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Photometry and polarimetry of asteroids: recent advances and challenges

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Abstract

We review recent advances in photometric and polarimetric observations of asteroids.

1. Introduction

Photometry and polarimetry are traditional techniques used to study surface properties of asteroids for many decades. But only recently with increasing amount, accuracy and phase angle coverage of observations we can estimate real diversity in magnitude and polarization phase angle effects for main asteroid composition types as well as for large and small asteroids.

2. Photometry

Magnitude phase angle dependencies with good phase-angle coverage and a small scatter have been measured for ~100 main belt asteroids in the restricted phase-angle range up to 25°−30°. Most observations were made in V or R filters. There are some measurements in BVRI filters but the wavelength dependence was found to be weak at phase angles α<30° and not well-studied yet (e.g., [12]). Available data show a strong correlation of parameters characterizing magnitude phase curves (phase slope, value and width of the opposition effect) on asteroid's albedo and taxonomic class. These conclusions [3] have been confirmed on two times larger data-set. Accurate measurements of phase angle dependence (well-sampled, corrected for the lightcurve changes, having an accuracy of individual photometric measurements <0.05 mag) can provide an independent estimate of asteroid's albedo and composition type. This has possible applications to the analysis of asteroid photometric data obtained by the Gaia space mission [5] and ground-based wide-field photometric surveys. Thanks to all sky surveys, a huge amount of sparse magnitude measurements of asteroids were obtained, e.g. from PanSTARRS1 [2] and PTF [14]. With increasing photometric accuracy and adequate modelling, such data may have potential importance for study asteroid phase angle behaviours.

The most important advances are connected with obtaining disk-resolved data in a wide range of phase angles for asteroids of different composition thanks to space missions [11, 13]. These data let to analyze optical heterogeneity of asteroid surfaces using methods validated for the lunar surface.

The integrated magnitude phase angle dependencies in a wide phase angle range up to 120°−160° have been measured for ~10 asteroids of different composition and sizes [11]. The data on phase curves obtained from space missions are well-consistent with ground-based observations.

3. Polarimetry

Polarimetric measurements have been made for ~500 asteroids but most of these data covered one or two phase angles. Only for 135 asteroids [8] it is possible to retrieve polarization phase curves, typically in V and R filters. Polarimetry has been recognized as one of the best available techniques to derive asteroid's albedo from remote observations. However, the polalimetric method is not widely used, mainly because of difficulties of obtaining good-quality polarimetric measurements in several observing runs to cover different phase angles.

At present, there is an increasing interest to polarimetry of near-Earth asteroids in order to determine their albedos, and thus, sizes. This is connected first of all with recent progress in instrumentation, but also with the fact that even with a single polarimetric measurement at large phase angles it is possible to obtain reliable albedo [4].

For a long time, the only near-Earth asteroids for which measurements close to polarization maxima were available belonged to the moderate or high albedo taxonomic classes [4]. First measurements of low-albedo asteroids revealed unexpectedly high positive polarization near maxima ~40-50% [9, 10].

Using polarimetric phase curves it is possible to distinguish several types of asteroids which are difficult to distinguish based on spectral data alone. Intriguing example is so-called “Barbarians”, asteroids having the largest inversion angles and believed to be very primitive objects (e.g., [7]).

Spectro-polarimetry of asteroids is considered as a promising new tool to provide information on asteroid surface properties which cannot be obtained by other techniques [1].

There are no yet measurements of a disc-resolved polarimetry for asteroids available, but a link between the disc-integrated polarimetric measurements and the local properties of Vesta’s surface obtained by the Dawn mission is well-seen [6].

4. Conclusions

The magnitude and polarization phase angle dependences have been measured for asteroids of main compositional classes in wide range of phase angles. With increasing amount and quality of observational data, many interesting features and interrelationships have been found. The improvement of interpretation models is crucial for further progress in the field.

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