

# Measuring the Menace: Advances in Determining the Size of Hazardous Near-Earth Objects

Planetary Defense Conference 2025

07 May 2025

Stellenbosch, South Africa

## Maxime Devogele<sup>1</sup>

Juan Luis Cano<sup>2</sup>, Richard Moissl<sup>1</sup>, Luca Conversi<sup>1</sup>, Marco Fenucci<sup>1</sup>, Dora Föhring<sup>1</sup>, Marco Micheli<sup>1</sup>, Rainer Kresken<sup>2</sup>, Francisco ocaña<sup>3</sup>, Ernesto Doeling<sup>2</sup>

<sup>1</sup> ESA ESRRIN / PDO / NEO Coordination Centre, Via Galileo Galilei, 1, 00044 Frascati (RM)

<sup>2</sup> ESA ESOC / PDO, Robert-Bosch-Straße 5, 64293 Darmstadt, Germany

<sup>3</sup> ESA ESAC / PDO, Cno. Bajo del Castillo, 28692 Vca. del Castillo, Madrid, Spain

## Task entrusted by EU to ESA within the Space Programme (2021)

Promotion of networking of Member State facilities and research centres:

*Within this task a mechanism will be developed for promoting networking activities among MS facilities and research centres in the field of NEO related activities. This task can be realized at varying budget levels. The main mechanism is the organization of a yearly conference on NEOs. One conference per year will be organized until Q4/2027.*

Previous workshops:

Dec 12-14 2022: EU-ESA Workshop on NEO Imminent Impactors Warning Coordination

Nov 21-22 2023: EU-ESA Workshop for the Increase of Emergency Response Agencies Awareness on the NEO Threat

- The workshop was held on 11-13 November 2024 at ESA ESOC center in Darmstadt, Germany
- There was 101 registrations with 40 in person attendees
- All the presentations and recording are available on the workshop website:

<https://indico.esa.int/event/530/>



- Invite the scientific community working on planetary science topics related to size determination of asteroids to a **state-of-the-art discussion**
- Discuss with observers and modelers to improve the strategies for **reporting photometric observations** of NEOs
- **Foster new collaborations** between different fields of asteroid physical characterization
- Generate a **list of actions and recommendations** to improve the size determination of potentially impacting asteroids and NEOs in general



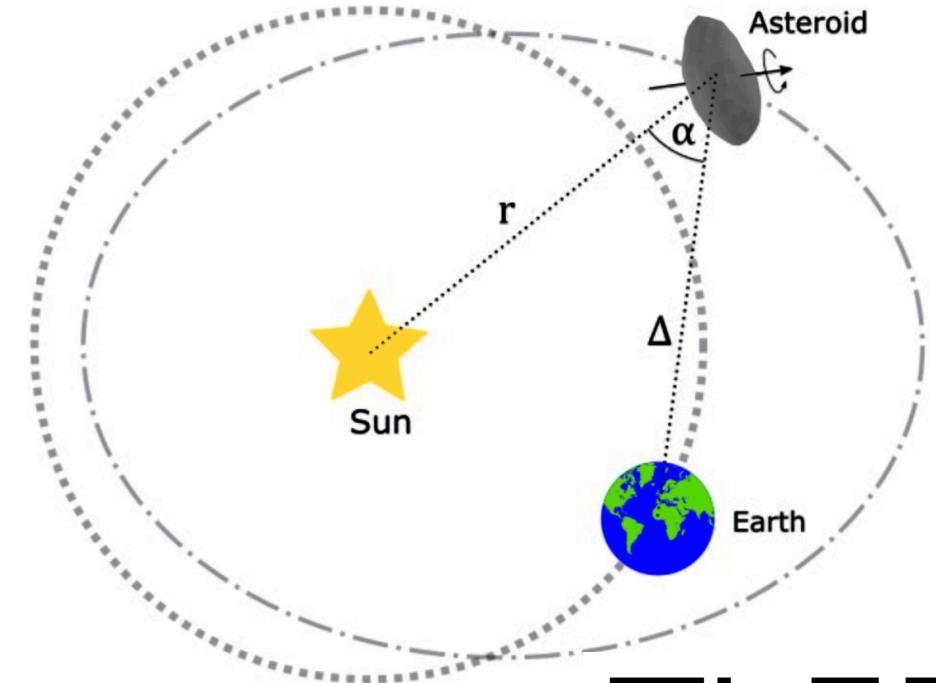
# How is the size of NEO determined?

- Relationship between the absolute magnitude  $H$ , their diameter, and albedo

$$D = \frac{1329}{\sqrt{p_V}} 10^{-0.2H}$$

$p_V$  is the geometric albedo i.e. how bright the object is

$H$  is the absolute magnitude of the asteroid (i.e. the magnitude that would be observed if the asteroid was observed at  $0^\circ$  of phase angle and at 1 au from the Sun and the Earth)



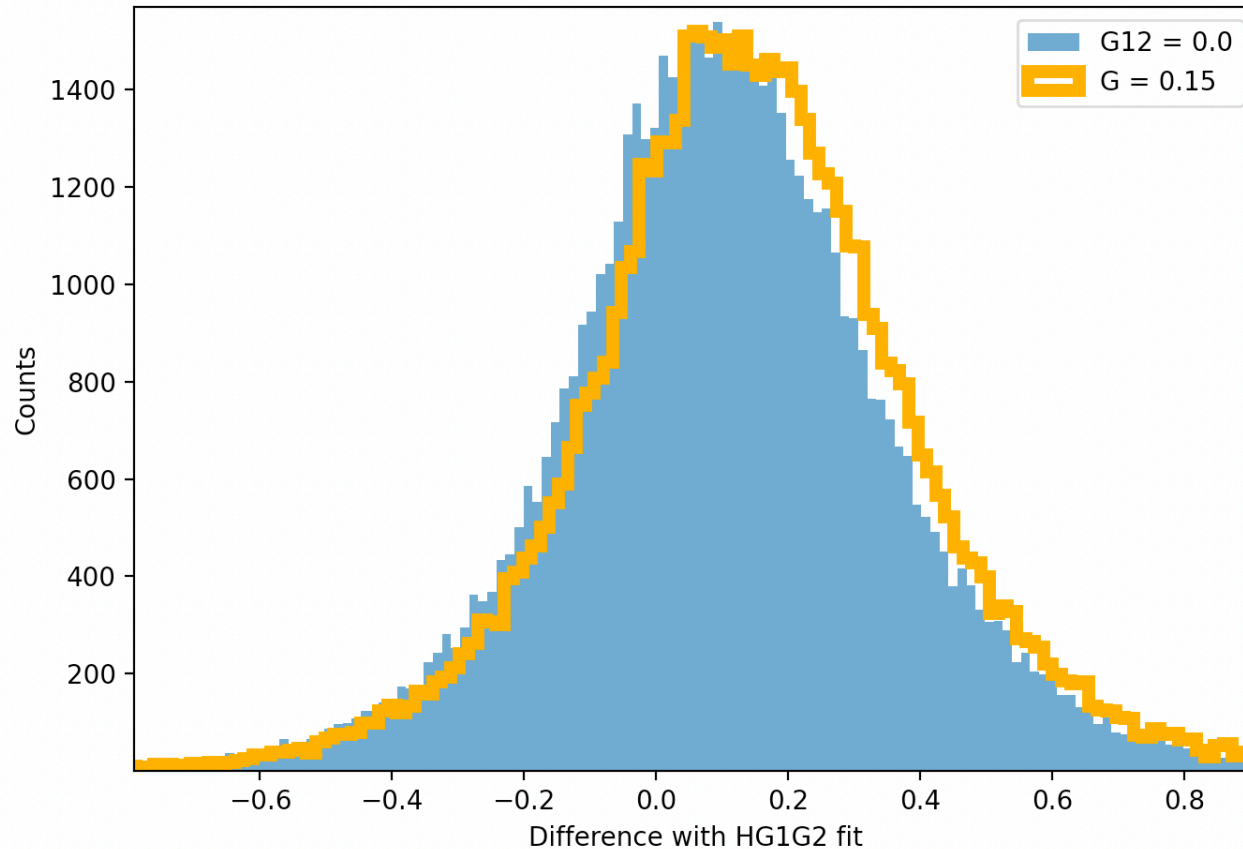
Source: The Open University (Revealing the surface of an asteroid using robotic telescopes)



# Phase curve of asteroids

Questions: Should we switch to HG12\* with a fixed G12\* and replace the HG with G=0.15?

Rationale: The HG1G2 is the best phase curve model and the G12\* is based on it



Preliminary tests show marginal improvements when using HG12\* with a fixed G12\* parameter compared with the HG function with G=0.15

Reduces the bias from  $\sim 0.14$  to  $\sim 0.10$

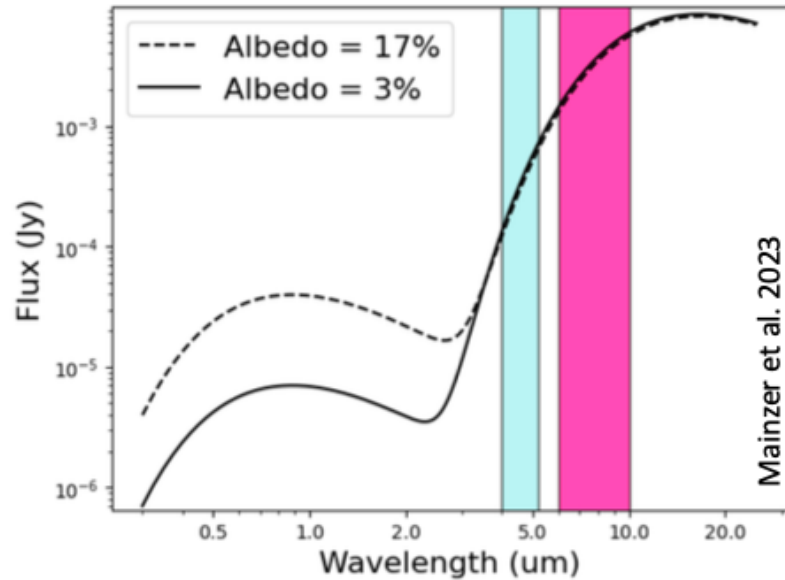


- There is a need for a central database of photometric observations (a la MPC for astrometric observations)
- A proposal was submitted to the IAU to set up a Working Group to explore the needs for an IAU-approved global archive for small body photometric data to complement the astrometric archive kept at the MPC; the proposal was approved by Division F and will report their findings before the next IAU General Assembly.



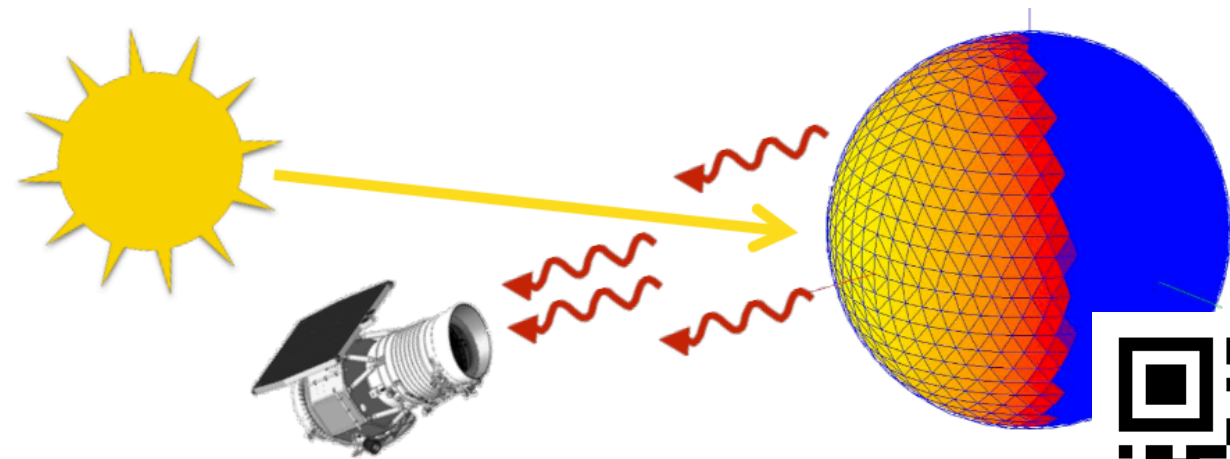
# How is the size of NEO determined?

- Thermal infrared observations of NEOs



Thermal emission is mostly independent on the albedo of the object. Thus, the observed flux is dependent on the size of the object.

About 90% of the incoming solar radiation is emitted in the IR



Credits: M. Delbo presentation

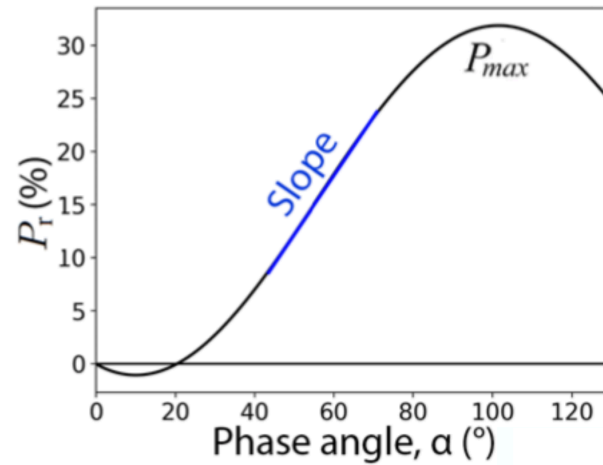
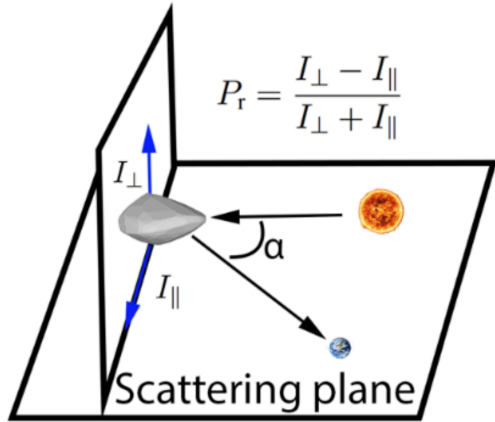


Request from the community: Ephemerides services should provide the phase angle with its sign (i.e. is the asteroid trailing or leading the Sun ?)

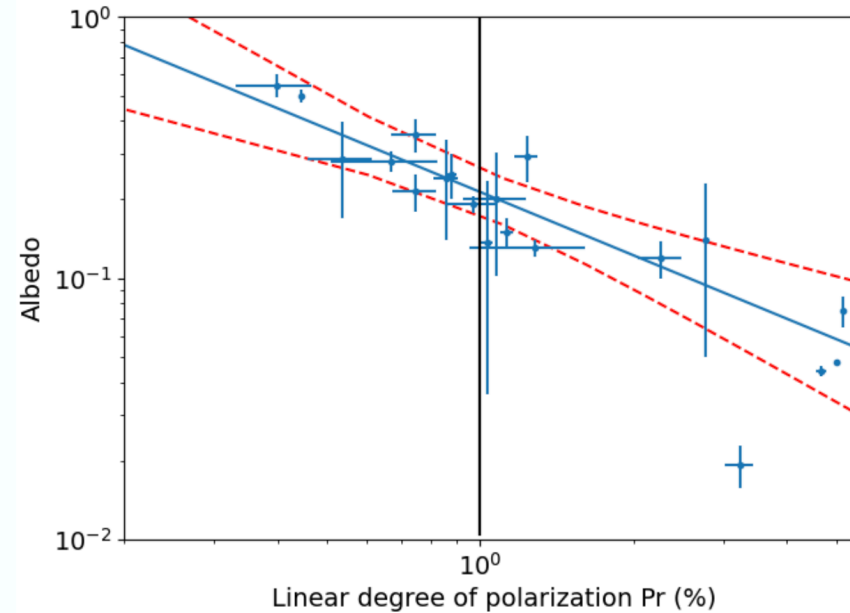
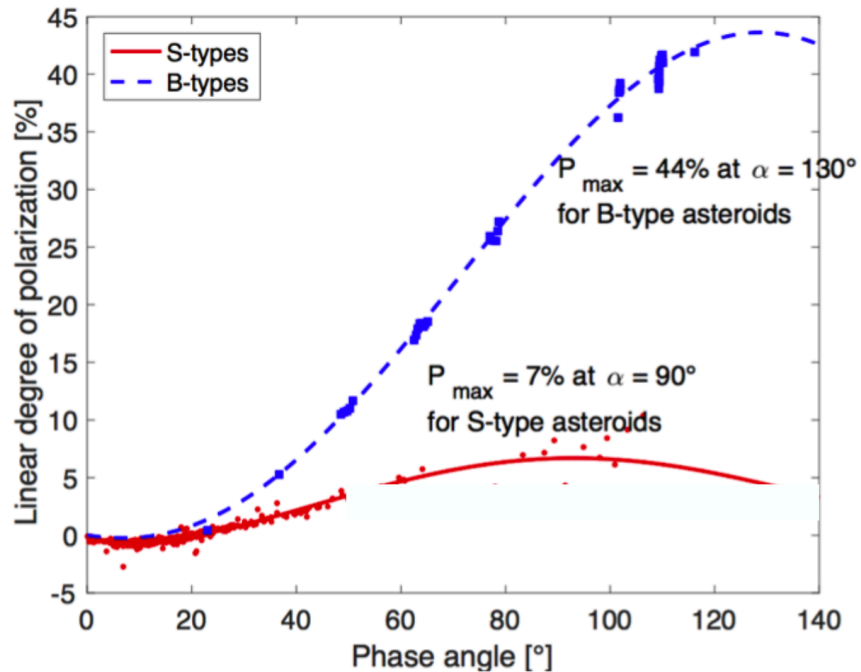
The ESA NEOCC is considering adding the sign as an option in its ephemerides service.



# Polarimetric observations



- The observed degree of linear polarization is inversely proportional to the albedo of the scattering surface

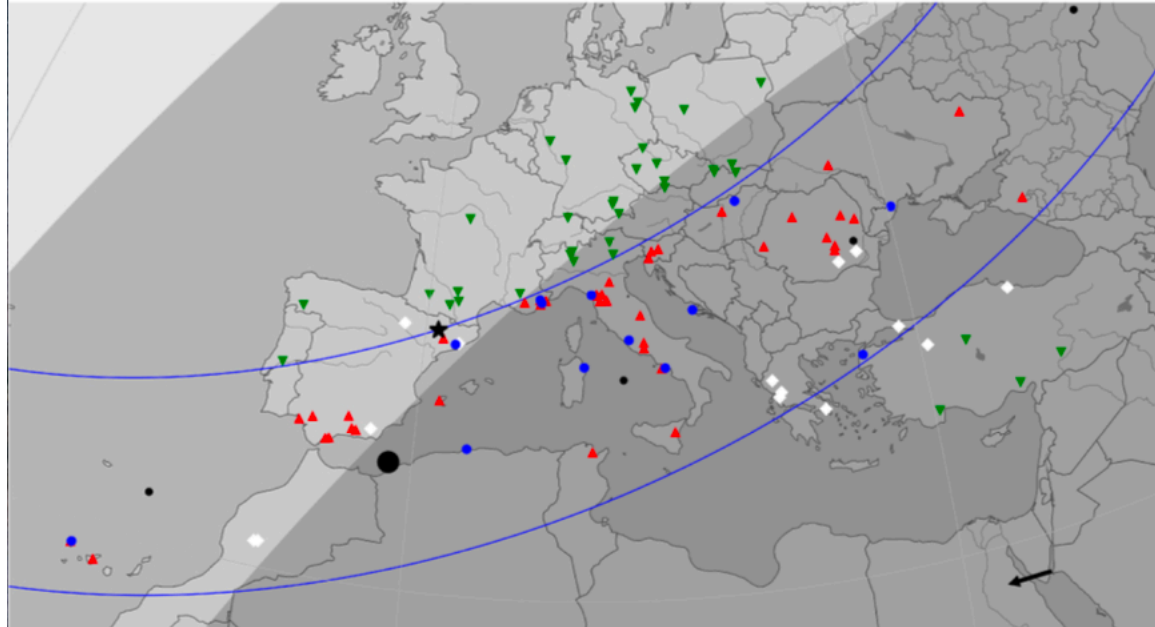


Request from the community: The calibration between polarimetry and albedo should be published and polarimetric observations should be used more often for albedo determination.

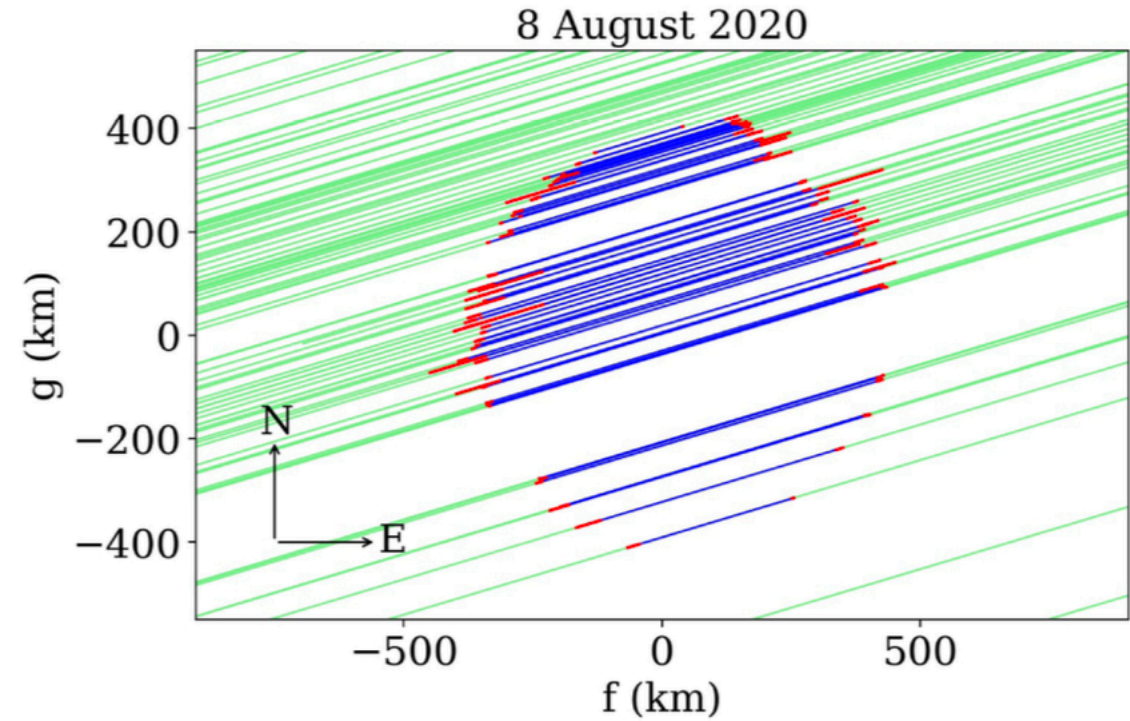
We are working on a paper to present our calibration of the linear degree of polarization as a function of albedo for all phase angles between 30 to 100°.



# Stellar occultations



Source: Rommel et al. 2023, A&A



# Results of the workshop



- The community should switch to more recent phase curve models as the old HG system is displaying H magnitude biases
- It would be extremely beneficial if asteroid surveys could target specific NEOs when they reach their minimum of phase angle
- Ephemerides service providers should display the sign of the phase angle as it is extremely important for thermal modeling
- There is a need for a central database of photometric observations (a la MPC for astrometric observations)
- A database of thermal infrared fluxes aggregating all space missions and ground-based telescopes observations would be extremely useful
- The calibration between polarimetry and albedo should be published and polarimetric observations should be used more often for albedo determination



- The European Commission tasked ESA to organize a yearly workshop to discuss and foster collaboration in the planetary defense community
- The 2024, was organized in 11-13 November in Darmstadt, Germany with for theme the improvement of the size determination of NEOs
- With 101 registered participant and 40 in person, the workshop was a great success
- The final results are still under review and a white paper is in preparation with a list of actions and recommendations for the planetary defense community

