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The CASLEO Polarimetric Survey of Main Belt Asteroids: Updated results

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Abstract

We present updated results of the polarimetric survey of main-belt asteroids at Complejo Astronómico El Leoncito (Casleo), San Juan, Argentina, using the $2.15\ m$ telescope and the Torino and CASPROF polarimeters. The goals of this survey are to increase the database of asteroid polarimetry, to estimate diversity in polarimetric properties of asteroids belonging to different taxonomic classes, and to search for objects that exhibit anomalous polarimetric properties. The survey began in 2003, and data for a sample of more than 170 asteroids have been obtained, most of them having been polarimetrically observed for the first time. Using these data we find phase-polarization curves and polarimetric parameters for several taxonomic classes.

1. Introduction

The light that we receive from any asteroid at visible wavelengths consists of partially polarized light produced by the scattering of the sunlight on the solid surface of the body. The polarization is usually found to be linear with its azimuth either normal or parallel to the scattering plane, which in the Solar System is the plane containing the asteroid, the Sun, and the Earth at the epoch of observation. In polarimetry, the results of observations are usually expressed using the parameter $P_r = (I_\perp - I_\parallel)/(I_\perp + I_\parallel)$, where $I_\perp$ and $I_\parallel$ are the intensities of the scattered light polarized along the planes perpendicular and parallel to the scattering plane, respectively.

P_r is found to change with the angle between the incident and observation rays, usually known as the phase angle, α. A plot of P_r against α is known to produce a characteristic curve described by some parameters whose measured values are found to be diagnostic of the overall texture and optical properties of the surface. For phase angles less than 20^o, P_r turns out to be negative, reaching a minimum of polarization, P_{min}, at phase angles $\alpha_{min} \approx 8 - 10^o$. This general behavior characterizes all asteroids observed so far with some minor differences [1] depending on the taxonomic class. Beyond $\approx 20^o$ of phase, the polarization changes sign at the inversion angle, α_0, and becomes positive. The existence of a branch of negative polarization exhibited by atmosphereless Solar System bodies is a well-known fact, which is generally explained in terms of the occurrence of coherent backscattering phenomena [5][6][10].

Although polarimetry provides useful information about the physical properties of the asteroid surface, polarimetric observations of these objects are not easy to obtain, because an asteroid must be followed at several phase angles to study its polarization curve, and this kind of coverage is difficult owing to object faintness, limited visibility, weather problems, etc. As a consequence, the database of asteroid polarimetric mesasurements is not large and very few objects have polarization curves that are well determined.

With the objective of increasing the polarimetric database and reaching a better knowledge of the surface properties of these objects, we began an extensive polarimetric survey in 2003 at the Complejo Astronómico El Leoncito (CASLEO) to obtain polarimetric measurements of main-belt asteroids. In this paper we present the first results of that survey.

2. Observations

We carried out observations during different observing runs between May 2004 and November 2009 at the $2.15\,m$ telescope of the Complejo Astronómico El Leoncito (CASLEO), San Juan, Argentina, using the Torino and CASPROF polarimeters. A full description of the Torino photopolarimeter can be found in [7] and [8]. Here we recall that this instrument allows for simultaneous measurement of polarization in five bands, using separate photomultipliers and a set of dichroic filters. On the other hand, CASPROF is a two-hole aperture polarimeter with rapid modulation provided by a rotating achromatic half-wave re-

tarder and a Wollaston prism polarizing beamsplitter. In this instrument the complementary polarized beams are detected with photomultipliers operating in pulse-counting mode, and the acquisition and guiding are accomplished with a CCD camera viewing the sky surrounding the entrance aperture. Since the received signal is, in general, exceedingly low in bands other than V and R in both instruments, only data obtained in these two bands were considered. From the analysis of several standard stars, we found the instrumental polarization fairly constant and stable, always below 0.1% for both instruments.

When it was possible, we observed the targets during runs some weeks apart to obtain measurements during the same apparition at different phase angles. Observing nights were generally assigned around the new Moon to minimize the contamination of sky polarization by moonlight when we used the CASPROF polarimeter. In all cases, we used the smallest diaphragm allowed by the observing conditions to minimize the contribution of sky background and took sky measurements frequently to test for any variation. Each night we observed a minimum of two zero-polarization standard stars and one high-polarization star to determine instrumental polarization. The standard star data were obtained from [9] and [4].

3. Results

The choice of targets was made in such a way as to preferentially observe for the first time asteroids for which no polarimetric data had beren obtasined before, or to fill gaps in the phase-polarization curve. During this survey we obtained more than 400 observations of 170 main-belt asteroids of different taxonomic types of the Bus taxonomic classification [2].

Using these data we find mean polarimetric parameters and mean phase - polarization curves for S-, L-, K-, B-, C-, and X-types, calculate the mean geometric albedo for these taxonomic types, find several "Barbarian" objects (asteroids characterized by phase-polarization curves with an unusually large inversion angle, after their prototype (234) Barbara ([3]), and detect objects that appear to follow phase-polarization curves that are not the expected ones for their taxonomic types.

4. Discussion

The obtained data-set of homogeneous data makes it possible to achieve a better knowledge of the polarimetric behavior of a variety of asteroidal surfaces, and to find polarimetric parameters and phase - polarization curves both for taxonomic clases as well as for individual objects. Several examples are given.

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References

[1] Belskaya, I. N.,Shkuratov, Yu. G., Efimov, Yu. S., et al. 2005: Icarus, 178, 213, 2005.

[2] Bus, S. J. 1999: PhD Thesis, Massachusetts Institute of Technology, Boston, 1999.

[3] Cellino, A., Belskaya, I. N., Bendjoya, Ph., di Martino, M., Gil-Hutton, R., Muinonen, K., & Tedesco, E. F. 2006: Icarus, 180, 565, 2006.

[4] Gil-Hutton, R., & Benavidez, P. 2003: MNRAS, 345, 97, 2003.

[5] Muinonen, K., Piironen, J., Shkuratov, Yu. G., Ovcharenko, A., & Clark, B. E. 2002: in W. F. Bottke jr., A. Cellino, P. Paolicchi, R. P. Binzel (Eds.), Asteroids III, Univ. of Arizona Press, Tucson, pp. 123-138, 2002.

[6] Muinonen, K., Zubko, E., Tyynelä, J., Shkuratov, Yu. G., & Videen, G. 2007: JQSRT, 106, 360, 2007.

[7] Piirola, V. 1988: in G. V. Coyne et al. (Eds.), Polarized Radiation of Circumstellar Origin, Univ. of Arizona Press, Tucson, pp. 735-746, 1988.

[8] Scaltriti, F., Piirola, V., Cellino, A. et al. 1989: Mem. Soc. Astron. Italiana, 60, 243, 1989.

[9] Turnshek D. A., Bohlin, R. C., Williamson II, R. L., Lupie, O. L., & Koornneef, J. 1990: Astron. J., 99, 1243-1261, 1344, 1990.

[10] Tyynelä, J., Zubko, E., Videen, G., & Muinonen, K. 2007: JQSRT, 106, 520, 2007.