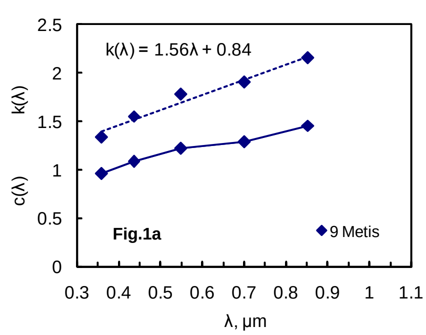
POLARIZED LIGHT SCATTERED FROM ASTEROID SURFACES. IV. TENTATIVE EXPLANATION OF POLARIZATION WAVELENGTH DEPENDENCES. L.F. Golubeva, D.I. Shestopalov, Shemakha Astrophysical Observatory, Shemakha AZ-3243 Azerbaijan, (lara_golubeva@mail.ru), (shestopalov_d@mail.ru).

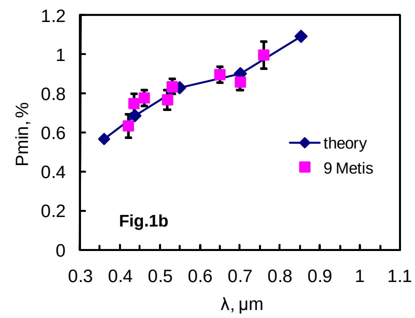
There is a body of evidence in favor of the fact that the degree of the negative polarization of light scattered from asteroid surfaces slightly depends on wavelength. In general, one can be of opinion that in the case of moderate-albedo asteroids the negative polarization branch becomes deeper when wavelength increases and, as a rule, an opposite trend appears for low-albedo asteroids [e.g., 1, 2 and references therein]. Though there are exceptions from this assertion as the spectral trend of the polarization degree is typically ~ 0.2% in the range of ~ 0.4 – 0.8 μm and sometimes comparable with measurement errors [2]. Here we consider the possible causes initiating the spectral variations of polarization degree.

In the Part II [4] we have found that for the E-, S-, M-, and C-type asteroids the average value of the maximum negative polarization, $|P_{min}|$ correlates with the average value of a surface photometric roughness, c, notably:
$|P_{min}| = 0.31c^2 + 0.3c$.

In turn, the c parameter depends on the optical density, τ, of asteroid material and the scaling factor, $k = H/L$, where H is an average height of surface microtopography and L is an average distance between surface features. Since τ depends on the albedo of surface material [5] we can write: $c = k[1 - F(A)]$. Having known the spectral albedo, $A(\lambda)$, of an asteroid and specifying $k(\lambda)$ we can calculate $P_{min}(\lambda)$ by the above equation.

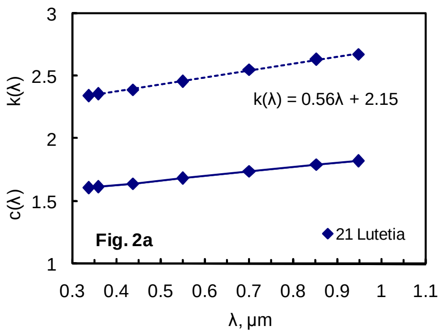
First understand whether the scaling factor k can depend on the wavelength of incident light. The answer is positive, we believe. The first what must be noted that the k parameter is not a result of measurements *in situ* by any tools; the parameter is remotely derived from the measurement of light beams starting from asteroids. The Umov law does not hold true for a smooth dielectric surface.

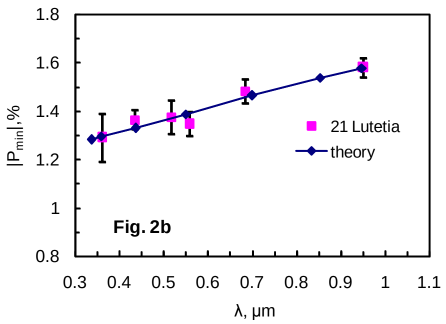




The polarization always reaches unit at the Brewster angle whereas the normal albedo of the smooth surface depends on the refraction index of surface material. The surface must be rough, asperous (and not even particulate) in order that the Umov law operated. If some surface areas have the height of irregularities less than ~ λ/8 (Rayleigh's criterion) then the areas will be appear as smooth. Only surface irregularities with height larger than λ/8 are effectively able to shadow the surface and provide the phase-angle variation of asteroid polarization and brightness [3, 4]. Another factor flattening the microtopography, which is observed remotely, is an diffuse scattering light from surface irregularities. If albedo increases with wavelength then the mutual illumination of surface features also increases with wavelength and the shadows from irregularities will be the more dilute the higher albedo. The background albedo as if reduces the height of surface features and, in such a way, reduces H, the average height of surface microtopography. So we believe that k parameter can vary with wavelength, and at that rate the form of these dependences can reflect the specificity of surface structure.

Below we use the normalized spectra of asteroids 9 Metis and 21 Lutetia and their geometric albedos at λ = 550 μm from ECAS [6] and albedo surveys [7, 8]. Polarimetric data for these asteroids were taken from [9]. The values of $|P_{min}|$ were calculated by the empiric formula [10] that approximates the phase-dependent polarization curves of asteroids.





Figures 1a and 2a show that in the case of M asteroid Lutetia and S asteroid Metis the *k* parameter (as well as the photometric roughness *c*) must change proportionally to wavelength to produce the conditions for increasing polarization with wavelength (Fig. 1b and 2b). The simplest hypothesis about the asteroid surface microstructure is that all surface features are about equidistant from each other and the heights of the features are equiprobable in the range from H_{min} to H_{max}. According to Rayleigh's criterion, H_{min} increases when λ increases and so the average height of surface microtopography *H* will be a linear function of wavelength of incident light. Notably, the slope of the *k*(λ) dependence correlates with the gradient of spectral curve and the value of albedo itself: the redder the spectrum and the higher albedo the greater the slope.

The examples above illustrate the significance of wavelength dependences of polarization in examination of asteroid surface microstructure. It should be noted, however, the findings strongly depend on the accuracy and representativeness of the observational data used. For example, the polarimetric and spectroscopic observations were carried out at various oppositions and there is no warranty that the same asteroid surface areas were observed. The second is that we use here the dependence between P_{min} and *c* obtained in the V bandpass. This should be tested whether the equation constants are invariants for various spectral ranges. We think the method can be refined by new asteroid observations and laboratory investigations. In the future, the method described here can be especially useful during cosmic mission to asteroids when there are favorable conditions for the disk-resolved polarimetric, photometric and spectroscopic observations.

References:

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