POLARIZED LIGHT SCATTERED FROM ASTEROID SURFACES. II. SURFACE PHOTOMETRIC ROUGHNESS. L. F. Golubeva, D.I. Shestopalov, P. N. Shustarev, Shemakha Astrophysical Observatory, Shemakha AZ-3243 Azerbaijan, (lara_golubeva@mail.ru), (shestopalov_d@mail.ru), (petersh50@mail.ru).

As has been shown in Part I (this volume), there are correlations between the average parameters of negative polarization branch and the phase coefficient of the average photometric functions of asteroids belonging to E, S, M, and C optical types. To understand a physical meaning of these correlations the average photometric functions for each optical type were approximated by the following equation, which has been successfully applied for asteroids (i.e. [1] and references therein):

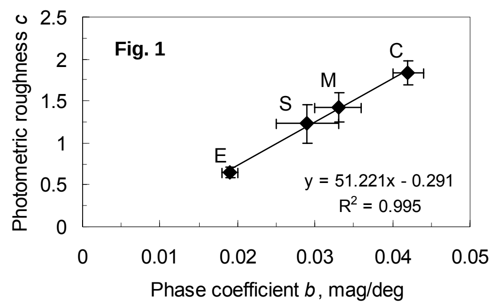
$$\Delta V(\alpha) = -2.5\lg\left[S(\alpha)\times\left(\frac{\pi-\alpha}{\pi}\cos\frac{\alpha}{2}\right)\right].$$

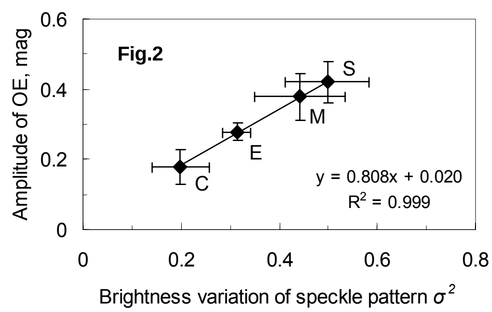
An expression enclosed in round brackets is the scaled brightness of an asteroid against the phase angle α [2]. Such a brightness distribution over sunlit asteroid surface is settled when a mesorelief of the surface is assumed to be so much irregular that none addititious asperities can already affect the reflection law [2]. The scaled phase function of a representative surface area is [3, 4]:

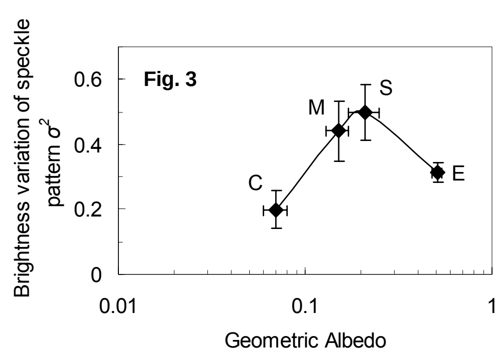
$$S(\alpha) = (e^{-c\alpha} + \sigma^2 e^{-(a+c)\alpha})/(1+\sigma^2)\ .$$

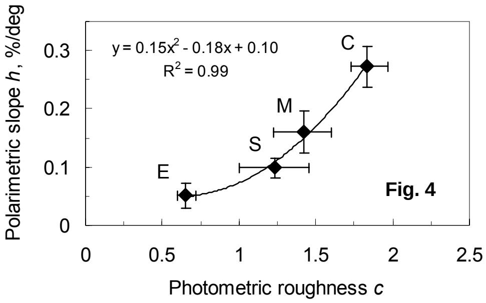
Here the a parameter defines the ability of surface particles to focus an incident light and create a patchy pattern on an underlying surface and σ^2 defines brightness fluctuation of this patchy pattern. A shadow effect produced by microtopography is characterized by the parameter $c = k(1-e^{-2\tau})$, where k is a ratio of the mean height of surface microrelief to the mean distance between random surface features and τ is the optical density of a surface material. The c parameter or, in other words, a surface photometric roughness, depends on surface albedo since the exponential $e^{-2\tau}$ is expressed in terms of albedo in accordance with Eq. (13) in [5].

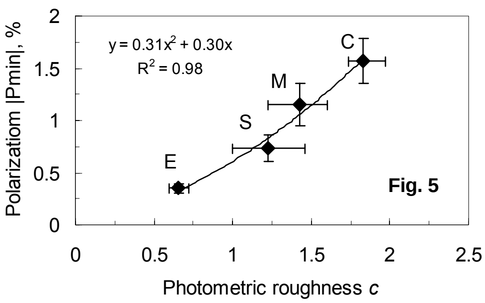
The modeling of the average photometric functions of asteroids shows as follows. The phase coefficient b strongly corresponds to the surface photometric roughness c (Fig.1). We believe the correlation will be also close for individual asteroids because the theoretical and the individual observational photometric functions match together within the observational error range [1]. The amplitude of an opposition surge correlates with the dispersion, σ^2, (Fig.2) of the brightness of the patchy pattern on a subsurface lay that underlies relatively large semitransparent particles. The σ^2 parameter shows an ∩-like distribution along asteroid geometric albedo (Fig. 3). As is evident from this Figure, the contrast of the patchy pattern relative to an underlying screen is maximal for moderate albedo and recedes for low- and high-albedo asteroids due to the overall high absorption of surface material in the first case and the high albedo of the scattered screen in the second case. This simple reasoning and Figure 2 taken together explain immediately an ∩-like dependence of the OE amplitude of asteroids on their geometric albedos that has been found in [6] and discussed in [7]. So we can be sure that our choice of theoretical photometric function for asteroids is quite reasonable. Note also that the a parameter of the theoretic phase function slightly varies from one asteroid optical type to another and contributes to the opposition surge at phase angles ~ 3° and less.

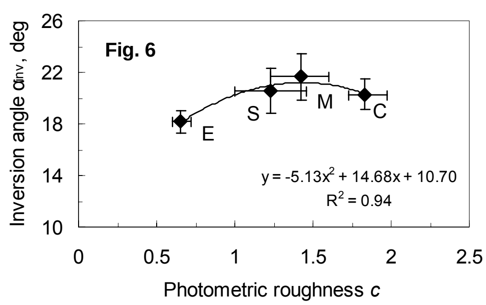


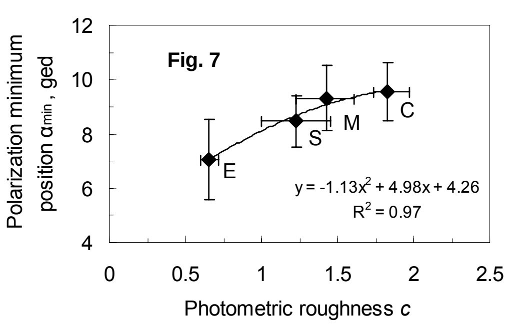


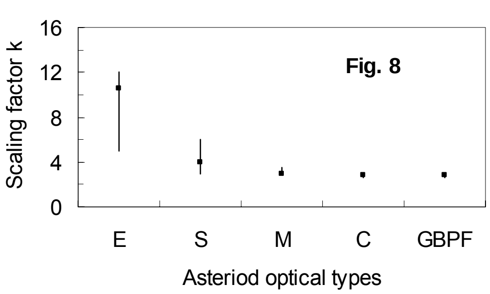


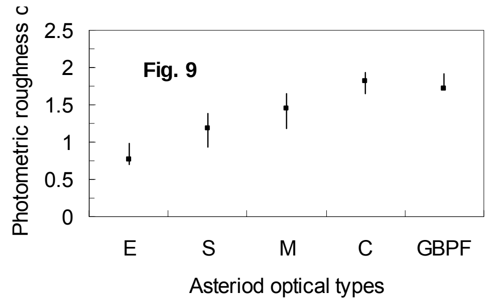












As the phase coefficient *b* strongly correlates with the photometric roughness *c* it is not wonderful that relationships between the parameters of polarization phase function (i.e., *h*, P_{min}, α_{min}, α_i) and *c* also exist (Figs. 4 – 7). So we confirm a conclusion stated in Part I (this volume) that the shading of surface owing to great asperity on a scale of microrelief plays an important role in the forming of the negative branch of asteroid polarization phase function.

Using the individual values of polarimetric slope *h* and geometric albedo as well as the relationship shown in Fig. 4 we calculated the photometric roughness *c* and the scaling factor *k* for asteroids belonging to various optical types. Among others, the E asteroids reveal both the maximal average value of *k* parameter and the maximal ranges of its variation (Fig. 8). This occurs as the bright surface of E-type asteroids effectively dilutes the shadows so that only high-pitched surface features can contribute to shadow-hiding effect. But the photometric roughness is minimal for E asteroids and increases with decreasing surface albedo (i.e., for moderate- and low-albedo asteroids of S, M, C and other types).

In the Part III we will examine some effects resulting from the polarization-roughness connections.

References:

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