MICROSTRUCTURE FEATURE OF F-TYPE ASTEROIDS WITH SMALL INVERSION ANGLES OF POLARIZATION,

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Summary: Laboratory measurements of low-albedo powdery samples making to interpret observational data for F-type asteroids show that the optical homogeneity of microstructure of their regoliths on the scales of the order of the wavelength may be responsible for the relatively small inversion angles observed for the F-type asteroids.

Introduction: Polarimetry is a powerful tool to investigate of physical properties of atmosphereless bodies, in particular, asteroids. An important output of the asteroid polarimetry is information as for the asteroid surface texture. Dollfus *et al.* [1] considered the relationship between the depths of negative polarization and the inversion angles as diagnostic for the surface texture. Progress in theoretical and laboratory modeling of backscattering phenomena [see, e.g., 2,3] returns an interest to asteroid polarimetric observations. Here we present results of an interpretation of new and previous observations of several F-type asteroids, which is based on laboratory simulations of lightscattering by particulate surfaces.

Why F-type asteroids are a type: The F-type was first introduced by Gradie and Tedesco [4] to distinguish low-albedo asteroids with a flat (that is why F) spectrum in the wavelength range 0.3 – 1.1 μm. The typical range of albedo of F-type asteroids is 0.03-0.07. Their flat spectra were characterized with little or no absorption features. In Tholen's classification there are 27 asteroids of the F-type that includes only about 3% of all classified objects [5]. The F-type asteroids are assumed to contain free organic compounds and resemble organic rich CI1-CM2 meteoritic assemblages [6]. We note a distinctive feature in the distribution of the F-class in the asteroid belt. Unlike other primitive classes dominated in the outer asteroid belt, there is an abundance of the F-type in the Polana family at about 2.44 AU [7]. Two near-Earth objects (3200 Phaeton and Wilson-Harrington) are also classified as F-type and both of them assumed to have the cometary origin [8].

The F-type asteroid has shown unique polarimetric characteristics. Objects of the F-type are characterized with the negative polarization branch atypical for low-albedo asteroids. The depth of its negative polarization is about 1% and the inversion angle is close to 14° (see Fig. 1), that is the smallest value ever observed for asteroids. We would remind that the typical values of these parameters for C-type asteroids, which are also very dark, is approximately 1.7 % and 18°, respectively [9].

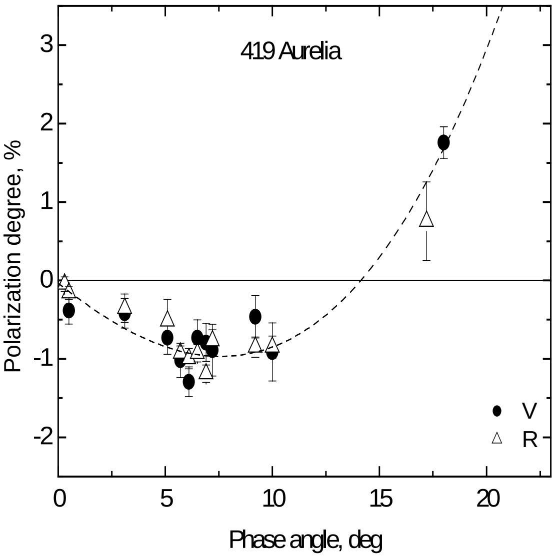

Fig. 1. Polarimetric phase dependence for the asteroid 419 Aurelia [9].

Laboratory simulations: The suggested here explanation of the polarimetric peculiarity of F-type asteroids is that their surfaces have more uniform optical microstructure than other low albedo bodies. In fact, laboratory studies of mixtures of powders that are very contrast in albedo have shown a sharp amplification of the negative polarization as compared to that for the mixture components [10]. Thus, one can anticipate that adding small amount of a bright powder (e.g., MgO) to a dark powder (e.g., pure carbon soot) noticeably changes the negative polarization, producing a small albedo effect.

Table 1. Parameters of the photopolarimeters.

	Small phase angles	Large phase angles
Ranges of phase angles	0.2 – 17°	2 – 160°
Steps of phase angels	0.024°	1°
Diameters of samples	60 mm	10 mm
Distance from sample to source and receiver	1200 mm	350 mm
Angular diameters of source and receiver apertures	0.05°	0.8°
Whole spectral range	0.4 - 0.8 μm	0.4 – 0.8 μm

To illustrate this we measured low-albedo samples with laboratory photopolarimeters that are constructed and located at Astronomical Institute of Kharkov National University. One of the photopolarimeters allows photometric and polarimetric measurements at small phase angles, 0.2° - 17°. The other one permits us to study a wide range of phase angles, from 2° to 150°. In Table 1 we show several characteristics of the instruments. As an example, Fig. 2 shows an image and scheme of the instrument for measurements in the wide range of phase angles.

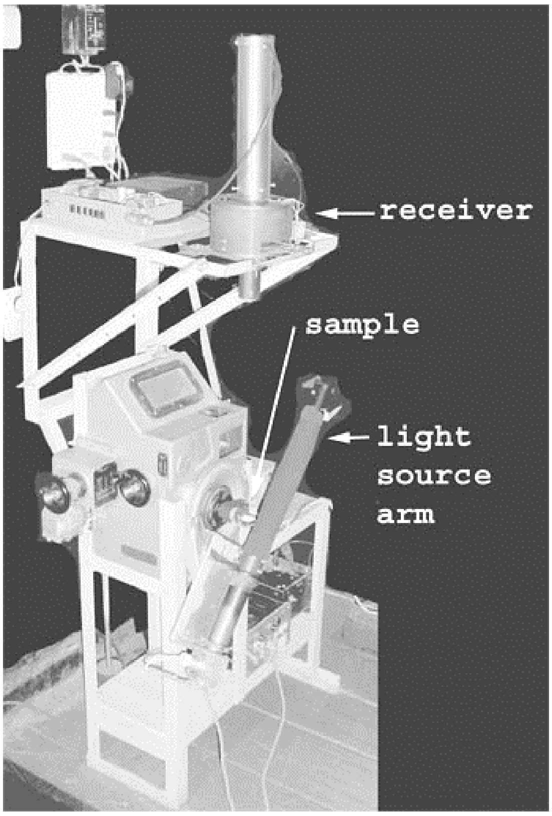

Fig. 2. Image and scheme of the laboratory photopolarimeter for measurements in the range of phase angles 2° - 150°.

Fig. 3 shows results of our laboratory measurements of pure carbon soot (albedo 3.6 % at phase angle 2°) and a mixture (albedo 4.3 % at phase angle 2°) of the carbon soot (95 wt. %) and very fine powder of MgO (5 wt. %). The mixture was dry and produced with shaking the powders in a test-tube. Points and crosses in Fig. 2 correspond respectively to measurements with the small-phase-angle and large-phase-angle photopolarimeters. After adding the high-albedo component, the sample albedo remains in the low-albedo domain, but for polarization the changes are significant. For instance, α_{inv} goes from 13.0° (for carbon soot) to 15.2° (for the mixture); this is considerable. We note also the large variation of P_{min}, approximately from 0.5 % to 0.8 %.

Conclusion. Thus, the relatively small values of the parameters P_{min} and α_{inv} for F-type asteroids can be treated as a revealing of the optical homogeneity of regolith microstructure on the scales of the order of the wavelength. This consists with the fact that the asteroids have flat spectra, as any spectral feature (bands or UV absorption) is largely produced with relatively bright regolith components that should also strengthen the negative polarization [10].

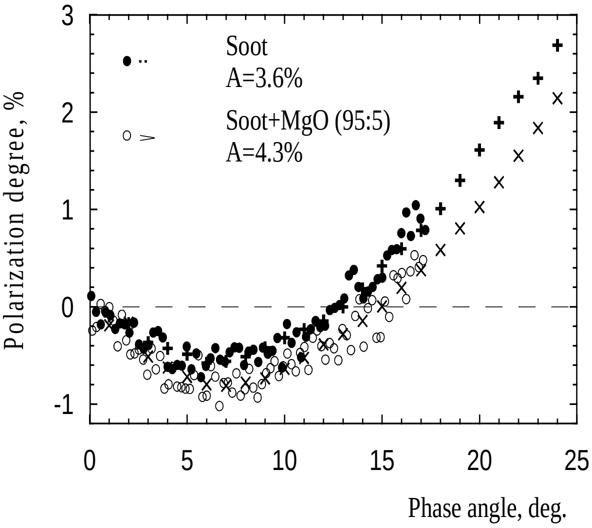

Fig. 3. Polarization phase dependences of modeling samples.

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