BOND ALBEDO OF ASTEROIDS FROM POLARIMETRIC DATA.

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It is well known that the higher surface albedo, the lower polarization of light scattered by this surface (so called Umov law). This principle allows to estimate geometric albedo of asteroids by their polarimetric properties (e. g. [1] and references therein). It is known also that the slope of linear part of photometric function of asteroids, β, correlates with the maximal negative polarization P_{min} [2]. The slope parameter, G, of HG-photometric system depends on the phase coefficient β [3] and also correlates with P_{min}. Furthermore, in accordance with [3] the phase integral q is derived from G via $q = 0.290 + 0.684G$. All this was impact to search for correlations between the Bond albedo of asteroids and their polarimetric characteristics.

The visual geometric albedo A_V and G of asteroids were taken from SIMPS [4] and [5] respectively. The visual Bond albedo of asteroids $S = q\ A_V$ was calculated using the above interrelation between q and G. In the asteroid sample used here, the Bond albedo varies in the range from 0.02 (F asteroid 704 Interamnia) to 0.33 (E asteroid 44 Nysa).

The polarimetric data of asteroids were taken from [6]. To approximate the polarimetric phase curves of the asteroids, the following five-parameter empirical formula for polarization of light scattered by particulate surface was used [7]:

$$P(\alpha) = B(1-e^{-m\alpha})(1-e^{-n(\alpha-\alpha_i)})(1-e^{-l(\alpha-\pi)}),$$

where α is the phase angle in the range of 0 – π radians, and the scaling factor B is expressed in terms of slope h of the polarization curve at an inversion angle α_i :

$$B = \frac{h}{n(1-e^{-m\alpha_i})(1-e^{-l(\alpha_i-\pi)})}.$$

Since polarimetric phase curves of the majority of asteroids are known in the range of phase angles 0 – 30°, both parameters n and l were chosen to be much less than 1 but more than 0. Note that the expression $P(\alpha) = a\ \exp(-\alpha/d) + b + k\alpha$ that was utilized in [8, 9] is, in fact, a particular case of the formula [7] and works only in the range of small phase angles ($0 \geq \alpha \sim \alpha_i$).

So, using the approximation formula [7] the polarimetric phase curves of the asteroids in the B, G, and V bandpasses were constructed and after that the parameters of the negative branch of the asteroid polarimetric curves as P_{min}, α_{min}, α_i, and the polarimetric slope h were estimated. Note that the parameters of the positive branch of the polarimetric curves as P_{max} and α_{max} were also estimated but statistical uncertainty of such an extrapolation was found to be high. Therefore these parameters are not used in the given work.

Correlations between S and h and also between S and P_{min} were found for the above bandpasses but the sample of asteroids measured in the V band with known values in question was only 5 as against 18 and 22 for the G and B bands. For this reason statistical analysis was limited to asteroids with polarimetric measurements in the B and G bandpasses. The following linear equations were derived:

$$\lg S_h = (-1.1\pm0.1)\lg h - (2.1\pm0.1)$$

and

$$\lg S_{Pmin} = (-1.3\pm0.2)\lg P_{min} - (1.19\pm0.04).$$

In order to verify how well the calculated values of the Bond albedo correspond to the original data, the differences between these values (i.e. $\Delta S_h = S_h - S$ and $\Delta S_{Pmin} = S_{Pmin} - S$) were compared with S, the original Bond albedo. It turned out that ΔS_h and S correlate well with correlation coefficient equal to 0.8. What causes such a behavior of h is yet not completely clear. One can assume that a "saturation effect" probably takes place for h at low Bond albedo. A current inference is that polarimetric slope h is hardly suitable for the Bond albedo estimation.

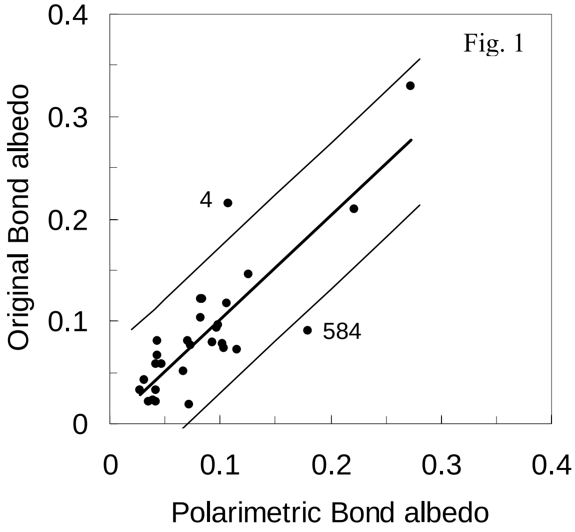
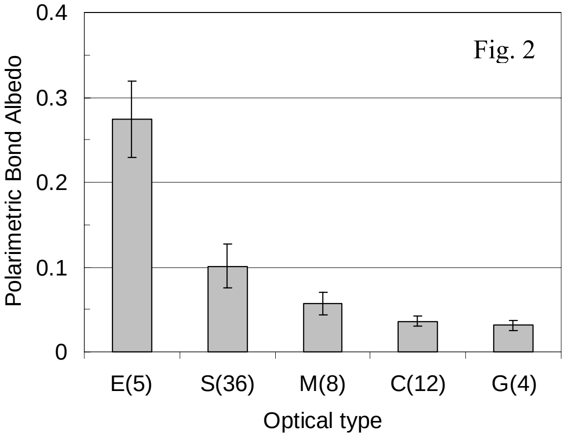


Fig. 1

Figure 1 demonstrates dependence of the original Bond albedo on S_{Pmin}, and also confidence boundaries for this regression line at significance level equal to 0.95. The regression equation is $S = (1.01\pm0.06)S_{Pmin}$, the correlation coefficient equals 0.83. In whole, there is satisfactory agreement between original and polarimetric values of the Bond albedo; only two asteroids, 4 Vesta and 584 Semiramis, lie beyond of confidence boundaries. As is known, Vesta has a heterogeneous surface and, apparently, this fact affects the polarimetric observations, which were made at different times and so at different rotation phases of the asteroid. It is possible that the same is true for asteroid Semiramis.



The average Bond albedo for the asteroid main optical types and the number of asteroids of the given optical type in our sample are shown in Figure 2. As is seen from this figure, the optical types of asteroids are well discriminated by the Bond albedo. Some asteroids from our sample with previously unknown optical type are listed in the Table.

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Asteroid	Preliminary optical type	Bond albedo
3086 Kalbaugh	S	0.11
3169 Ostro	M	0.05
25143 Itokawa	S	0.1
33342 1998 WT24	E	0.23
100085 1992 UY4	S	0.08

References: [1] Cellino A. et al. (1999) *Icarus 138,* 129–140. [2] Golubeva L. F., Shestopalov, D. I. (1983) *Sov. Astron. J. 27,* 351 – 357. [3] Bowell E. et al. (1989) In *Asteroids II* (R. P. Binzel, T. Gehrels, and M. S. Matthews, Eds.), 524–556. [4] Tedesco E. F. et al. (2002) *Astron. J. 123,* 1056–1085. [5] Tholen D.J. (2009) *NASA PDS,* Asteroid Absolute Magnitudes V12.0. EAR-A-5-DDR-ASTERMAG-V12.0. [6] Lupishko D.F., Vasilyev S.V. (2008) *NASA PDS,* Asteroid Polarimetric Database V6.0. EAR-A-3-RDR-APD-POLARIMETRY-V6.0. [7] Shestopalov D. (2004) *JQSRT 88,* 351–356. [8] Kaasalainen S. et al. (2003) *Icarus 161,* 34–46. [9] Muinonen K. et al. (2009) *Meteoritics & Planet. Sci. 44*, 1937–1946.