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 $P_{\text{max}} \approx 7\%-8\%$ occurs at the phase angle $\alpha_{\text{max}} \approx 100^\circ$ 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 $\alpha \approx 100^\circ$ [2-5] varying over Phaethon’s surface [6]. The location of polarization maximum is estimated to be at $\alpha \approx 120^\circ$. 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 $\alpha \geq 80^\circ$. 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

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

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 $P_{\text{max}}$ 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.

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References


