Asteroid shape modeling driven by archival stellar occultation data

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Supervised by
Anna Marciniak

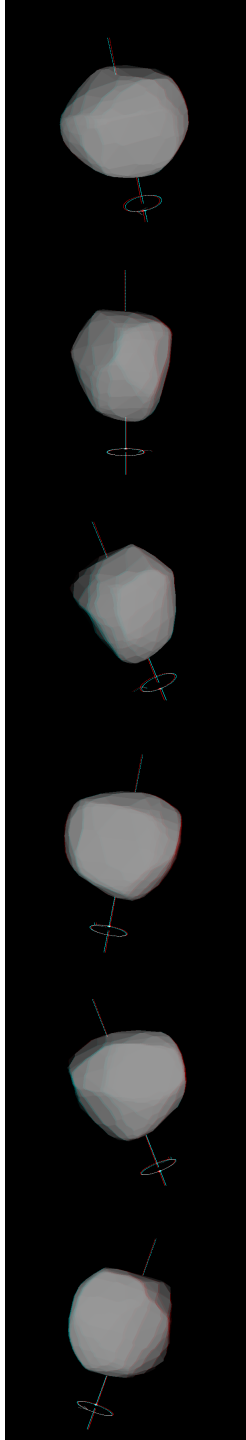
Credit: http://isam.astro.amu.edu.pl

Planned master’s thesis

Credit: https://uczelniabadawcza.amu.edu.pl

Why do we model the shapes of asteroids?

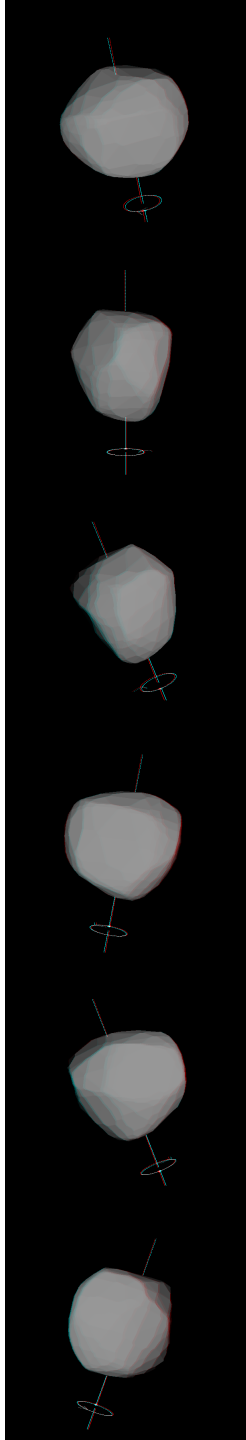
- Understanding the shape of an asteroid helps characterize its physical properties (size, density, and surface features).
- Studying asteroid shapes can provide insights into their formation, evolution, internal structure and composition.
- Spin and shape modeling can help study asteroid families.
- Better understanding of Yarkovsky effect that is also responsible for NEAs transportation and meteorite delivery to Earth.
- Planning spacecraft missions to asteroids.



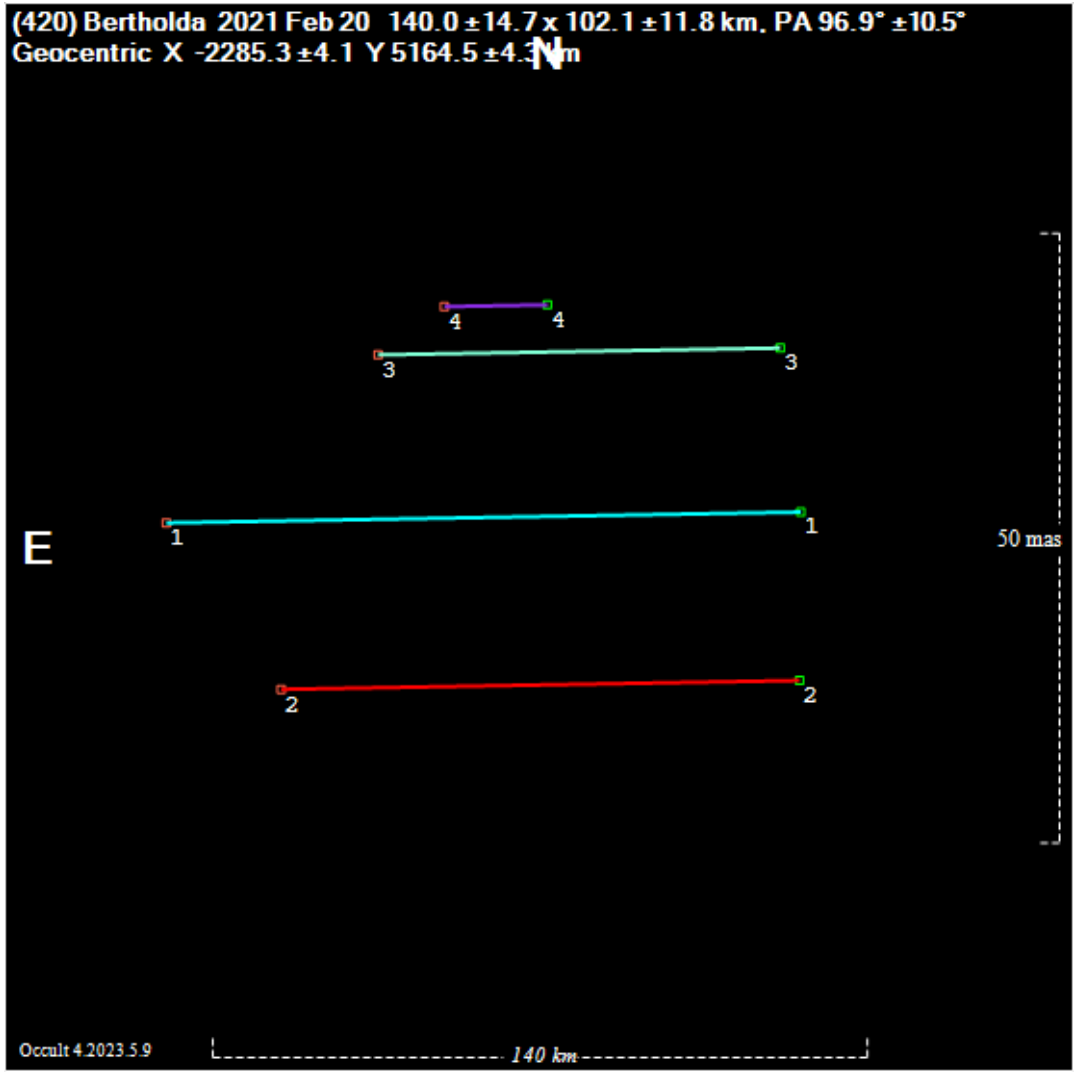
Motivation for the project

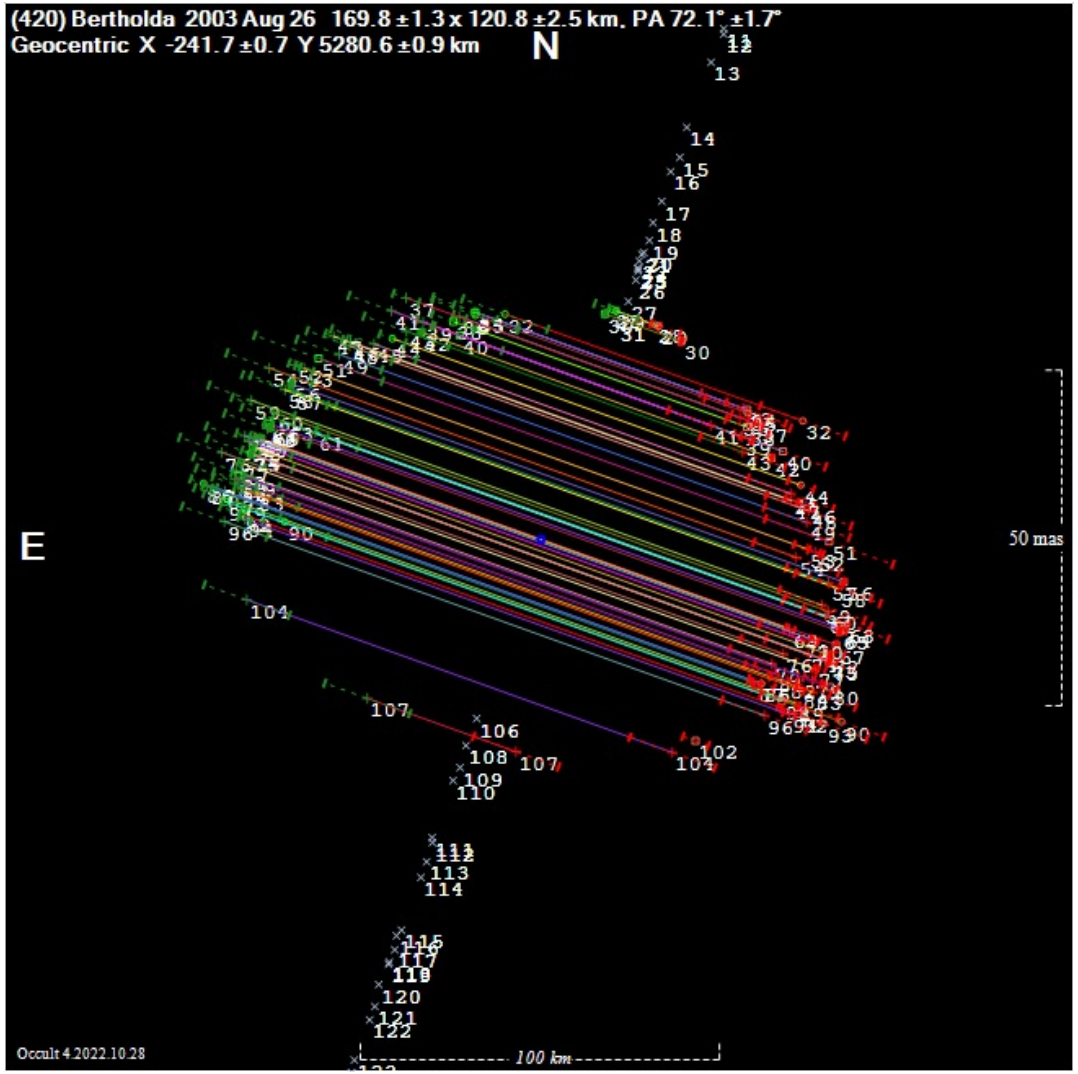
- Good occultation data for asteroids with no shape model

2021 - Euraster	2022 - Euraster
188	245
37 good multichord observations	15 good multichord observations

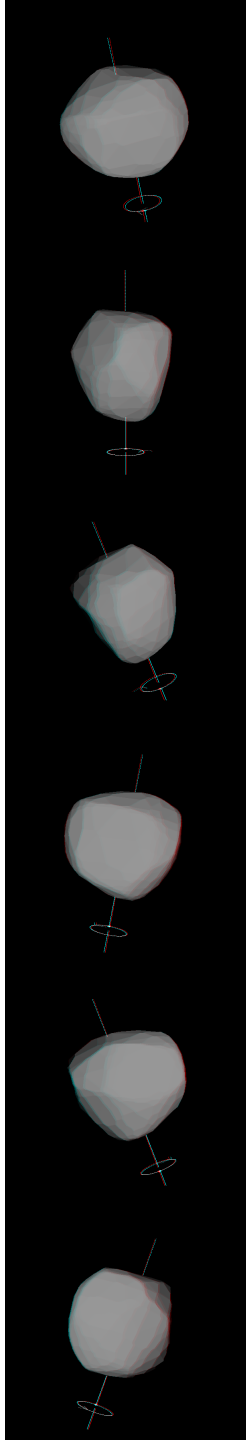


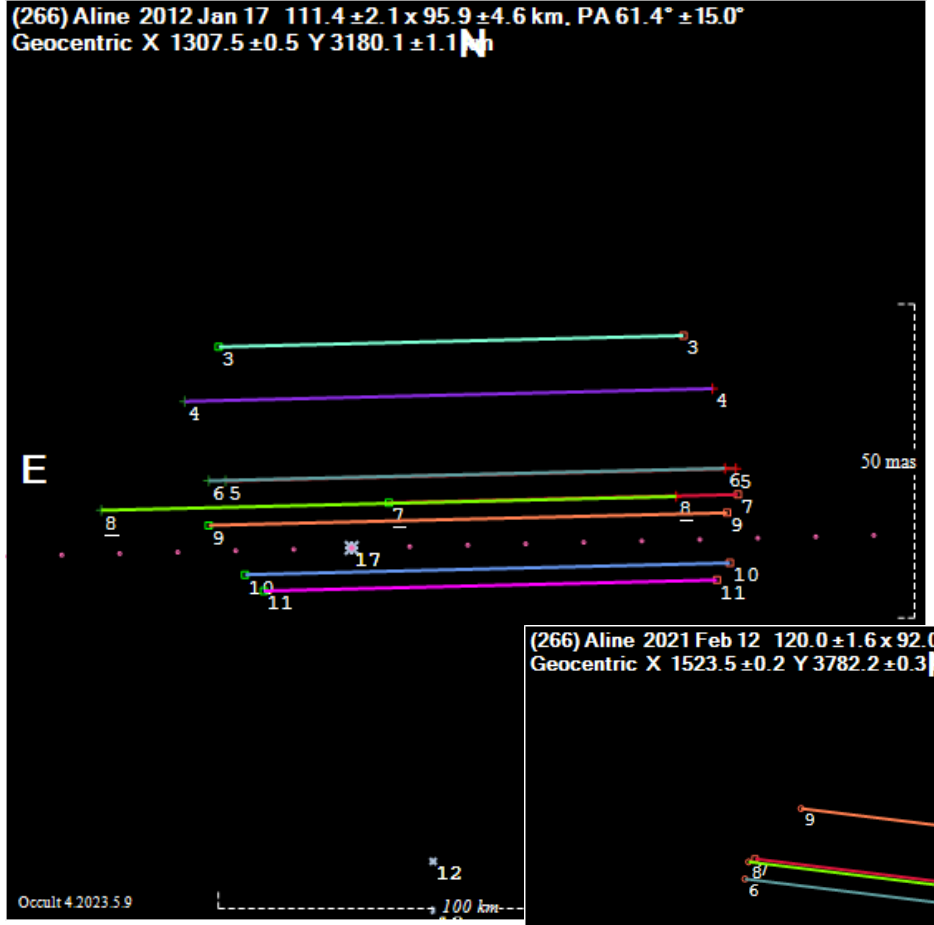
Sometimes…

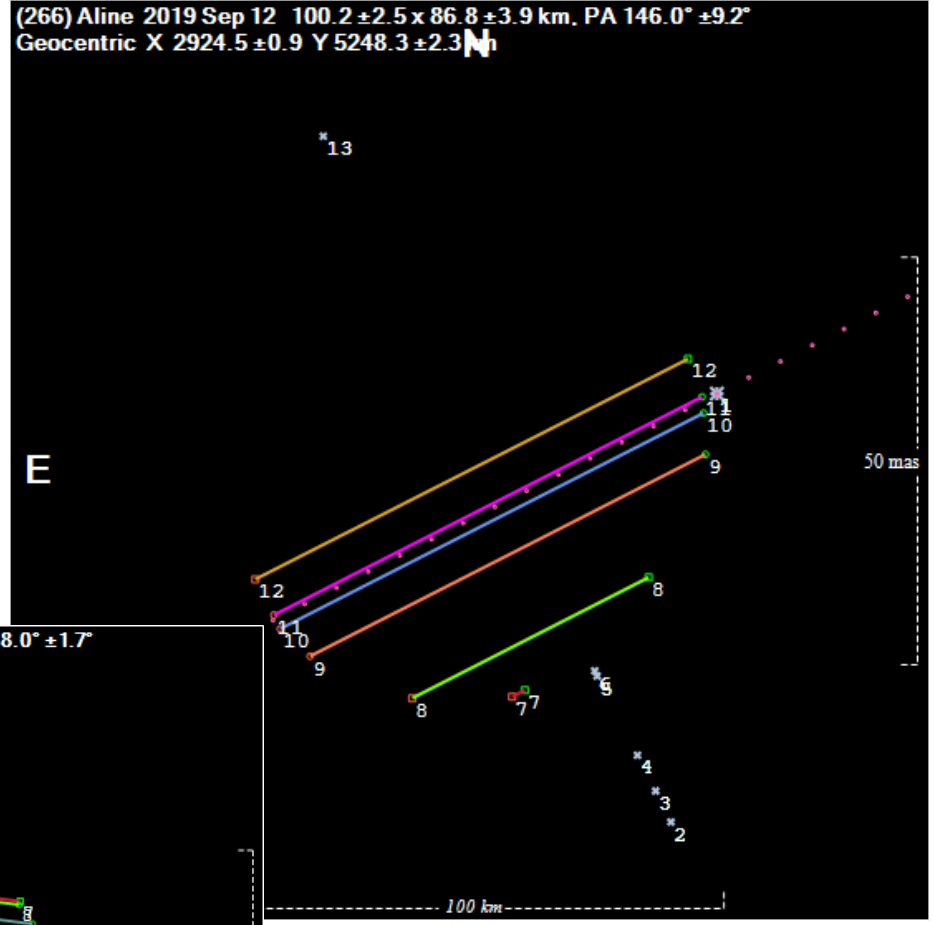


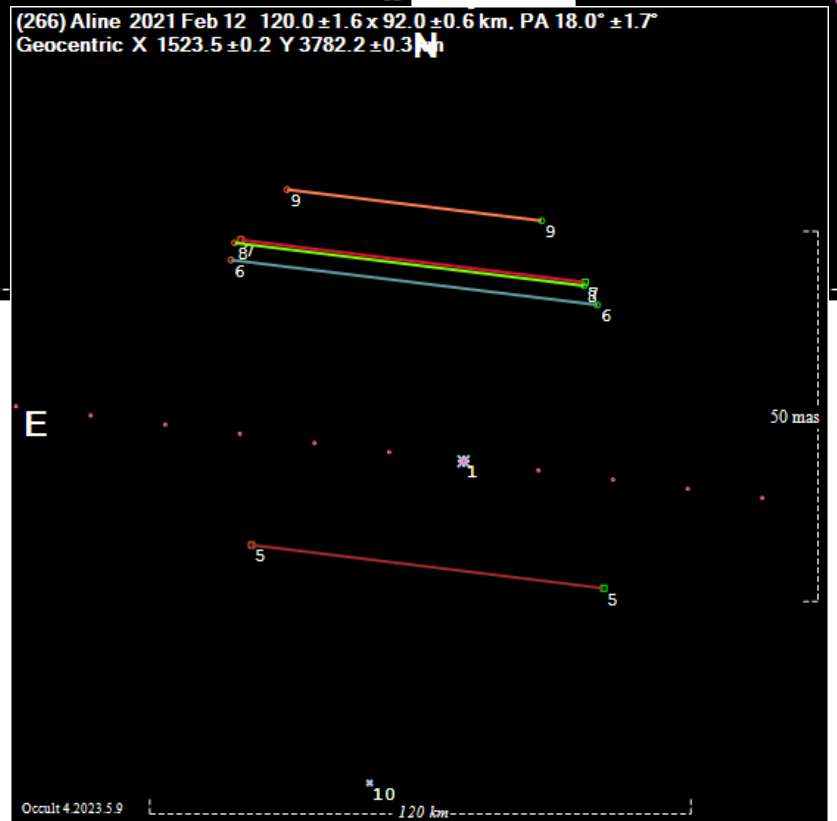


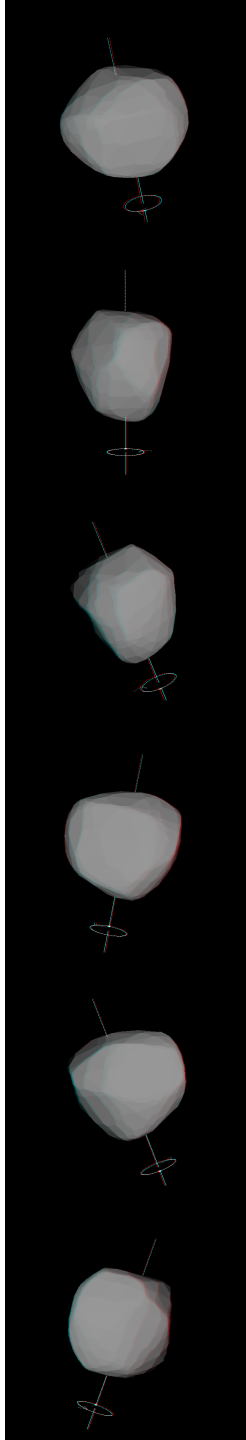
Credit: Occultation Prediction Software by David Herald











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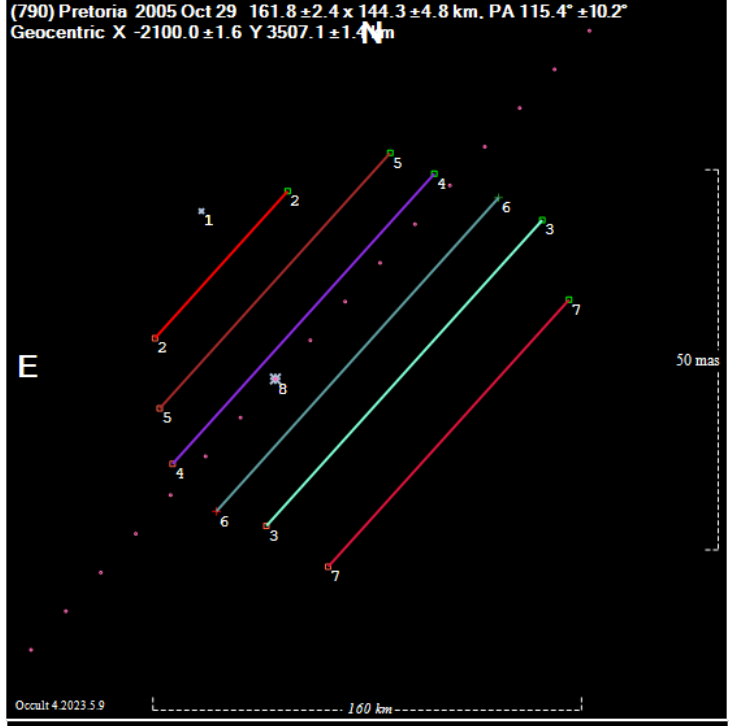
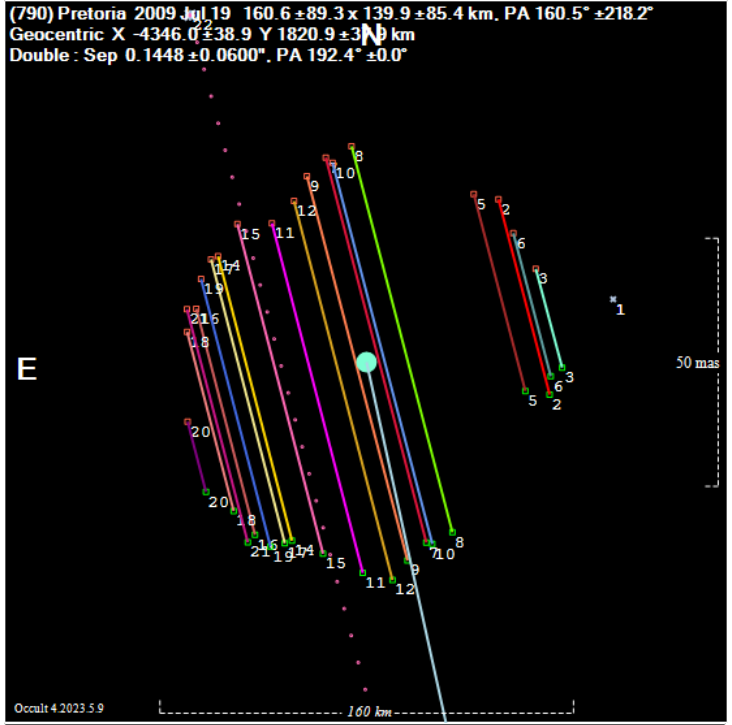
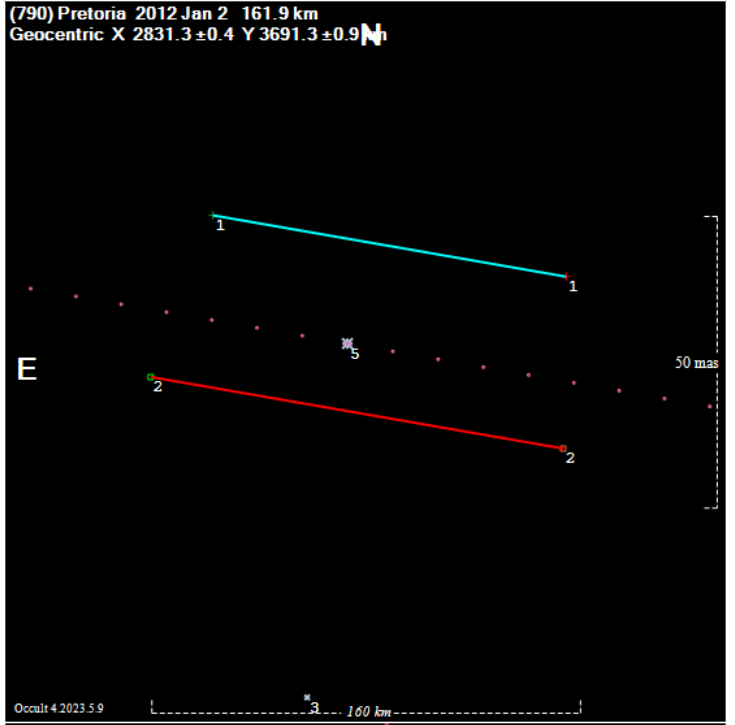
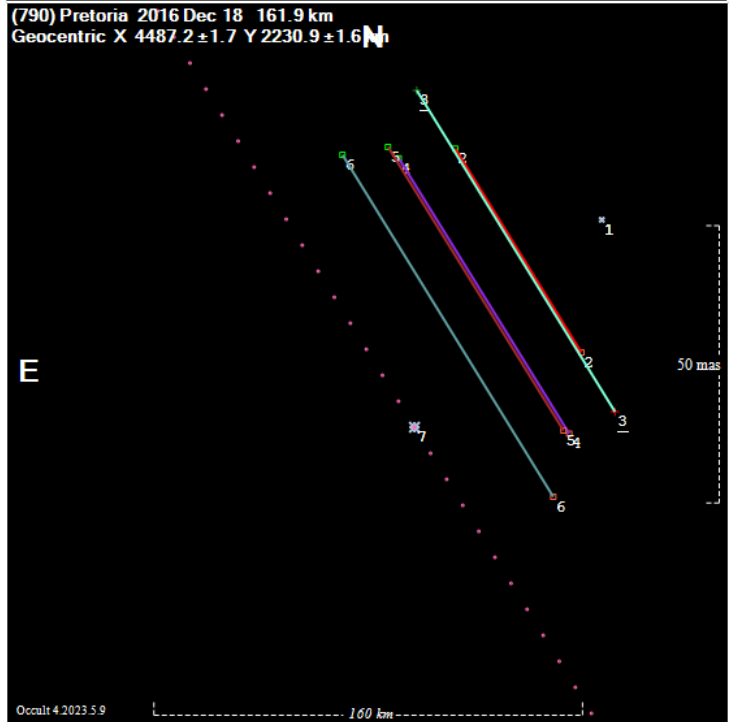
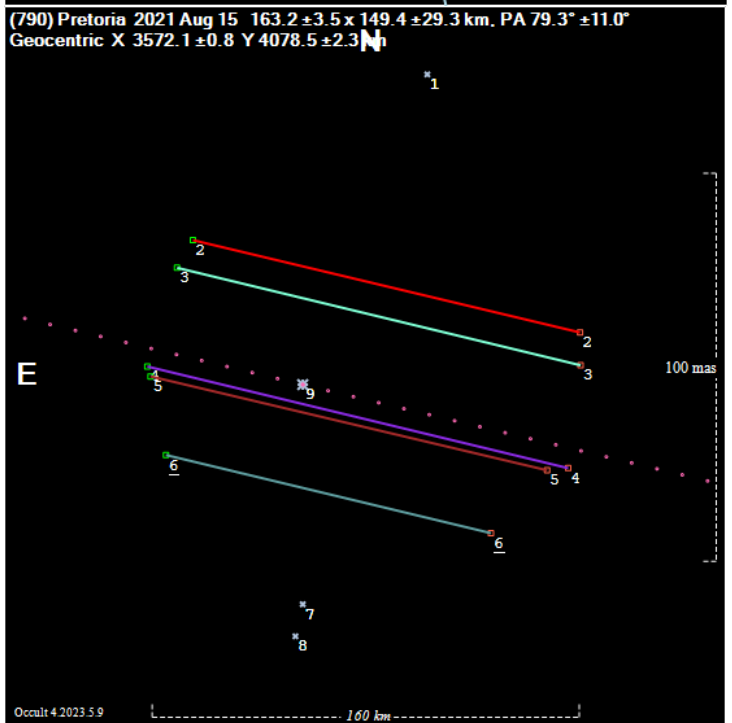
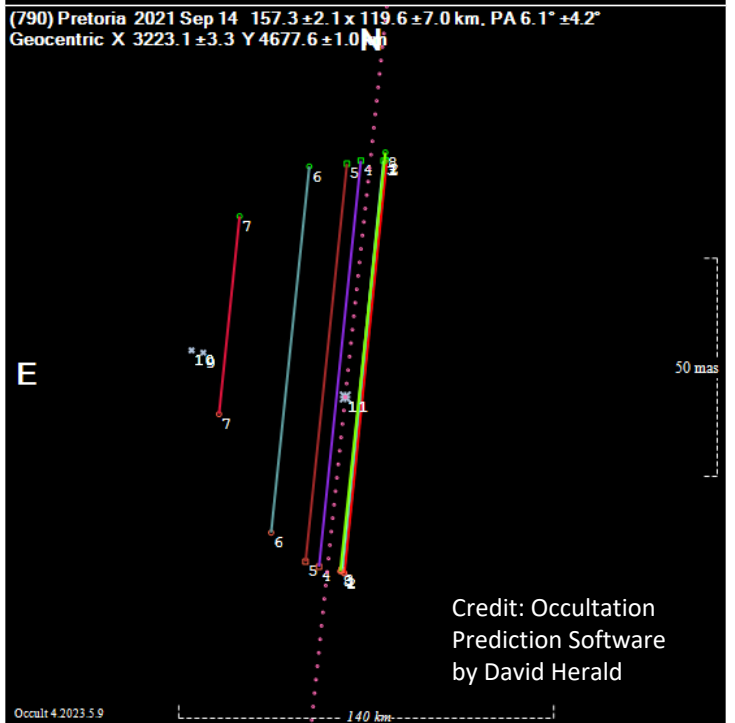

(790) Pretoria 2005 Oct 29 161.8 ±2.4 x 144.3 ±4.8 km, PA 115.4° ±10.2°
Geocentric X -2100.0 ±1.6 Y 3507.1 ±1.4 km
E
N
50 mas
Occult 4.2023.5.9
160 km

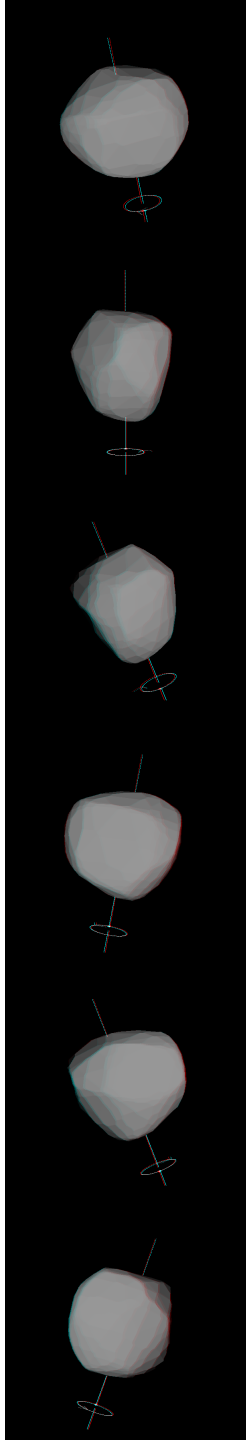

(790) Pretoria 2009 Jul 19 160.6 ±89.3 x 139.9 ±85.4 km, PA 160.5° ±218.2°
Geocentric X -4346.0 ±38.9 Y 1820.9 ±3[illegible] km
Double : Sep 0.1448 ±0.0600", PA 192.4° ±0.0°
E
N
50 mas
Occult 4.2023.5.9
160 km

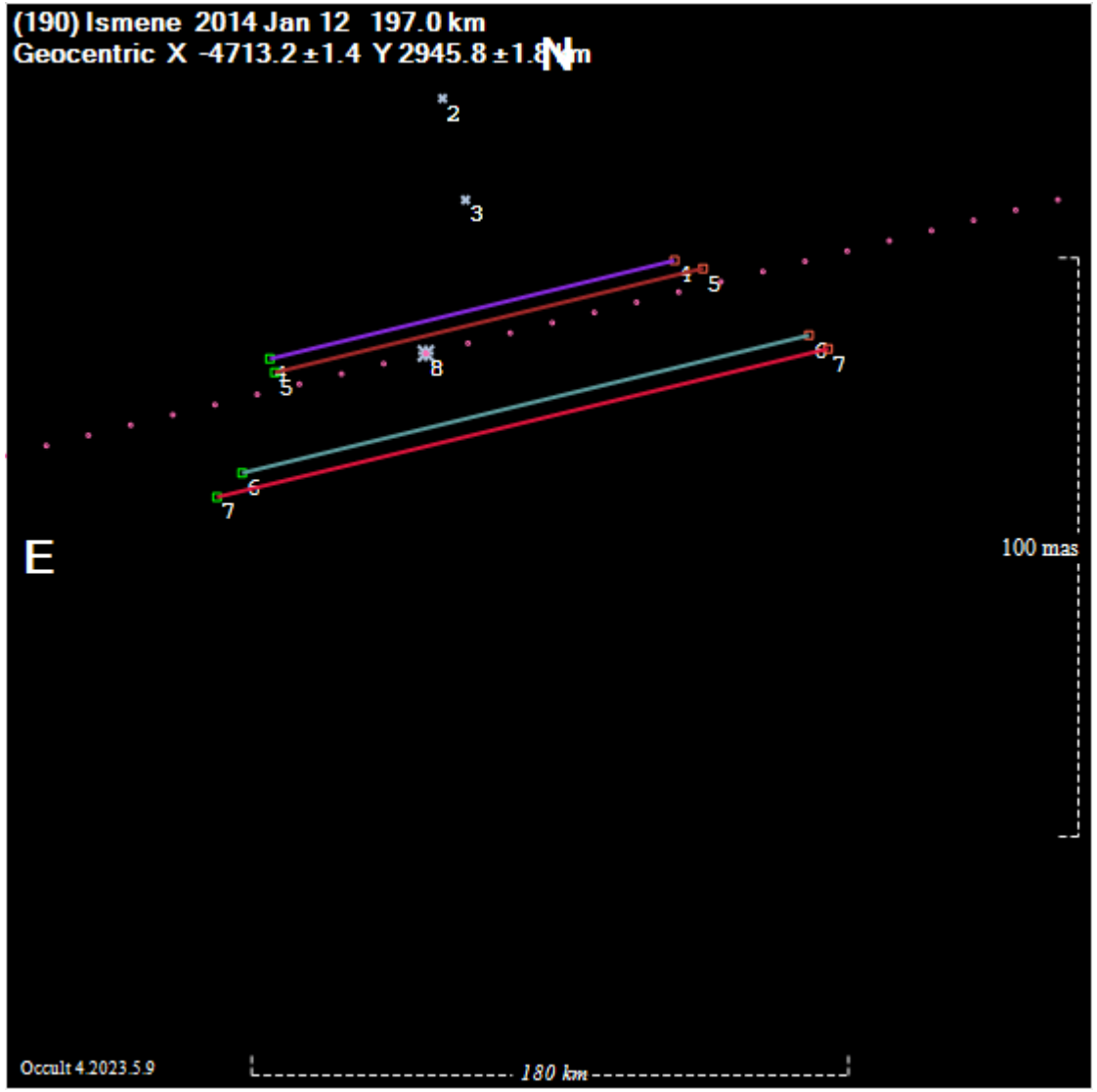

(790) Pretoria 2012 Jan 2 161.9 km
Geocentric X 2831.3 ±0.4 Y 3691.3 ±0.9 km
E
N
50 mas
Occult 4.2023.5.9
160 km

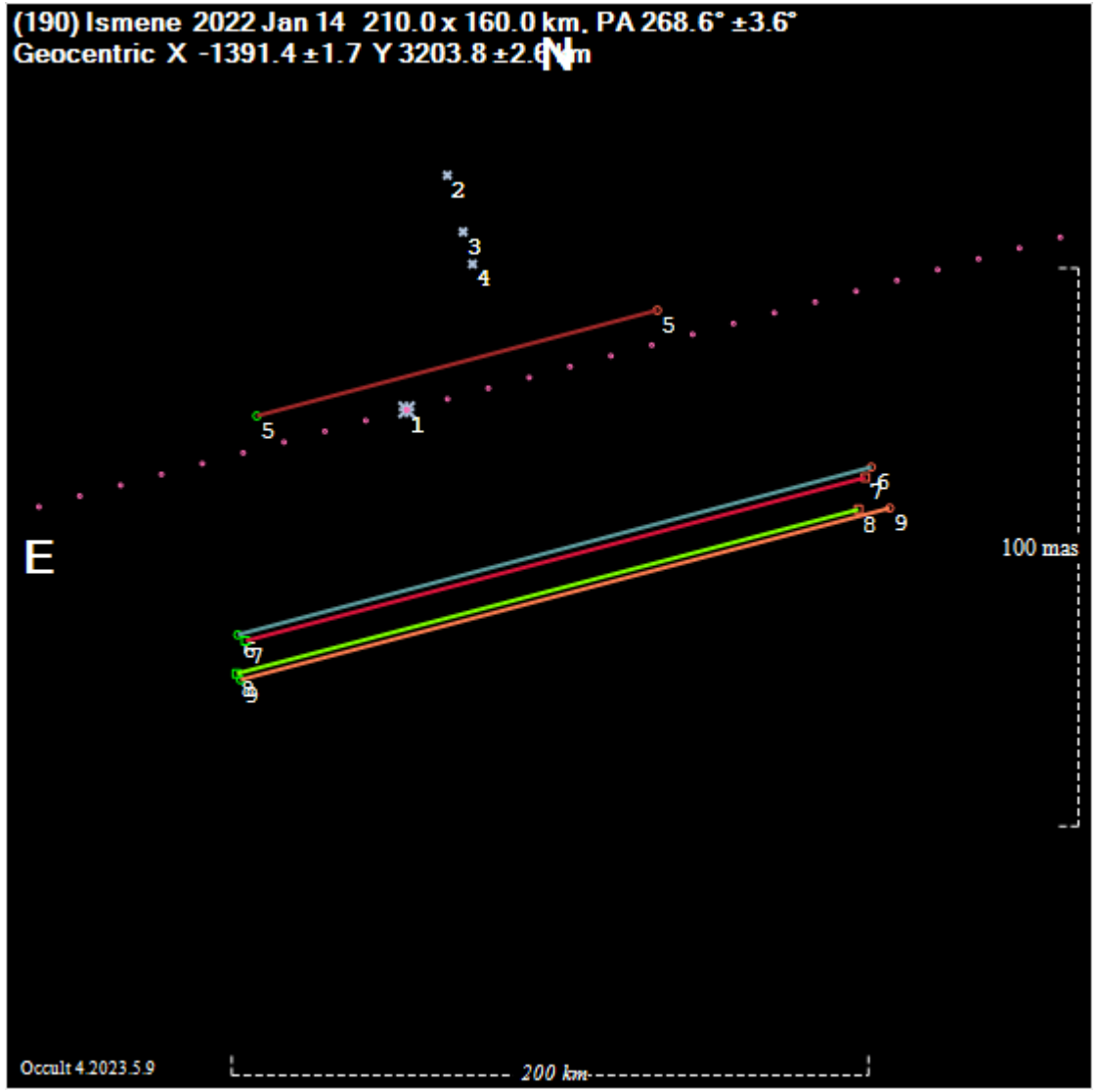

(790) Pretoria 2016 Dec 18 161.9 km
Geocentric X 4487.2 ±1.7 Y 2230.9 ±1.6 km
E
N
50 mas
Occult 4.2023.5.9
160 km

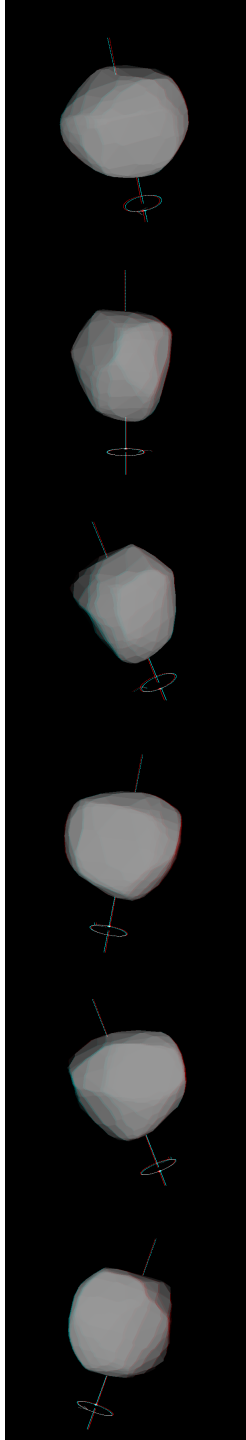

(790) Pretoria 2021 Aug 15 163.2 ±3.5 x 149.4 ±29.3 km, PA 79.3° ±11.0°
Geocentric X 3572.1 ±0.8 Y 4078.5 ±2.3 km
E
N
100 mas
Occult 4.2023.5.9
160 km


(790) Pretoria 2021 Sep 14 157.3 ±2.1 x 119.6 ±7.0 km, PA 6.1° ±4.2°
Geocentric X 3223.1 ±3.3 Y 4677.6 ±1.0 km
E
N
50 mas
Occult 4.2023.5.9
140 km
Credit: Occultation
Prediction Software
by David Herald



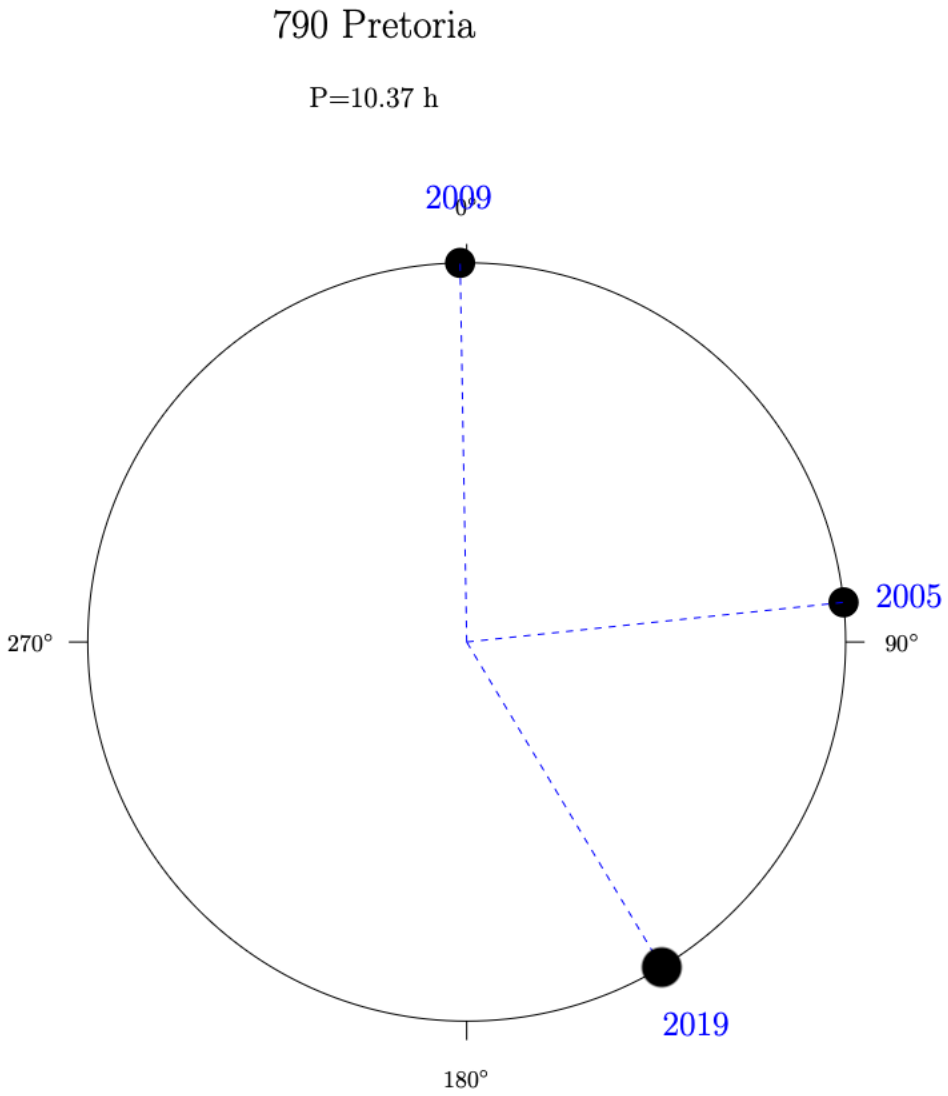


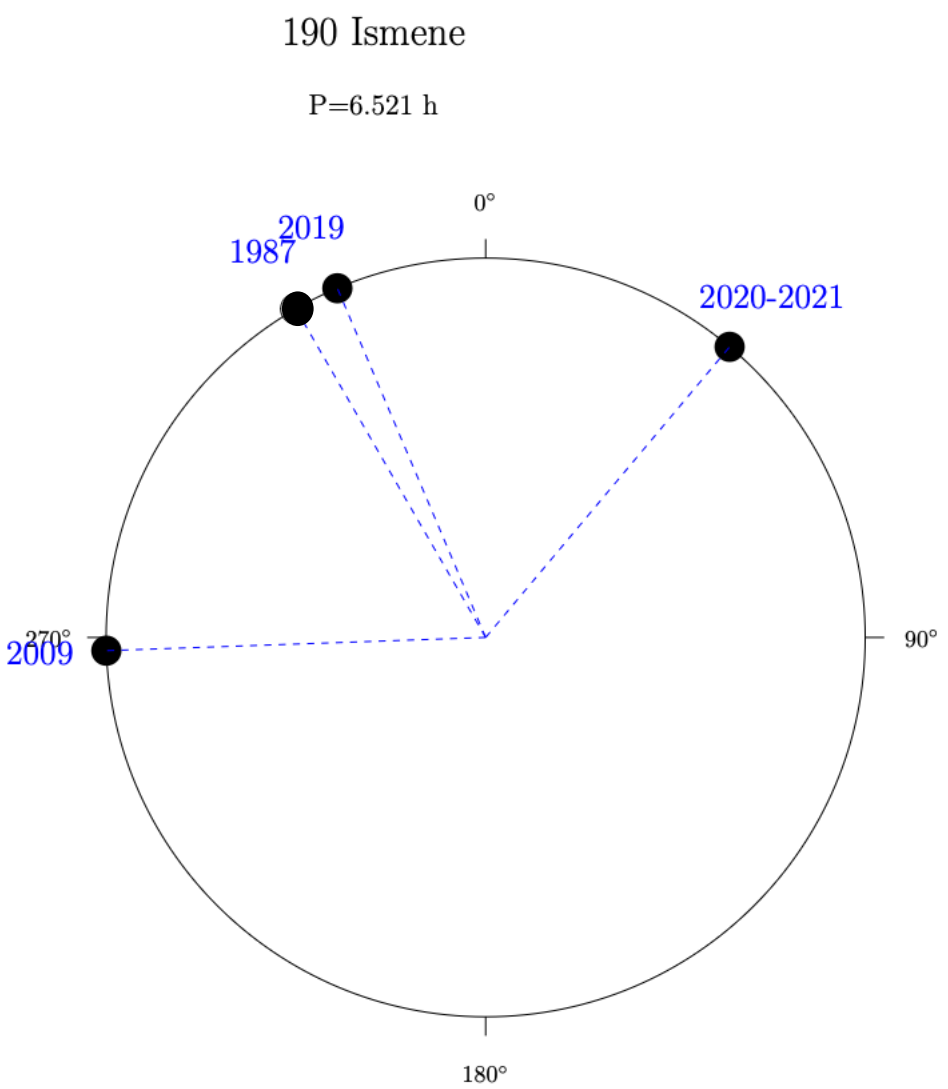


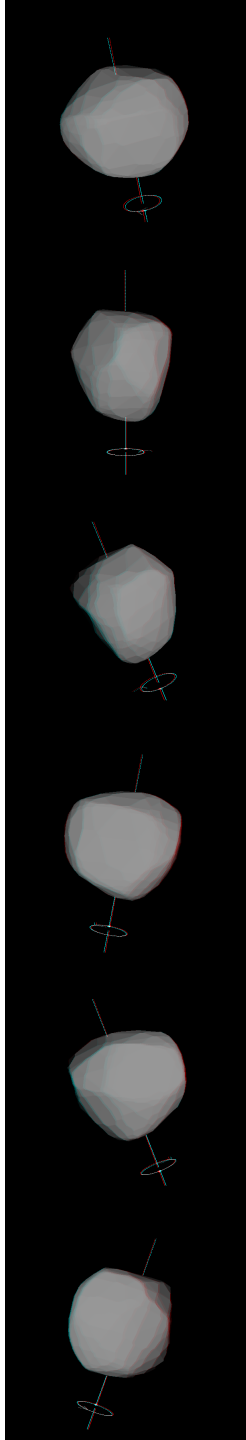


Credit: Occultation Prediction Software by David Herald

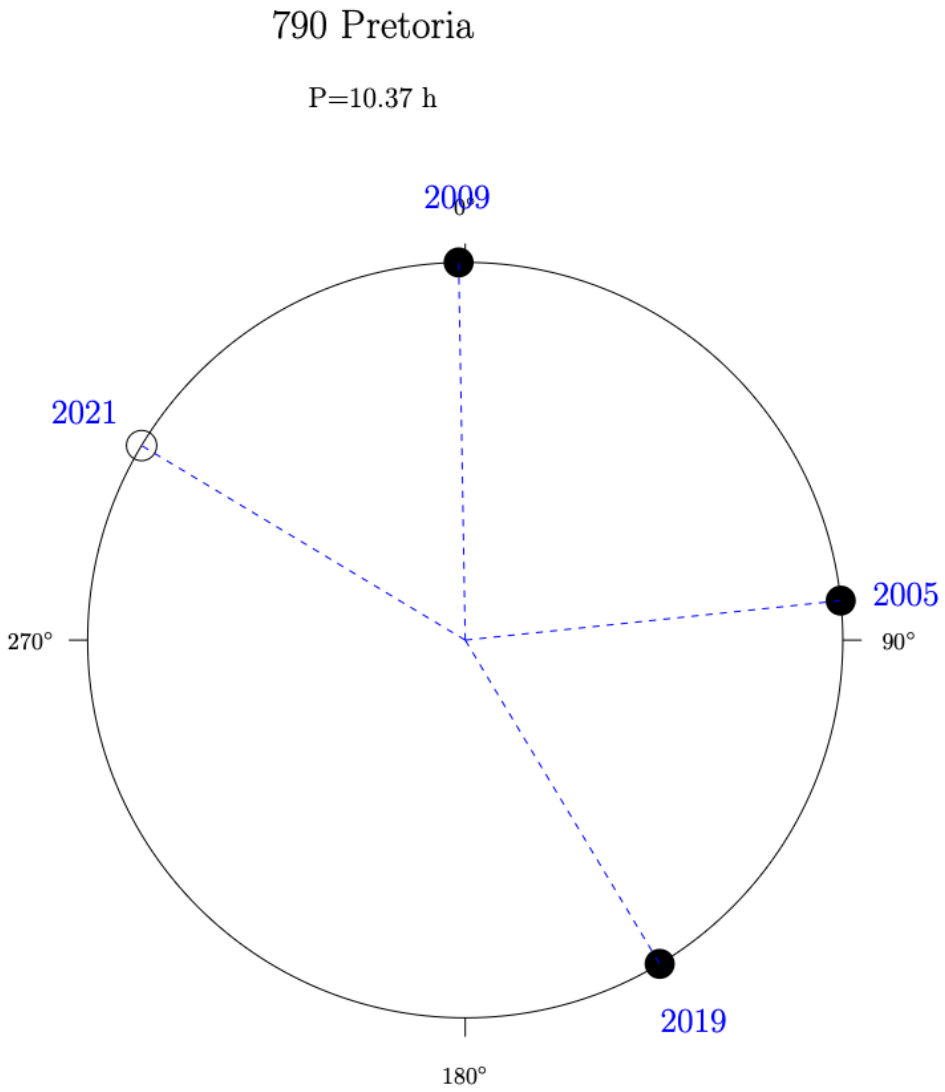
Reason for no model

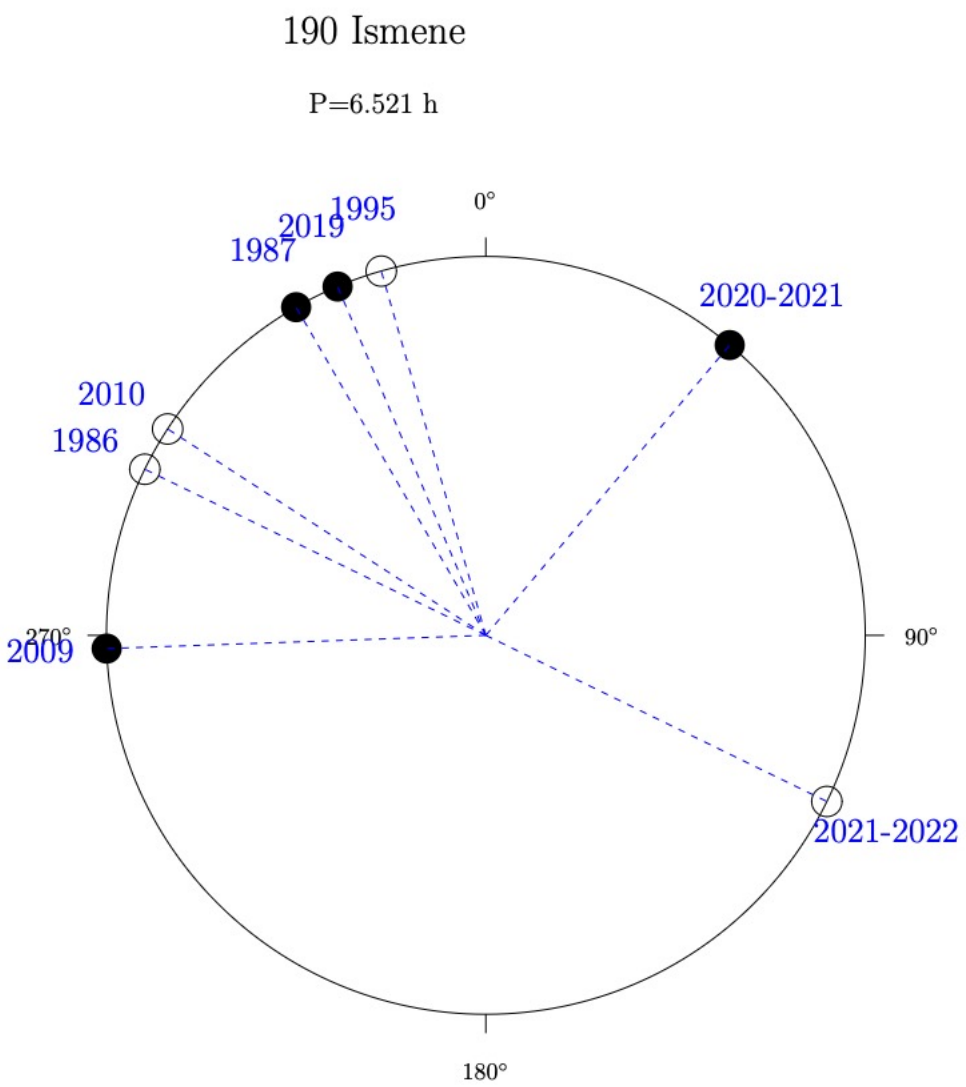


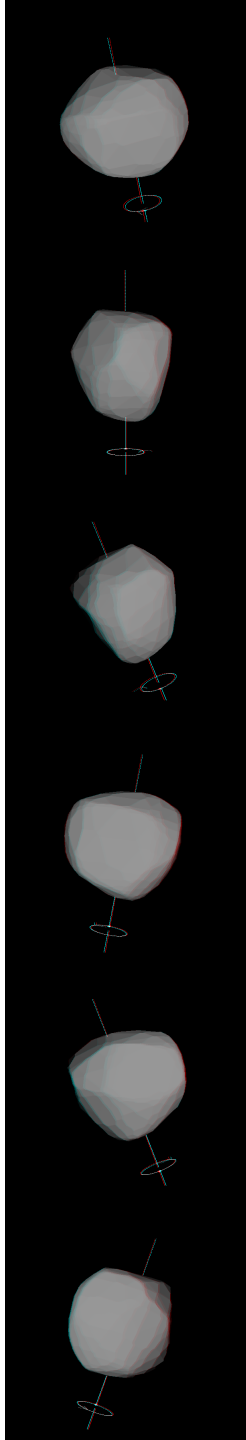




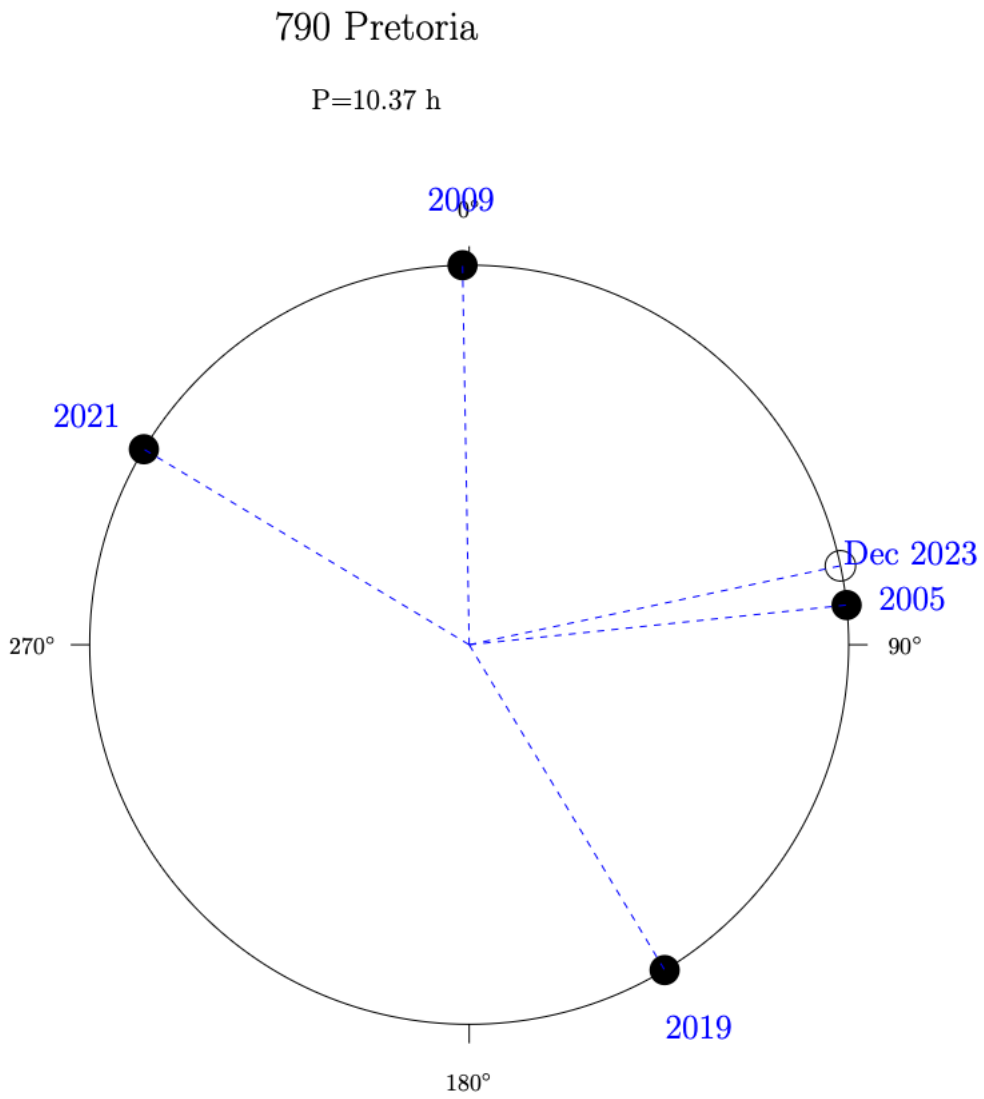
No open access data

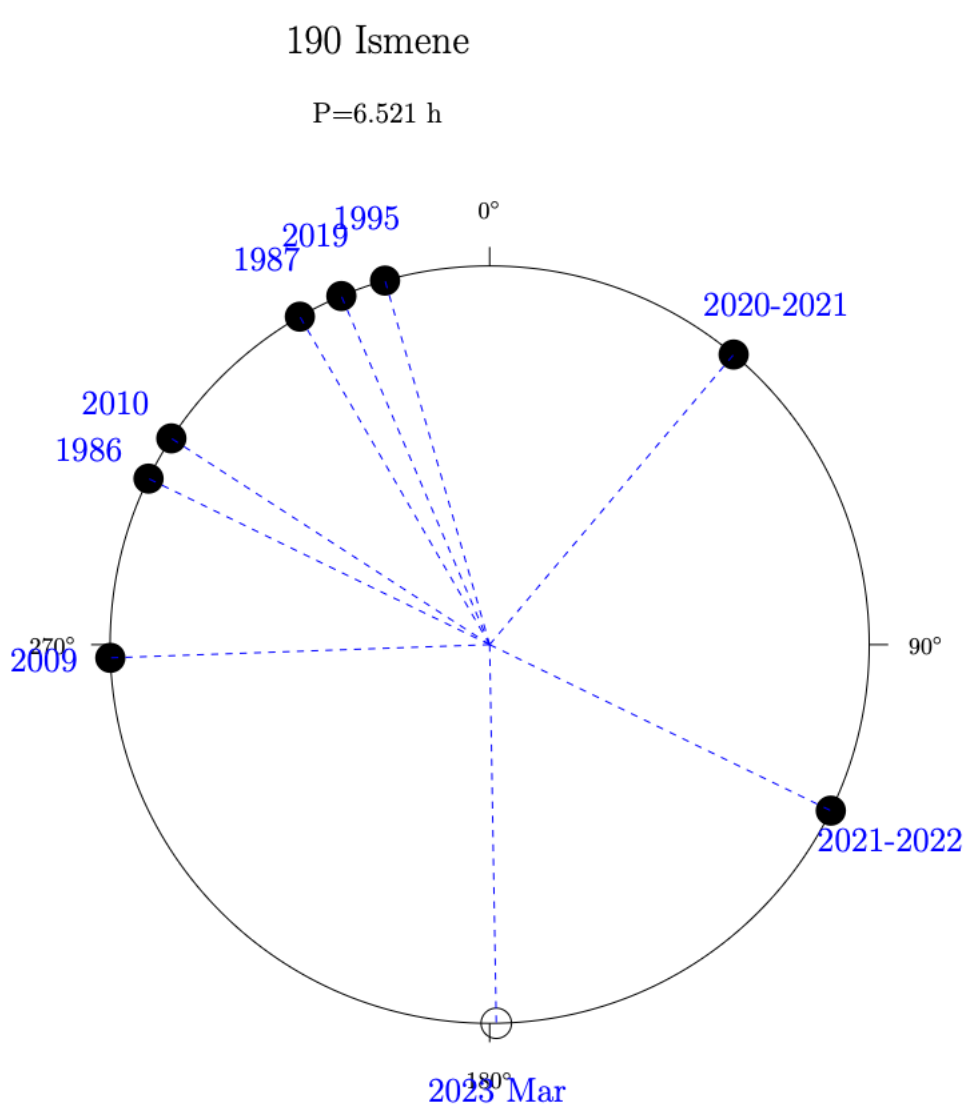


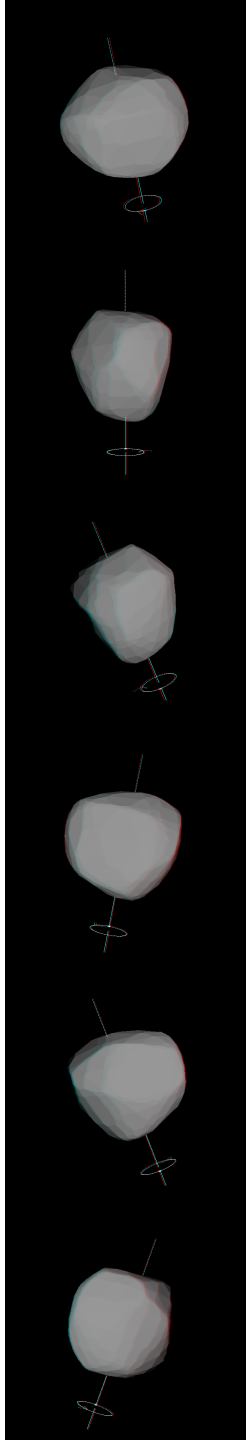




Additional apparition

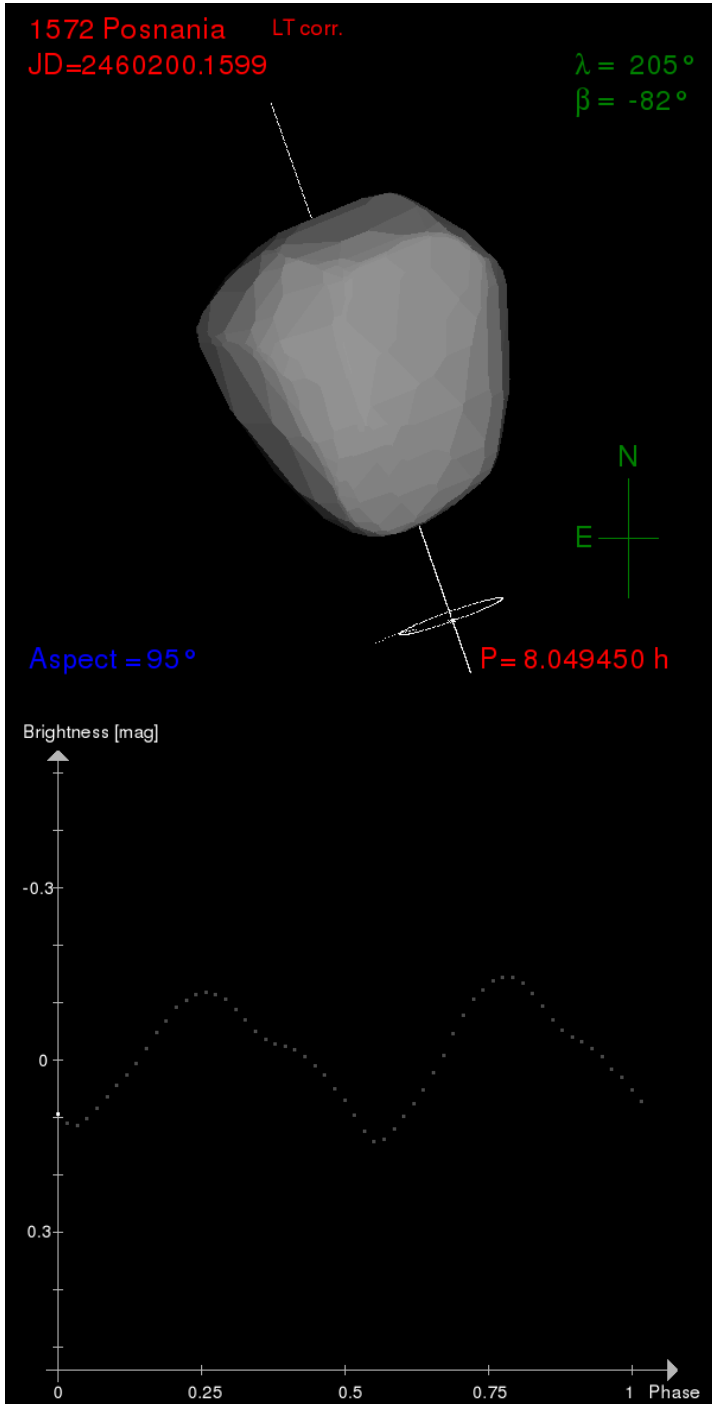


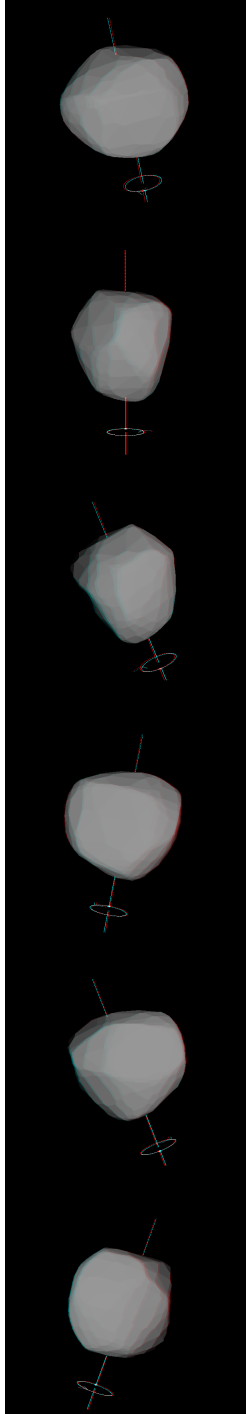




Idea for master's thesis

- Observe additional apparition
- Gather all archival photometric data
- Model the shapes of asteroids based on photometric data - convex inversion method (Kaasalainen & Torppa, 2001; Kaasalainen et al. 2001)
- Scale that models with occultation data
- Or use both photometric and occultation data in a simultaneous optimization process using the ADAM method (All Data Asteroid Modelling) (Viikinkoski et al. 2015)





Hanuš et al. (2013)

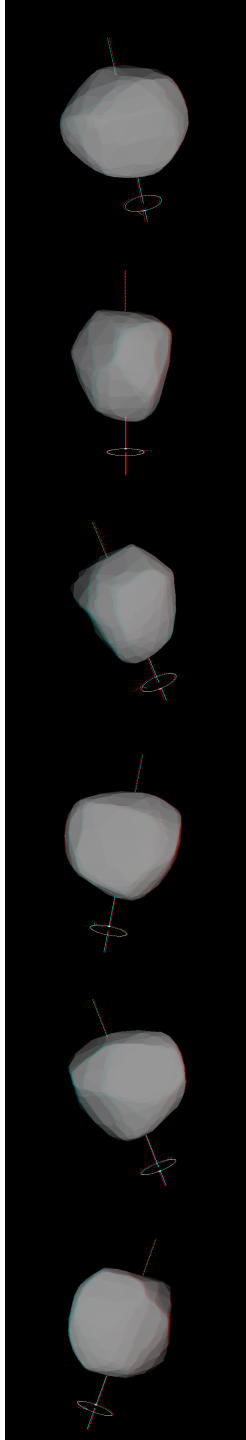
Credit: http://isam.astro.amu.edu.pl

Asteroids in our project

Selection criteria:

- Main belt asteroid
- Not extremely long rotation period
- Well-varied geometries Sun – Asteroid - Earth
- The date of additional apparition must be before the thesis defense – June 2024

2021 - Euraster	2022 - Euraster
11	5



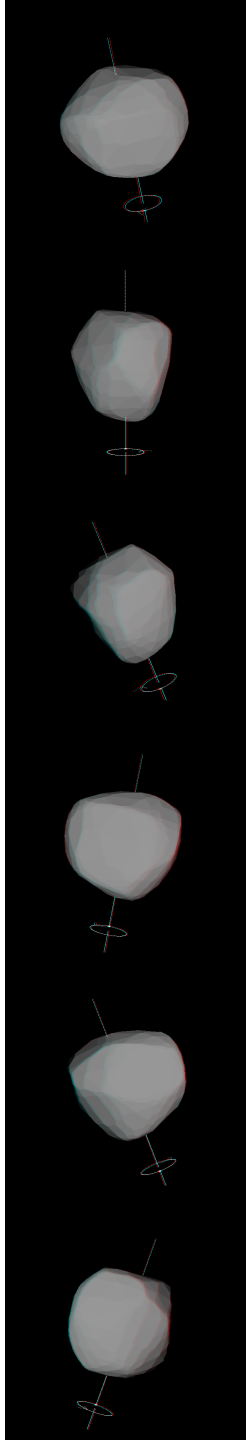
Telescopes network

TESS (Transiting Exoplanet Survey Satellite)

Credit: https://heasarc.gsfc.nasa.gov/documents/TESS-Litho.pdf

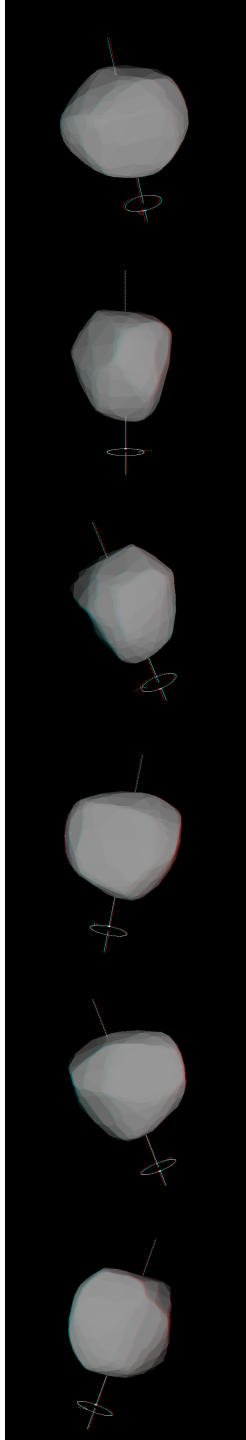
Summary

- Presented project is part of my master's thesis. Goal of this project is to select asteroids with good occultation results, model those asteroids, and scale them in size.
- Over a dozen asteroid spins and shapes are going to be modeled. For that purpose, photometric campaign has been started.
- We hope that asteroids, which we chose will not be problematic.
- Publication with results from the master’s thesis is planned.



References

- Ďurech et al. (2015), Asteroid Models from Multiple Data Sources
- Hanuš et al. (2013), Asteroids' physical models from combined dense and sparse photometry and scaling of the YORP effect by the observed obliquity distribution
- Marciniak et al. (2012), Photometry and models of selected main belt asteroids. IX. Introducing interactive service for asteroid models (ISAM)
- Viikinkoski et al. (2015), ADAM: a general method for using various data types in asteroid reconstruction
- Kaasalainen & Torppa (2001), Optimization Methods for Asteroid Lightcurve Inversion: I. Shape Determination
- Kaasalainen et al. (2001), Optimization Methods for Asteroid Lightcurve Inversion: II. The Complete Inverse Problem
- Occultation Prediction Software by David Herald (Occult)




Thank you