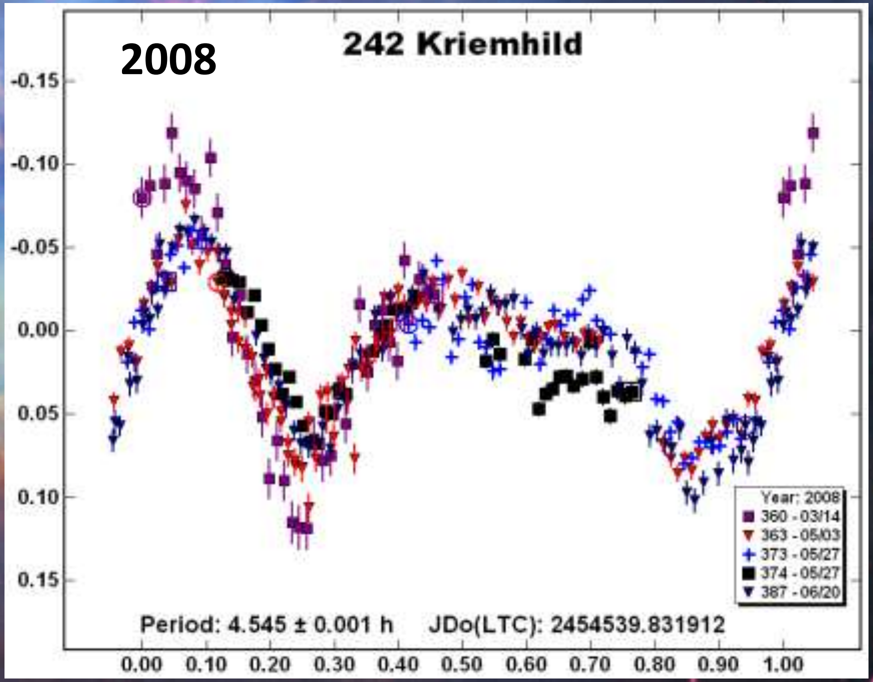


B Sicardy *et al. Nature* 478, 493-496 (2011) doi:10.1038/nature10550

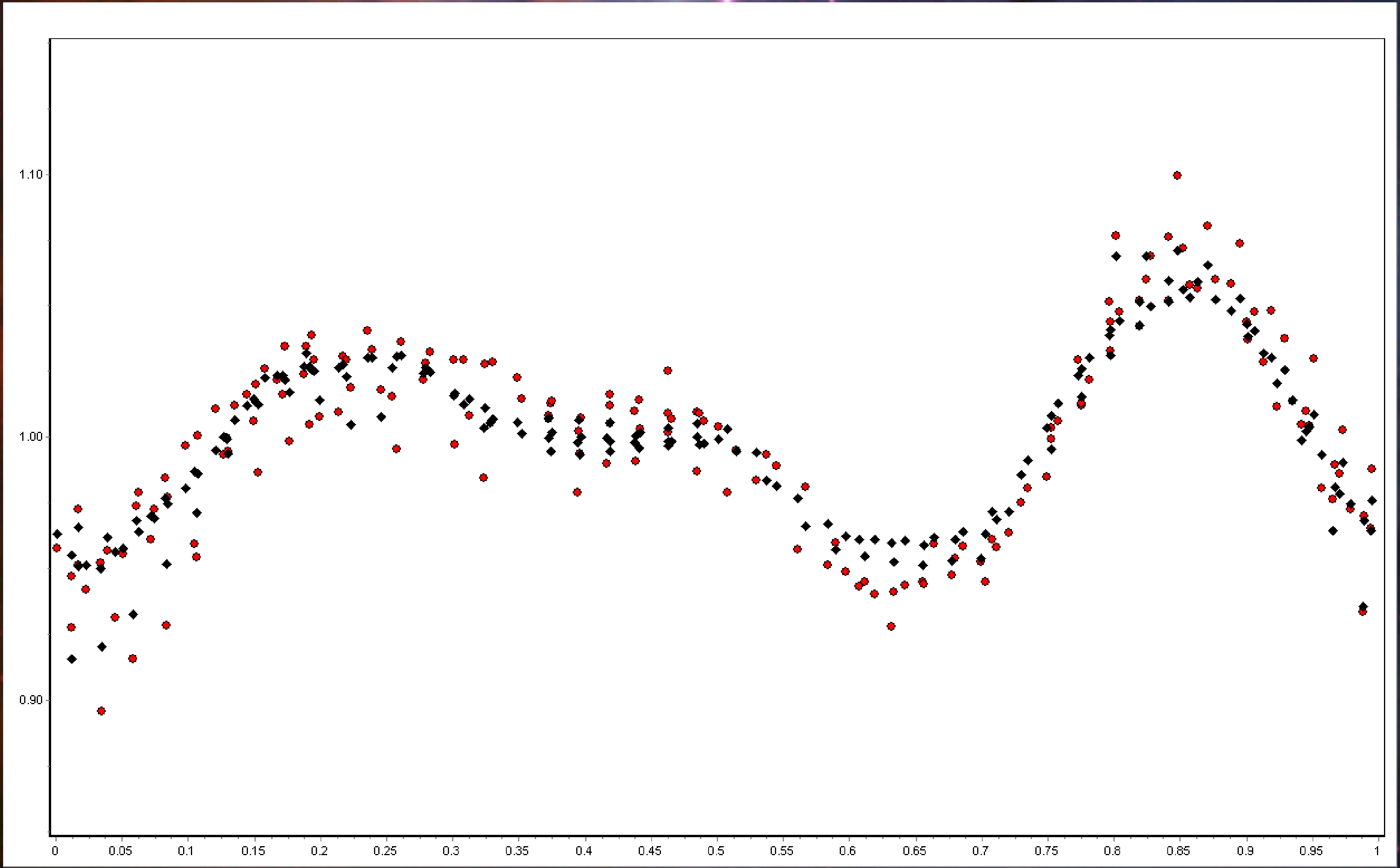


Due to different viewing geometries, the lightcurves look different from year to year, although the rotation period stays the same

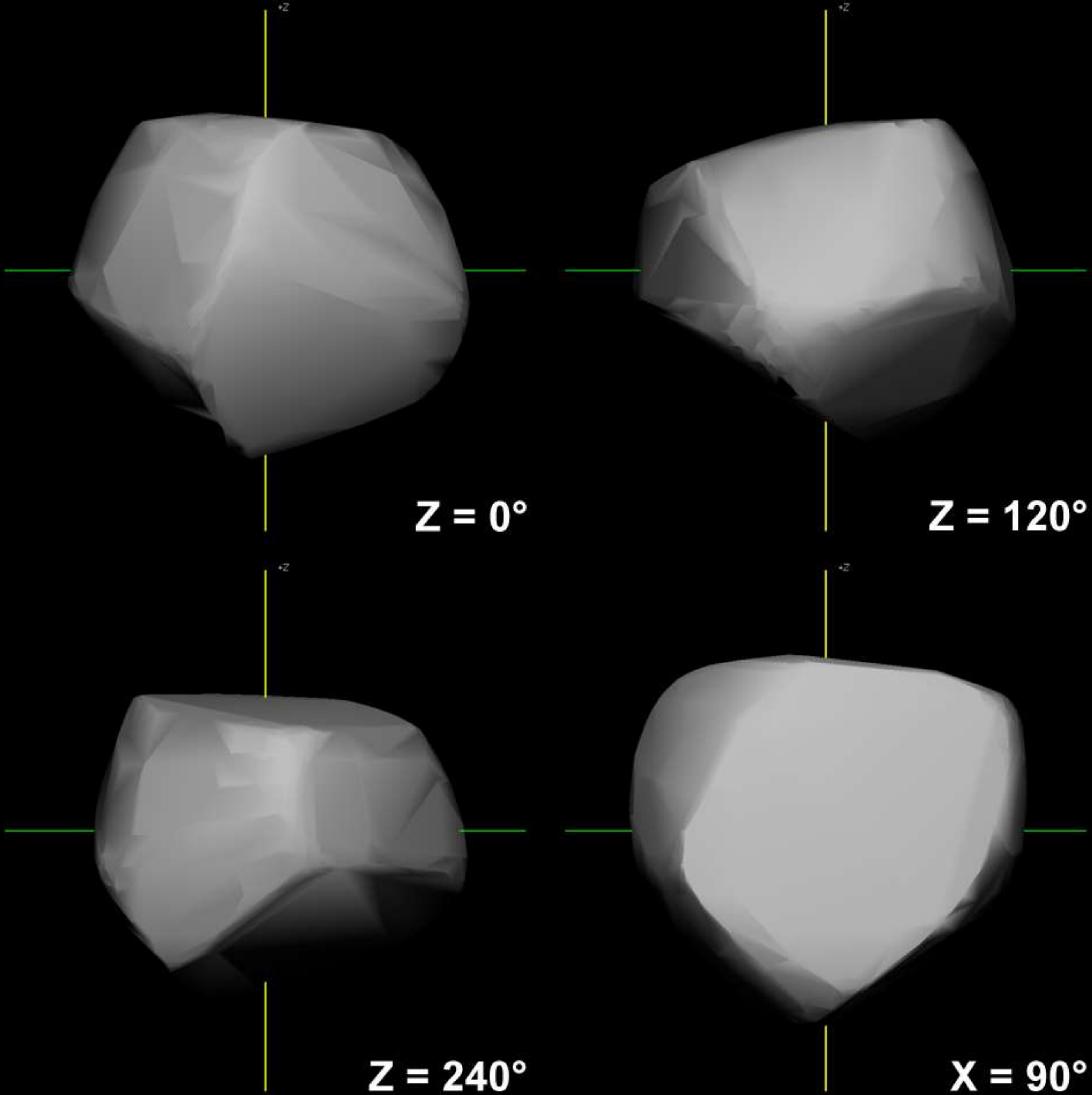




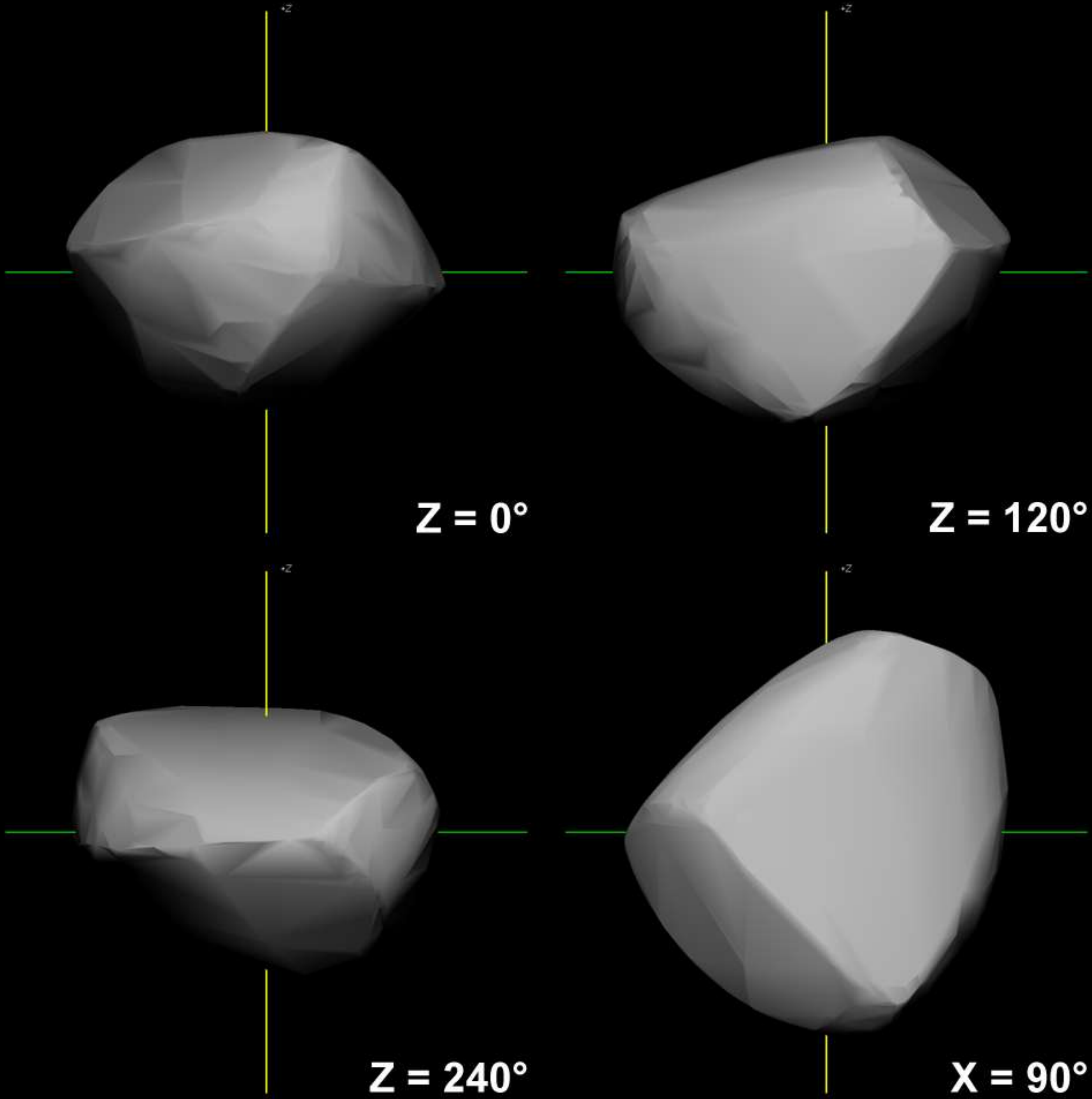
Comparison between actual lightcurve for 242 Kriemhild (black dots), and 'modeled' lighcurve (red dots).

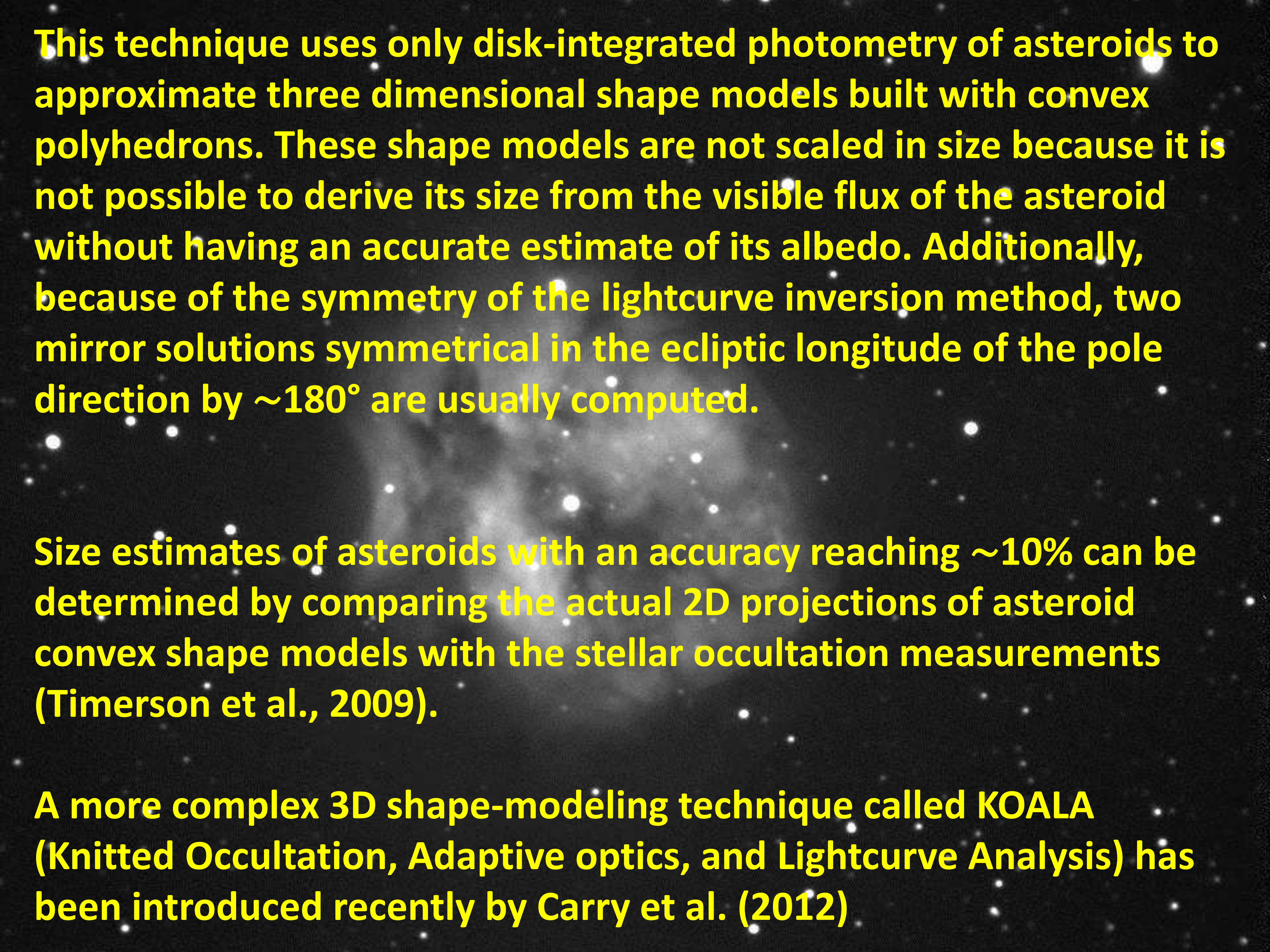


242 Kriemhild



287
Nephthys

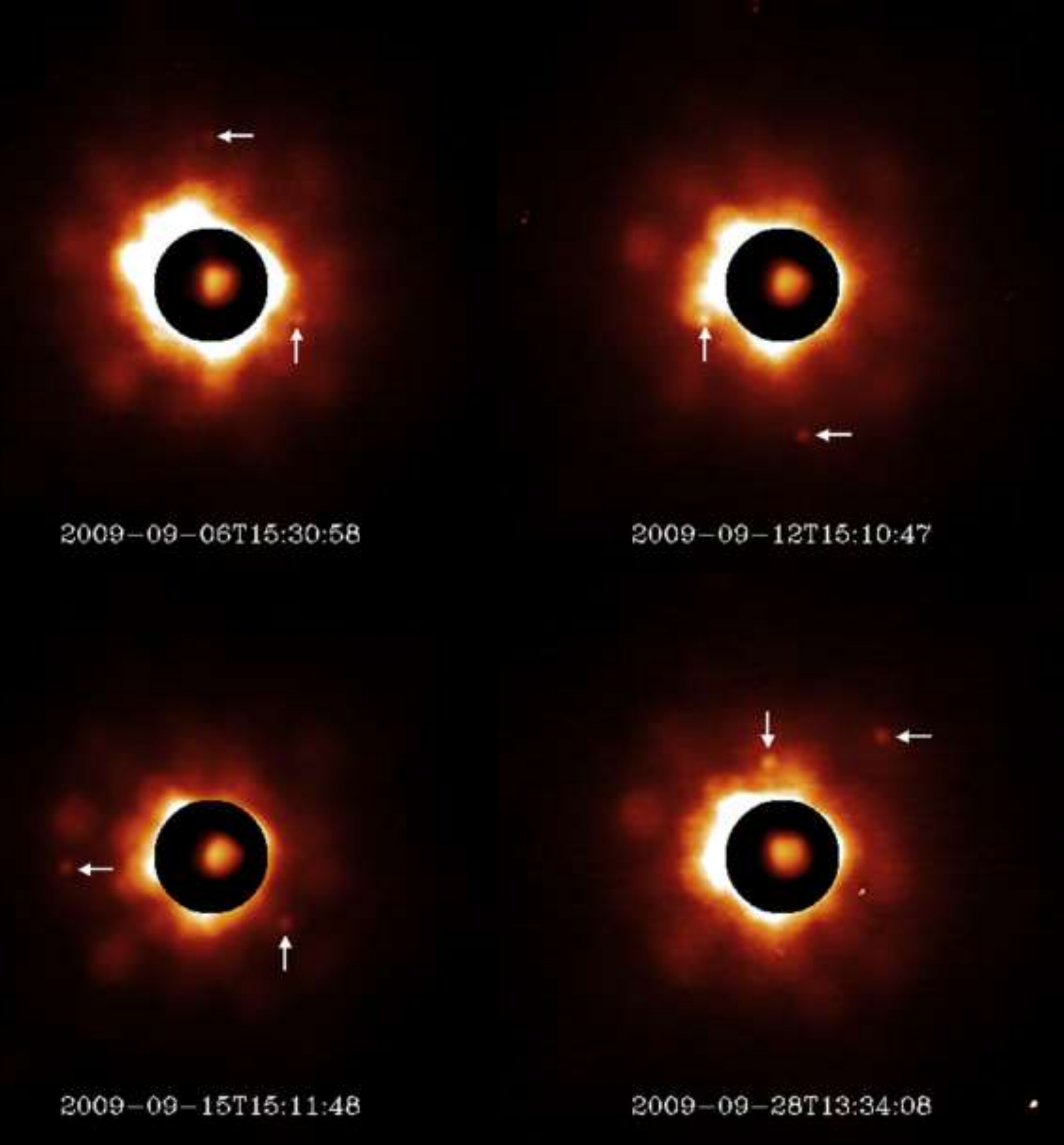




This technique uses only disk-integrated photometry of asteroids to approximate three dimensional shape models built with convex polyhedrons. These shape models are not scaled in size because it is not possible to derive its size from the visible flux of the asteroid without having an accurate estimate of its albedo. Additionally, because of the symmetry of the lightcurve inversion method, two mirror solutions symmetrical in the ecliptic longitude of the pole direction by ~180° are usually computed.

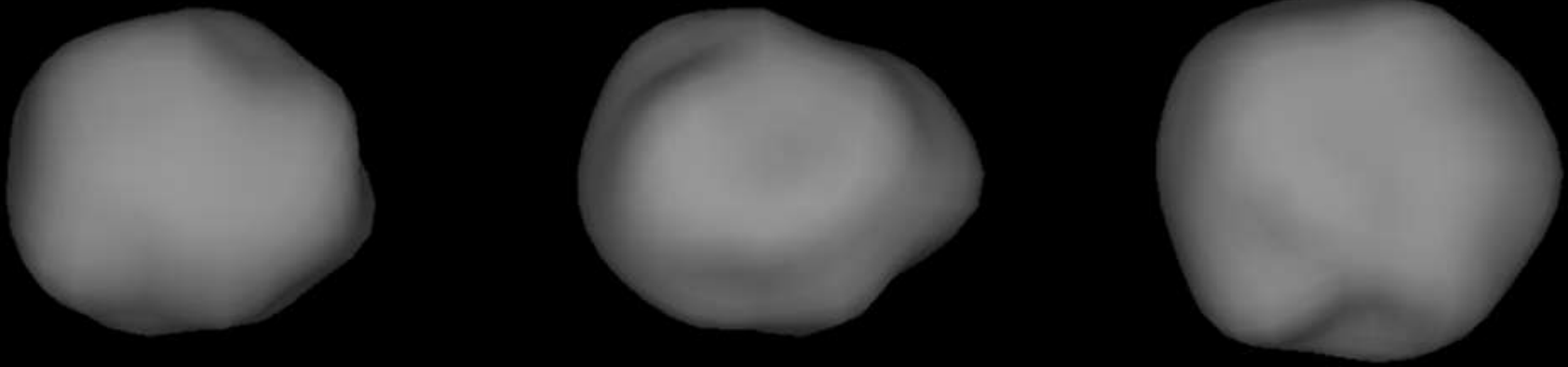
Size estimates of asteroids with an accuracy reaching ~10% can be determined by comparing the actual 2D projections of asteroid convex shape models with the stellar occultation measurements (Timerson et al., 2009).

A more complex 3D shape-modeling technique called KOALA (Knitted Occultation, Adaptive optics, and Lightcurve Analysis) has been introduced recently by Carry et al. (2012)



F. Marchis et al. Icarus, 224 (2013), pp. 178–191

W.M. Keck II AO observations of (93)Minerva and its two moonlets (September 2009) using an Fe II band filter. The positions of the moonlets are indicated with horizontal and vertical arrows for Minerva I and Minerva II respectively.



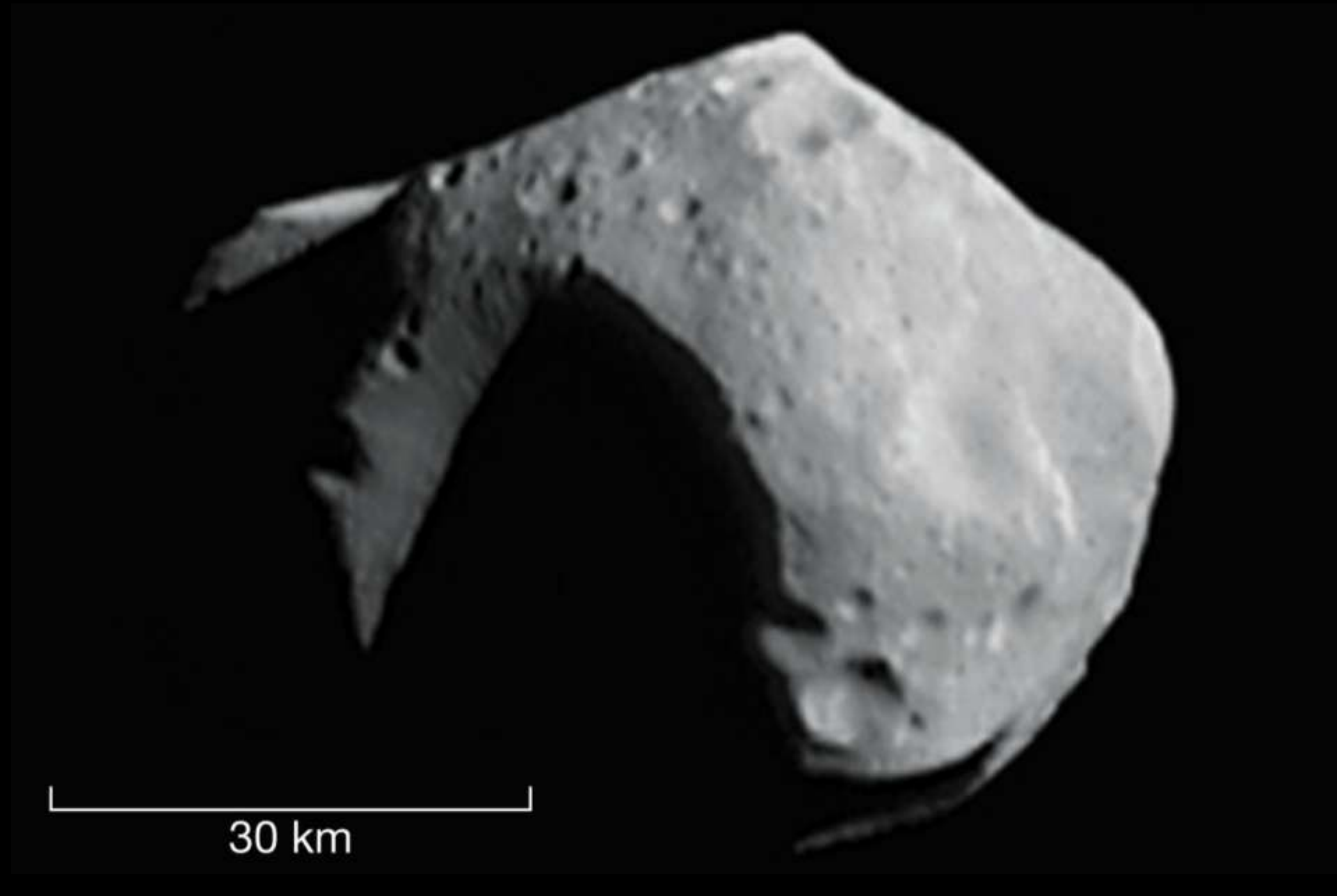
Non-convex shape model of Minerva’s primary derived from combining lightcurve, adaptive optics and stellar occultation data shown from equatorial level (left, center) and pole-on (right).

Taxonomic classes:

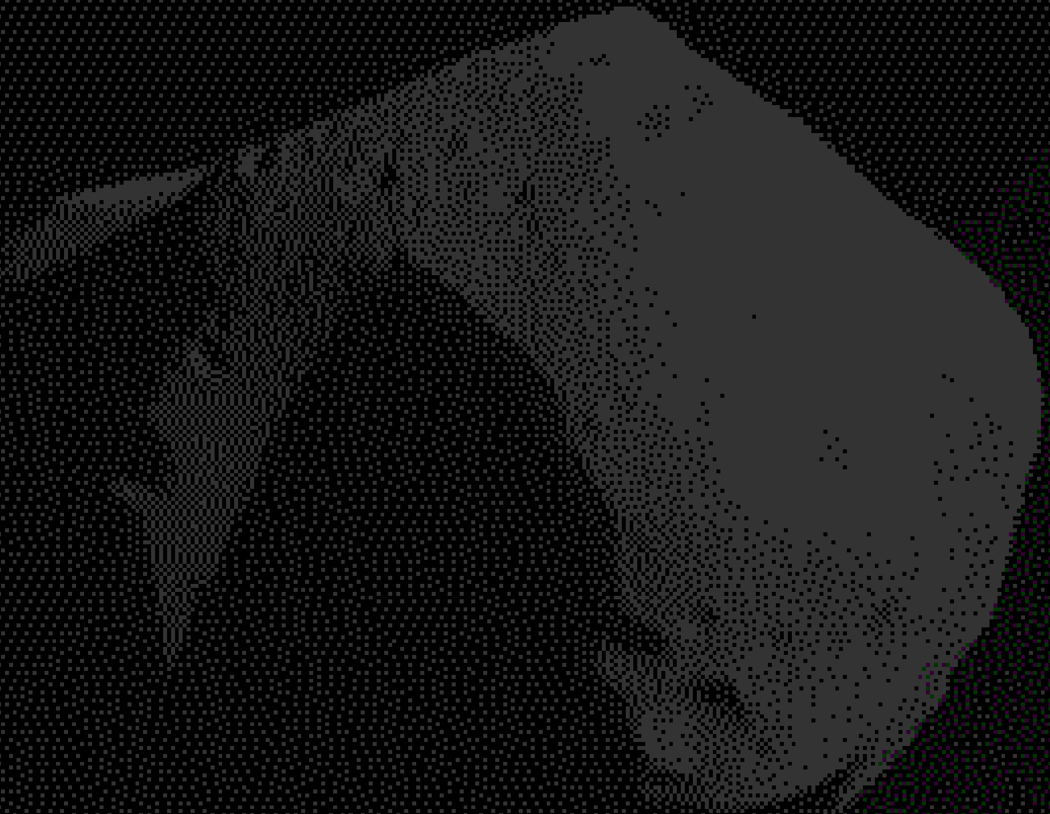
Small Main-Belt Asteroid Spectroscopic Survey (SMASS)

- C-group of carbonaceous objects
- S-group of silicaceous (stony) objects –includes A-class
- X-group of mostly metallic objects

C-type asteroid 253 Mathilde



S-type asteroid 243 Ida (Dactyl)



Mathilde

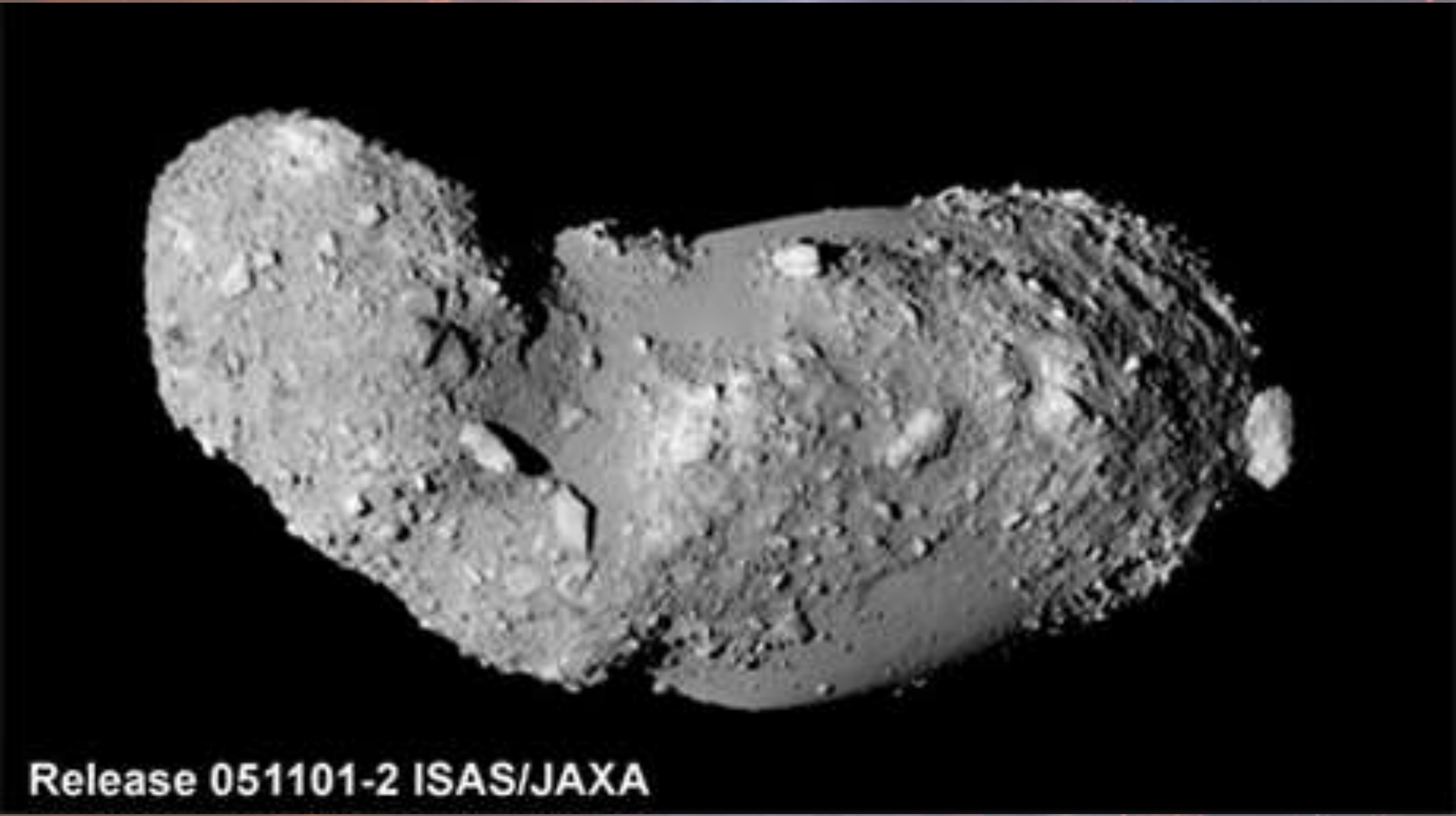
Ida

433 Eros, S-type, “solid” rock

S-type asteroid 25143 Itokawa

535m × 294m × 209m

Release 051101-1 ISAS/JAXA



Release 051101-2 ISAS/JAXA

A-class Asteroids

The search for the “missing mantle” of the asteroid belt

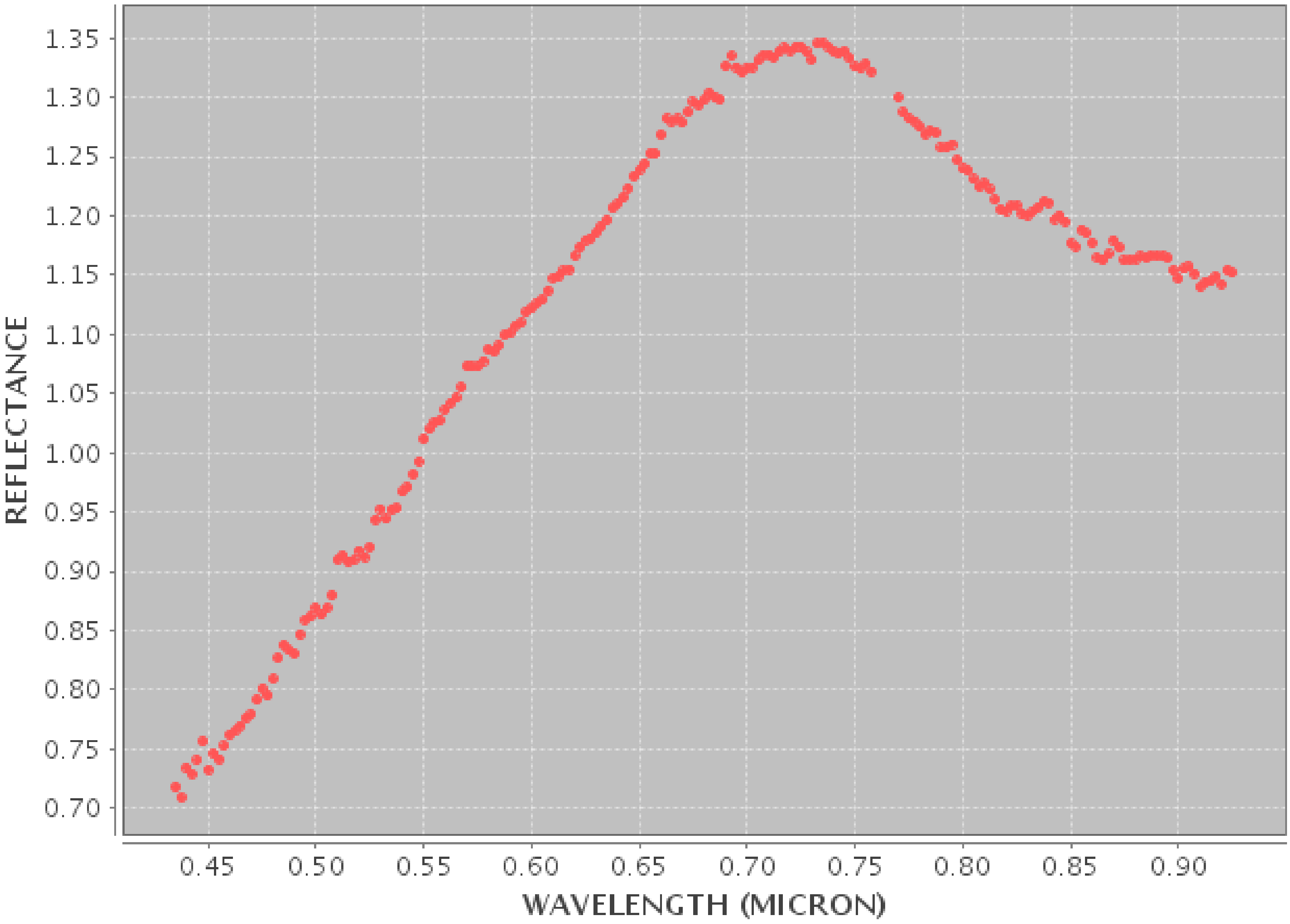
The differentiation of a body of ordinary chondritic composition is believed to result in an object with an iron-nickel core, a thick olivine-dominated mantle, and a thin plagioclase/pyroxene crust

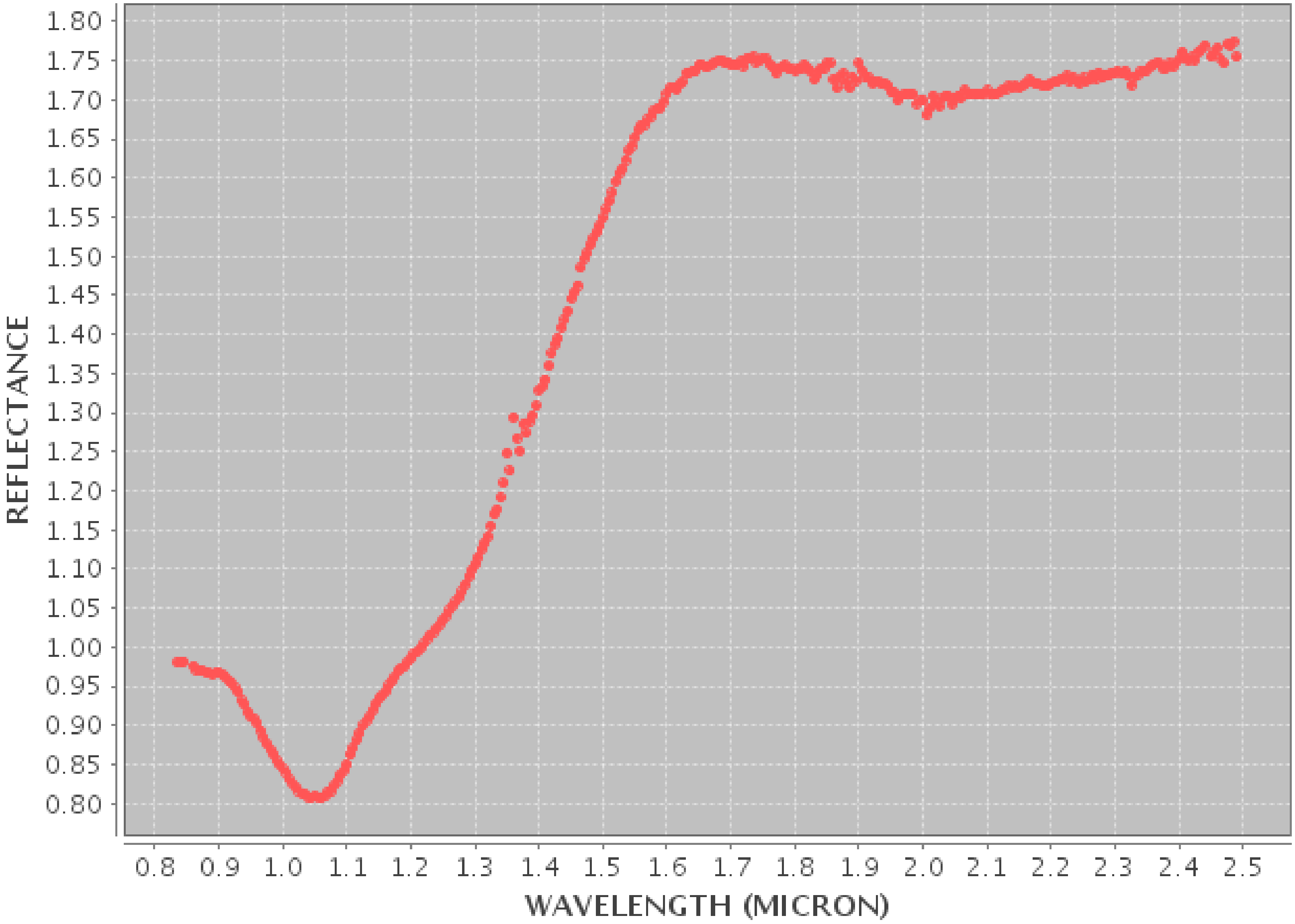
The existence of achondrites, which are meteorites of magmatic origin in terrestrial collections indicate that some planetesimals experienced temperatures during solar system formation high enough to result in partial or full interior melting and differentiation. In fact, based on the number of iron meteorites in terrestrial meteorite collections, it is estimated that ~108 asteroidal parent bodies experienced partial or total melting and differentiation within the first few Mega-annum (Ma) of solar system history.

Big question in planetary geology is the rarity of olivine-dominated A-class asteroids
--no more than 17 known objects and number is not increasing as we are studying smaller asteroids

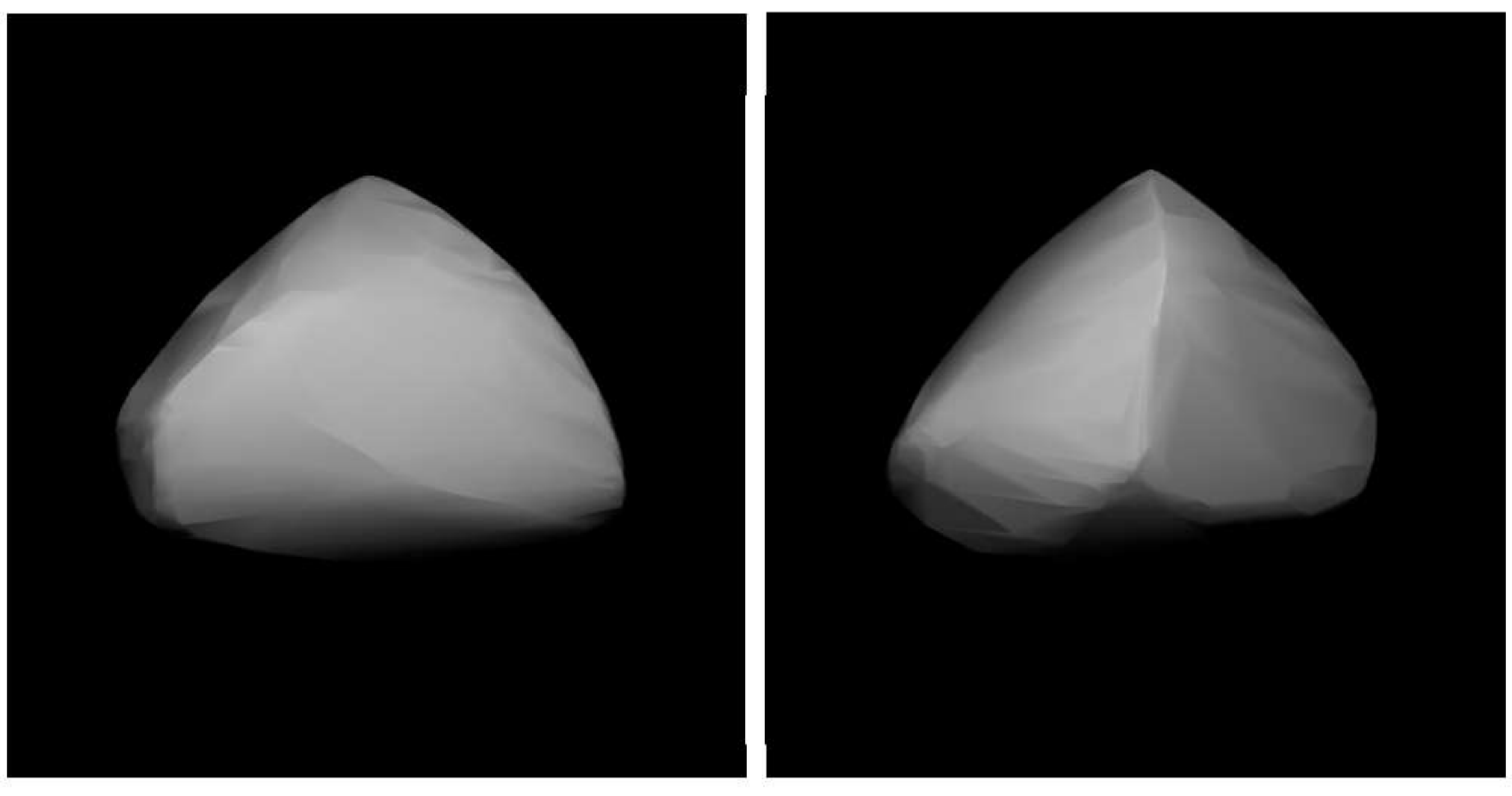
(1) have been shattered to small sizes (<5 km) over the collisional lifetime of the asteroid belt
(2) are abundant but their spectra have been altered in some way masking their presence (rubble pile asteroids)
(3) differentiated asteroids did not form thick olivine-rich, metal-poor mantles, and differentiation on these bodies is not understood.

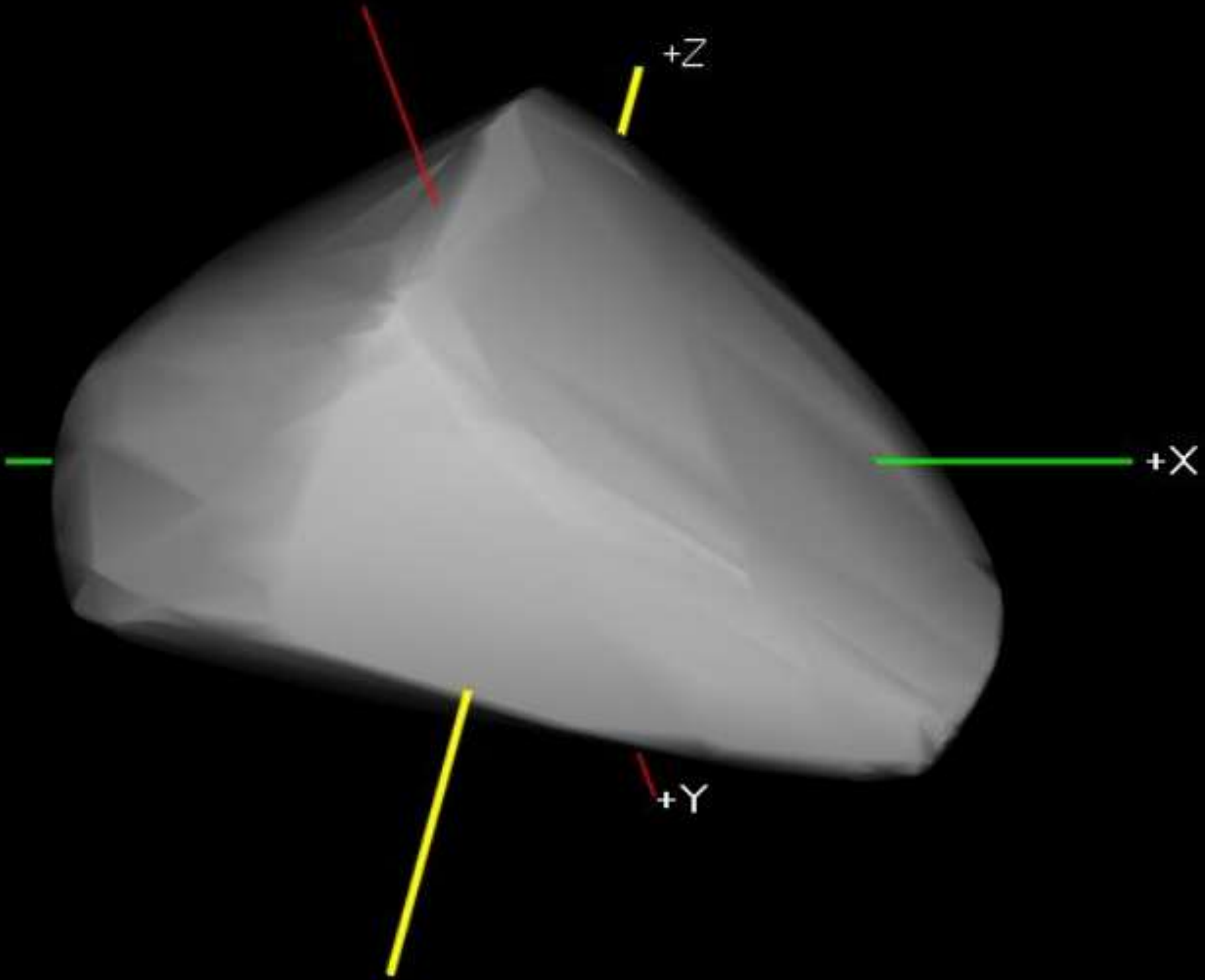
446 AETERNITAS AVERAGE CCD SPECTRUM





NEAR-IR SPECTRUM OF ASTEROID 446 AETERNITAS




+Z
+X
+Y