THEORY AND APPLICATION OF THE NEGATIVE BRANCH OF POLARIZATION FOR AIRLESS PLANETARY OBJECTS, Audouin Dollfus, Observatoire de Paris, 92190 Meudon, FRANCE, and Milo Wolff, Technotran, 1600 Nelson Avenue, Manhattan Beach, CA. 90266, USA.

The light which is reflected at the rough or powdered surface of a solid body emerges partially polarized. The polarization curve versus phase angle display towards the small phase angles a negative branch which characterizes the rough surface, because the negative polarization mechanism involves multiple reflection between the particles. Varying the phase angle causes both the singly-reflected and the doubly-reflected light paths to probe the intricacies of the three-dimensional particle surface. Accordingly, the shape of the negative branch is a result of the structure of the surface material.

The theory developed by M. Wolff (1975) (1980) accounts for the polarization produced as a function of phase angle, in terms of simple physical processes; it involves three parameters which are the two refractive indexes MR and MI and the fraction EXT of the surface which produces a directly reflected light.

The theory is compared with laboratory measurements on a large variety of terrestrial, meteoritic, lunar and artificial samples (cf. Dollfus and Geake, 1975).

a) A computation of the minimum polarization P_{min} versus reflectance R shows a double valued function of the imaginary index MI. When MI is large, the "region of metallic reflection" describes in principle metallic powders; it is approximatively matched by Aluminium powders produced by filings; the other metallic powders measured have an albedo lower than computed, however. When MI is small, a "region of diffuse reflection" is occupied by silicates, glasses, chondrites and other semi-transparent materials; it is also occupied by most asteroids, moons and airless planets.

In practice, the real index MR, and the imaginary index MI, are obtained from a plot of polarization-slope versus albedo. Alternatively, if MR is assumed typical of silicate soils (1.8), the MI index can be obtained from albedo measurements using the relation:

$$R = 0.0038 \times (MI)^{-0.59}$$

Values of MI can be extracted for the solar system objects and are listed in Table I

Table I : Values of parameter MI for Solar System objects

Object	Parameter MI
Asteroid 4 Vesta	global : 0.0010
Satellite JIV Callisto	global : 0.0015
Mercury	global : 0.0030
The Moon	lightest terrae .. : 0.001
	dark maria .... : 0.010
S type asteroids	lightest .... : 0.0025
	darkest .... : 0.010
C type asteroids.....	lightest .... : 0.020
	darkest .... : 0.050

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b) We computed also the minimum polarization versus phase angle. Here, the real part of the index, MR, does not play a significant role, but the plots are dominated by the influence of parameter EXT, the fraction of surface **not** covered with pits or particles. A relationship is found between the parameter EXT and the inversion angle V_o at which the zero polarization occur.

$$\log EXT = 0.59 - 0.071 \times V_o$$

Table II list the values of EXT derived for Solar System objects and typical silicate powders.

Table II : Values of parameter EXT for Solar System objects

Object	Parameter EXT
Asteroid 4, Vesta	0.13
Mercury (global)	0.13
Mars (global)	0.13
The Moon (global)	0.14
Lunar fines	0.10 to 0.18
Callisto (leading hem.)	(0.16)
" (trailing hem.)	0.40
S-type asteroids	0.15 to 0.25
C-type asteroids	0.12 to 0.24
Silicate powders $\leqslant$ 25 μm	0.10 to 0.30
Silicate rocks (fractures)	>0.3

c) From this comparison between the theory and observations, the following results emerge about the surface textures of airless planetary objects : All the large atmosphereless silicaceous Solar System objects already measured, down to the diameter of Vesta which is 500 Km, namely Mars, Mercury, the Moon, Callisto (leading hemisphere) and Vesta are covered with regoliths of fines which are globally characterized by EXT = 0.13 to 0.16. The individual samples of lunar fines range from 0.10 to 0.18.

The smaller asteroids are coarser grained, as was already noted by Dollfus and Zellner (1979) and some ballistic and impact physics considerations are at hand to understand the effect. The C type asteroids, assumed to be carbon rich, appear to be finer grained than the silicaceous S type asteroids; EXT lies between 0.12 and 0.24 for these C objects, against 0.15 to 0.25 for the S objects.

The trailing hemisphere of Callisto has a very coarse grained texture, with a value of EXT : 0.40 almost reminiscent of bare rocks, a unique case for which clues about the past evolution of Callisto can be derived (Dollfus 1975, Mandeville et al, 1979).

From the clear separation between the dielectric (small MI) and metallic (high MI) surfaces which emerges from the theory, the M type asteroids, assumed to be metallic, are also fine-grained at their surfaces.

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