Properties of Near Earth Asteroids S-, C-, E, and B-types based on polarimetry: from (1685) Toro to (3200) Phaethon

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The polarimetric study of the Near-Earth Asteroids (NEAs) allows us to cover the large range of phase angles, including the value and position of polarization maximum, and thereby supplement the inaccessible angles for the Main Belt asteroids. This gives the possibility to determine the geometric albedo of asteroids using the P_{max}–albedo relation, to compare the properties of surfaces of asteroids of different origin and with varying degrees of regolith maturity, and to investigate the similarities or differences between the mechanisms of scattering of light by dust particles of the cometary atmospheres and surfaces of asteroids. In addition, many NEAs are potentially hazardous objects.

Despite the long history of polarimetric studies, only several NEAs were explored at large phase angles and the most complete phase dependences of polarization were determined, including polarization maximum. They are: middle-albedo asteroids S-type (1685) Toro, (4179) Toutatis, and (23187) 2000 PN_9; high-albedo E-type asteroid 1998 WT 24 (33342); and intermediate-albedo B-type asteroid (3200) Phaethon. For two low-albedo asteroids (2100) Ra-Shalom and (152679) 1998 KU_2, the phase-angle dependence of polarization were obtained only up to 59.7° and 81°, respectively.

A special attention will be paid to the results of unique photometric and polarimetric multispectral observations of enigmatic asteroid (3200) Phaethon performed at the 6-m telescope of the Special Astrophysical Observatory of the RAS and the BVRI aperture polarimetry at the 2.6-m and 1.25-m telescopes of the Crimean Astrophysical Observatory during November–December 2017 within the range of phase angles of 19.2–134.9°. We found that the polarization maximum of Phaethon is $P_{max}\approx48\%$ at the phase angle of about 110° in the V-band. To date, Phaethon shows the highest maximum degree of polarization that was determined among the earlier observed bodies in the Solar System. Note that Phaethon is the target of upcoming space mission the JAXA Destiny$^+$.

We analyze the similarities and differences in the parameters of phase-angle dependences of polarization between different taxonomical classes of asteroids as well as between asteroids and comets in the sense of the current theories of light scattering. In particular, to better understand the possible causes of unique polarization and color properties of asteroid Phaethon, we used the modified *T*-matrix method, called *Sh*-matrix method, for simulation of the scattering properties of particles of arbitrary shape. We will discuss the results obtained.