OPTICAL POLARIMETRY AND RADAR AS A TOOL FOR PLANETARY DEFENSE

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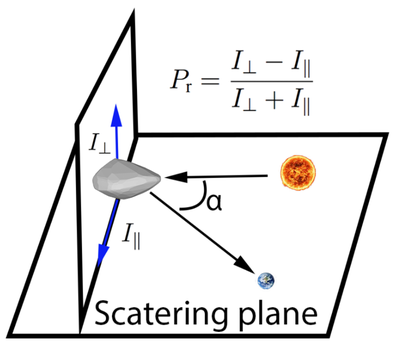
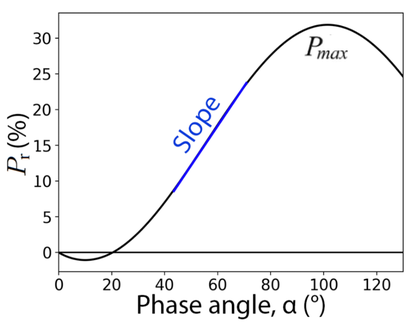
Asteroid sizes determination

Determining rapidly and reliably the size of a newly discovered possible impactor is essential to assess the potential consequences of an impact. To that aim, a good knowledge of the visual albedo is necessary. However, The determination of an asteroid albedo is a difficult task that primarily relies on assumptions/calibrations/models that are imperfect. Thus, measured albedos are often associated with large uncertainties that affect the determination of the size.



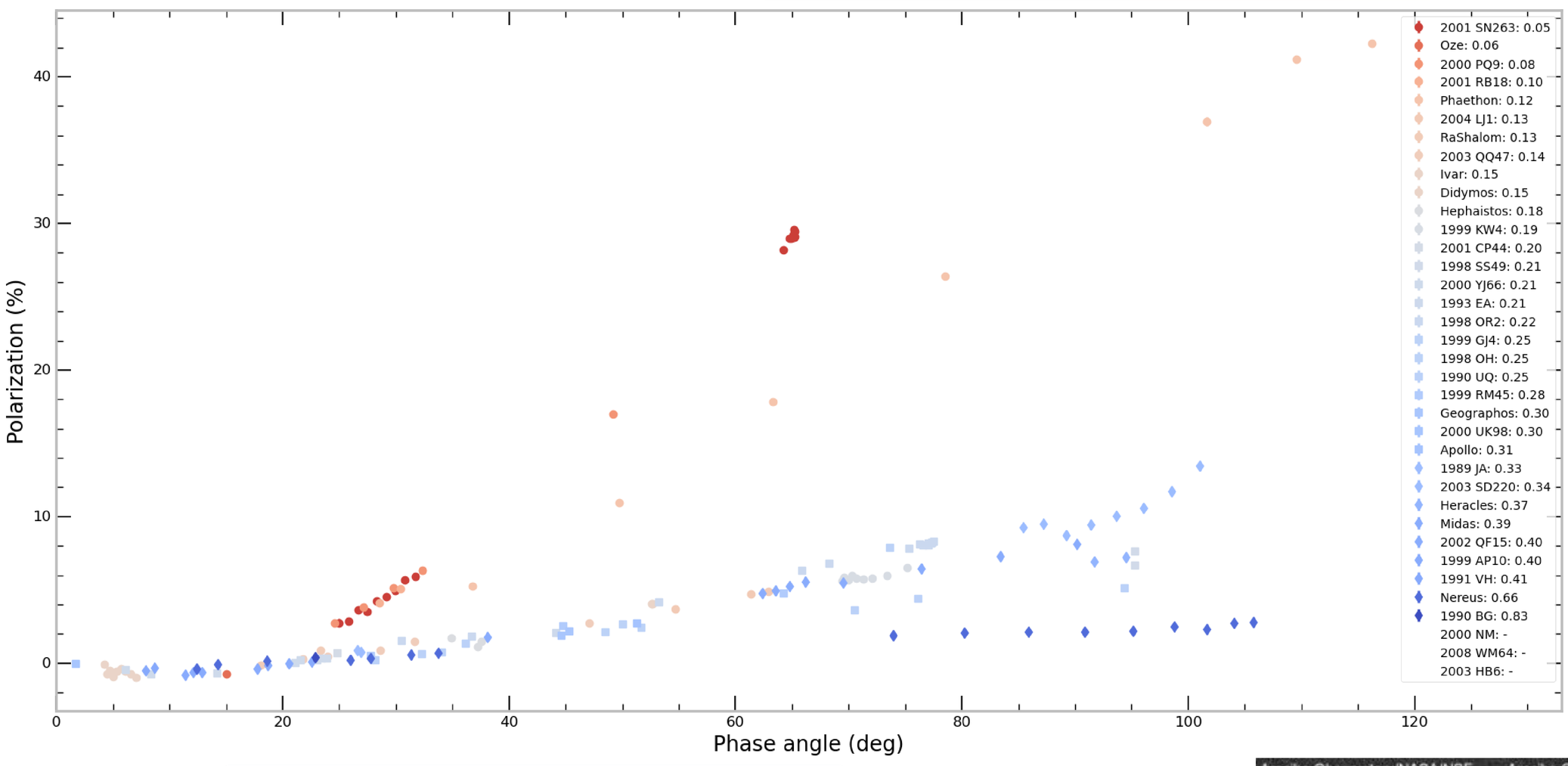


Polarization-albedo relationship

The degree of linear polarization, P_r of the sunlight scattered by an asteroid surface is primarily dependent on its albedo p_V [1]. There exists an anti-correlation where high albedo results in low polarization and vice versa. Polarization is also dependent on the solar phase angle α at which the target is observed.

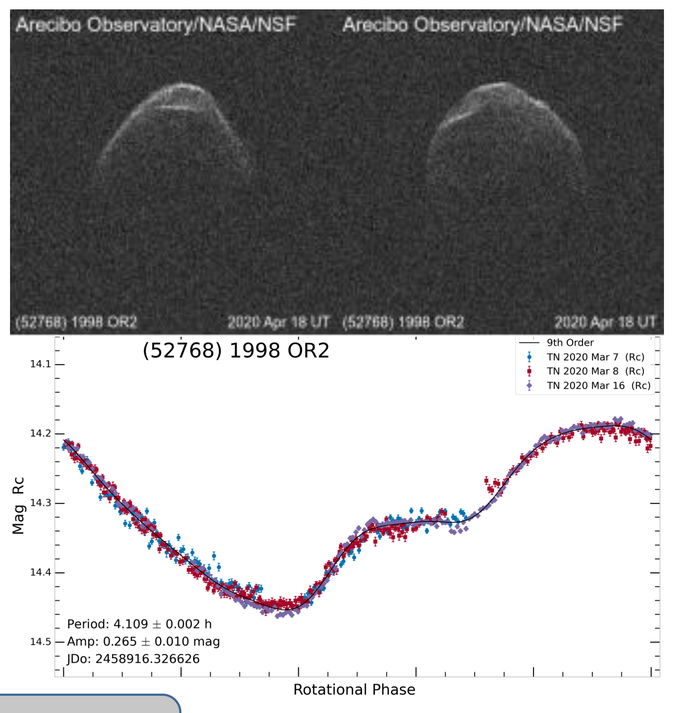
If this relationship has been calibrated for MBAs [2] at low phase angles, it is not the case for NEOs which are observable at much higher phases, up to 140°. We thus propose to calibrate the polarization-albedo relationship for NEOs by obtaining new polarimetric measurements at high phase angles, as well as independent albedo values, for 30+ NEOs. This calibration will allow to substantially reduce the size uncertainty on newly discovered object by obtaining even a single polarimetric measurement at phase angles > 40°.

Polarimetric observations are conducted with the ToPol polarimeter [3] mounted on the Omicron-West 1-m telescope at the Calern Observatory, France for targets reaching V < 14.5. We have so far observed 36 targets in polarimetry at various phase angles, as shown in the figure below. Different polarization for objects with different albedo is already visible, especially at larger phase angles.



Albedo from multiple data sources

To calibrate the albedo-polarization relation, we do not only need good polarimetric measurements, but also reliable albedo determinations. We are thus conducting observations with different techniques. Lightcurves are obtained using the TRAPPIST-South and -North 0.6-m telescopes [4] located at La Silla Observatory, Chile, and the Oukaïmeden Observatory, Morocco, respectively. They are used to refine the periods, construct phase curves to determine the absolute visual magnitudes H_V, and for spin axis orientation and shape modelling purposes. Sizes are obtained via thermal radiometry at IRTF and using archival radar data from the Arecibo Observatory and/or new observations at Goldstone. For certain targets, the lightcurves and delay-Doppler radar images are also used with the SHAPE software [5] to derive the spin axis orientation and to reconstruct a shape model. We are also looking for large-scale features present on the radar images and the shape model that could be linked to rotational variation of the degree of linear polarization.



Conclusion

We are gathering polarimetric measurements of NEOs at various phase angles that will be used to calibrate the polarimetry-albedo relationship. To obtain new or improved albedo for the target observed in polarimetry, we are also combining radar, photometric, and radiometric observations. With proper calibrations, even one polarimetric observation at α > 40° could reduce the size uncertainty of an impactor by a factor of ~10.

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References

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