EPSC Abstracts
Vol. 9, EPSC2014-820, 2014
European Planetary Science Congress 2014

Spectropolarimetry: a new diagnostic tool for asteroid characterisation?

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Abstract

We report about our spectro-polarimetric survey of asteroids.

1 Introduction

Asteroid polarimetry measures the linear polarisation of the sunlight scattered by asteroid surfaces at visible wavelengths. Most of the activity has been traditionally focused on the variation of the broadband linear polarisation in the V filter as a function of the phase angle (the angle between the Sun, the asteroid, and the observer). The observed curves of polarisation versus phase-angle may be used to derive the albedo of the objects. This is possible thanks to some empirical relations between surface albedo and certain features of the polarisation curve, such as its minimum and the slope of the positive branch (see, e.g., Cellino et al. 2012, and references therein). In principle, polarimetry is an observing technique that allows us to estimate the albedo without the need of any ancillary information about the objects. In turn, the albedo is strictly related to the surface composition and texture, and is therefore an extremely important parameter in asteroid science, needed for any reliable physical characterisation of these bodies. Obtaining good-quality phase polarisation curves requires observations to be performed over time intervals of several weeks, in order to sample satisfactorily the variation of the degree of polarisation as a function of phase.

Something that has been poorly studied so far is the dependence of the degree of polarisation upon wavelength. No systematic analysis of asteroid polarimetric data obtained in different colors was done before the first work by Belskaya et al. (2009), who have studied broadband polarimetric measurements in different filters. Belskaya et al. (2009) showed that at large phase angles, moderate-albedo asteroids exhibit a fraction of linear polarisation which is higher at shorter than at longer wavelength, whereas at smaller phase angles, the polarisation is higher at longer than at shorter wavelengths. Low-albedo objects were found to exhibit the opposite behaviour! Guided by this finding, during the last year we have requested and obtained a moderate amount of telescope time both at the ESO Very Large Telescope and at the ING William Herschel Telescope to check if one single polarisation measurement taken at different wavelengths either at large phase angles ($> 20^\circ$) or at a phase angle around 10° could be sufficient to distinguish between asteroids belonging to a variety of albedo and taxonomic classes.

2 This survey

We have obtained optical spectro-polarimetry of about 20 asteroids with the FORS instrument of the ESO VLT the ISIS instrument of the WHT. In this talk, we will report about the results obtained so far. In the longer term we want to observe at least two objects belonging to each taxonomic classes. Ideally, each object should be observed at least once at large phase-angle (where polarisation appears perpendicular to the scattering plane) and once at small phase angle (where polarisation is parallel to the scattering plane).

So far, taxonomic classification of asteroids has been based on purely spectroscopic data, aimed at deriving the spectral reflectance of the objects, but after establishing a link between albedo and wavelength-dependence of the fraction of linear polarization, asteroid spectropolarimetry may substantially refine the taxonomic classification, possibly being able to derive simultaneously the reflectance spectrum AND the albedo. This would be a very important step forward in asteroid science, including also applications to the physical characterization of potentially hazardous near-Earth objects, and benchmarks for future applications to exo-planets. Finally, our observations will be very important for applications of light scattering modelling techniques (e.g., Muinonen 2004).

Acknowledgements

Part of this work has been possible with the help of COST Action MP1104, “Polarisation as a tool to study the Solar System and beyond”.

References

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