EPSC Abstracts
Vol. 13, EPSC-DPS2019-885-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Polarimetry in study of near-Earth asteroids

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Abstract

Polarimetric observations of 9 near-Earth asteroids obtained in at large phase angles are presented. The polarization-albedo relationships for positive branch of polarization are revised and used to estimate albedo and to constrain surface texture of the measured NEAs.

1. Introduction

Polarimetric observations of near-Earth asteroids (NEAs) give a unique opportunity to investigate polarization phase angle behaviour at large phase angles close to polarization maximum. Currently polarimetric observations have been published for less than 20 NEAs. These observations were typically made in V or R filters. It was found that the maximum value of polarization degree P_{max}~7-8% occurs at the phase angle α_{max} ~100° for the moderate-albedo NEAs decreasing and shifting to smaller phase angles in the case of high-albedo asteroids (see [1] for a review). The first measurements of a polarization maximum for a low-albedo asteroid were obtained for (3200) Phaethon at its closest approach to the Earth in 2016-2017. Several groups of observers carried out polarimetric observations of Phaethon at different instruments and found extremely high positive polarization 40-50% at phase angles α~100° [2-5] varying over Phaethon's surface [6]. The location of polarization maximum is estimated to be at α~120°. An even larger value of linear polarization at maxima is expected for the darker NEAs (101955) Bennu [7] and (152679) 1998 KU2 [8]. All these measurements reveal a great potential of polarimetric techniques to study surface properties of NEAs.
We present the first results of our long-term observational program aimed to measure polarization at large phase angles for NEAs during their close approach to the Earth.

2. Observations

We observed 9 near-Earth asteroids at large phase angles and for 5 of them we were able to catch phase angles α≥80°. Observations of 7 asteroids were made at the 2-m telescope of the Bulgarian National Astronomical Observatory in Rozhen. Observations of (4183) Cuno and (18736) 1998 NU were carried out at the 2.15-m telescope of the Complejo Astronómico El Leoncito (CASLEO) and at the 2.6-m telescope of the Crimean Astrophysical Observatory, respectively. The list of asteroids, the dates of polarimetric measurements and the values of phase angles are given in Table 1.

Table 1: List of asteroids for which polarimetric measurements were carried out

Asteroid	Date	Phase angle, deg
(3122) Florence	2017 Dec 21	38
(3200) Phaethon	2017 Dec 15-Dec 21	48-116
(4183) Cuno	2012 May 23-Jun 20	10-80
(18736) 1998 NU	2019 Mar 10	36
(66391) 1999 KW4	2018 May 22	68
(85989) 1999 JD6	2015 Jul 08-23	46-96
(90075) 2002 VU94	2017 Mar 27	34
(143404) 2003 BD44	2017 Mar 25-Apr 20	7-90
(2015588) 2003 HF2	2017 Mar 29	90

3. Constraints on albedo and surface texture

In order to obtain an albedo value from polarimetric observations, a few empirical correlations are usually

used to relate the albedo with polarimetric slope, minimum and maximum of polarization.

A correlation between P_{max} and albedo is still not established for asteroids although it was extensively studied for the Moon and in the laboratory for lunar, meteorite and terrestrial samples of various texture. The value and position of polarization maximum were found to be highly sensitive not only to the surface albedo but also to the regolith grain size (e.g., [9]).

We use the obtained and published polarimetric measurements of NEAs at large phase angle to revise polarization-albedo relationships and to put constraints on albedo and surface texture of the measured NEAs.

4. Conclusions

We present new polarimetric measurement for 9 NEAs at large phase angles. We revise polarization-albedo relationships and use them to estimate albedos of the measured asteroids. Due to large differences in the polarization degree for high, moderate, and low-albedo asteroids, even with a single polarimetric measurement at large phase angles it is possible to obtain reliable values of albedos of a NEA. It is especially valuable for estimations of albedos and sizes of potentially hazardous NEAs.

Acknowledgements

ZD and TB acknowledge financial support by the Bulgarian National Science Fund under contracts DN 08/1/2016 and DN 18/13/2017.

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