CHARACTERIZATION OF THE LUNAR DUST EXPLORATION ENVIRONMENT BY POLARIMETRIC SIGNATURE : NEGATIVE POLARIZATION BRANCH OF AGGREGATES OF VARIOUS POROSITY.

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Introduction: The polarimetric signature of dispersed individual Lunar regolith particles enables the characterization of the dust exploration environment. We investigate here the value of the Negative Polarization Branch (NPB) as a signature to characterize individual particles to determine if it can be used in a similar way as for surfaces of planets and atmosphere-less bodies. Numerous works have focused on inferring the properties of planetary surfaces through the characteristics of their observed polarization phase-curves ([1]-[4]). The comparison of astronomical observations to laboratory measurements on terrestrial substances has been used as a technique to characterize planetary surfaces and infer texture or surface roughness ([5]-[7]). The present work initiate a systematic study of the polarimetric properties of individual grain models in order to characterize the lunar exploration environment, where individual dust grains are dispersed above the surface. We present here the results for single spherical particles and for aggregates of spherical particles with different porosity.

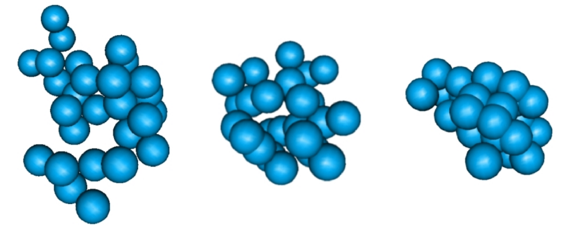

Figure 1: Prototype aggregates of porosity 0.9 (left) and 0.8 (middle) and 0.6 (right). Constitutive grains are of equal size.

Methodology: The linear polarization phase curve for single spheres of silicate and for aggregates of spherical silicate grains of different porosity have been computed using the Discrete Dipole Approximation (DDA) for a range of grain size. Computations have been carried with the DDSCAT code [8]. Targets consist of single spheres and of random aggregates of 26 spheres of equal size of three different porosity as shown in figure 1. The complex refractive index is chosen to reflect the optical properties of a typical silicate and is taken to be m=1.62+i0.003. The incident light is unpolarized and of wavelength 628.3nm. The size parameter is varied for each kind of target; it is defined as X=ka where k is the wavenumber of the incident radiation, and a is the radius of the sphere of equivalent volume. For aggregates, we define X_{agg} as the size parameter of the whole aggregate, and X_i as the size parameter of its constitutive individual spherical grains.

Summary of results : Figure 2 shows typical polarization curves and figure 3 shows the value of selected curve characteristics for a range of aggregate size for the three values of porosity, as well as for single spheres. Calculations show that polarization phase curves for spherical particles exhibit a sharp transition over a narrow range of size parameter between two distinct regimes, one typical of Rayleigh scattering and another dominated by a large NPB. The linear polarimetric signature observed for aggregates is a composite of a) the polarization induced by individual grains composing the aggregate and b) the polarization due to the aggregate as a whole particle. The weight of each component varies depending on the porosity of the aggregate. A NPB similar to the one observed for atmosphere-less astronomical bodies is seen for different ranges of the size parameter. It appears as a remnant of the negative branch exhibited by the single spherical particles. The sharper narrow negative branch that is measured for some particulate surfaces in the laboratory or seen in astronomical observations is not observed here. These results suggest that the wide negative branch is due to the scattering by individual grains and single aggregates while the narrow negative branch is more likely due to coherent backscattering or shadowing effects in bulk material. The shape and evolution of the NPB could be used to characterize spherical particles, but does not appear to be a practical candidate to differentiate univocally between aggregates of different porosity.

References: [1] Geake & Geake 1990, *MNRAS 245*, 46, [2] Kolokolova et al. 1993, *MNRAS 260*, 550, [3] Lasue et al. 2006, *Journal of Quantitative Spectroscopy & Radiative Transfer 100*, 220, [4] Shkuratov et al. 2007, *Journal of Quantitative Spectroscopy & Radiative Transfer 106,* 487, [5] Lyot 1929, *Annales de l'Observatoire de Paris Section de Meudon 8,* 1, [6] Dollfus 2000, *Icarus 146*, 420, [7] Hadamcik et al. 2006, *Advances in Space Research 38*, 2006, [8] Draine & Flatau 2004, http://arxiv.org/abs/astro-ph/0409262v2.

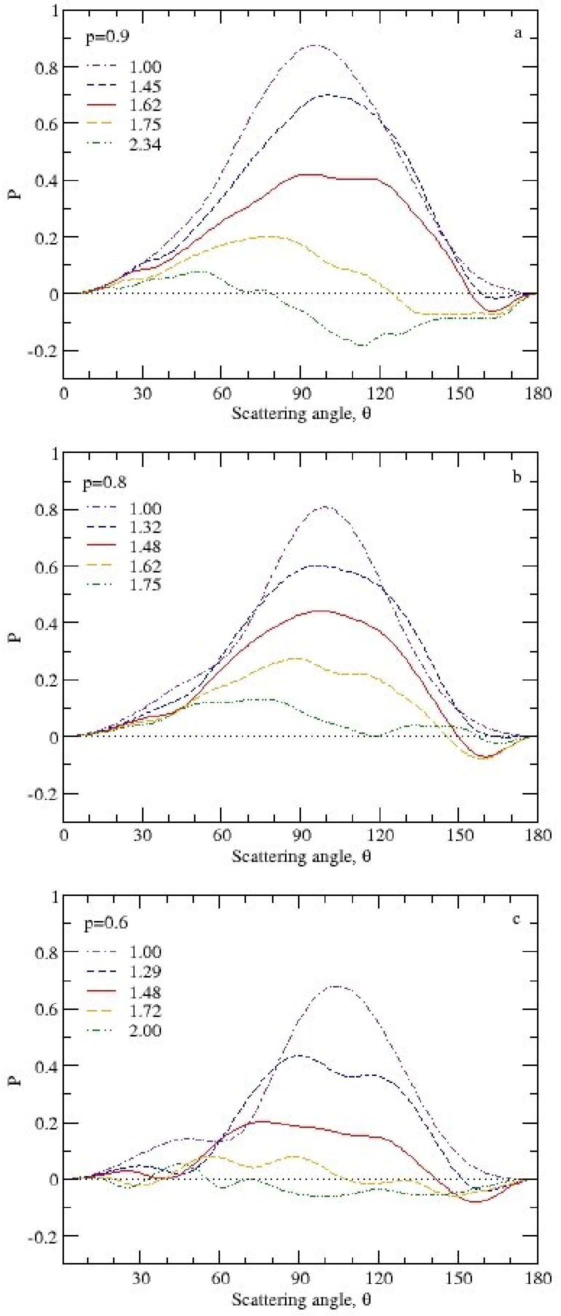

Figure 2: Linear polarization (P) phase curves for aggregates of silicate spheres of porosity (a) p=0.9, (b) p=0.8 and (c) p=0.6. For each porosity five values of Xi are shown, as labeled on each graph. As the porosity decreases, so does the amplitude of the degree of polarization. For compact aggregates of large size, (for example Xi=2.0 for p=0.6) the polarization curve becomes flat.

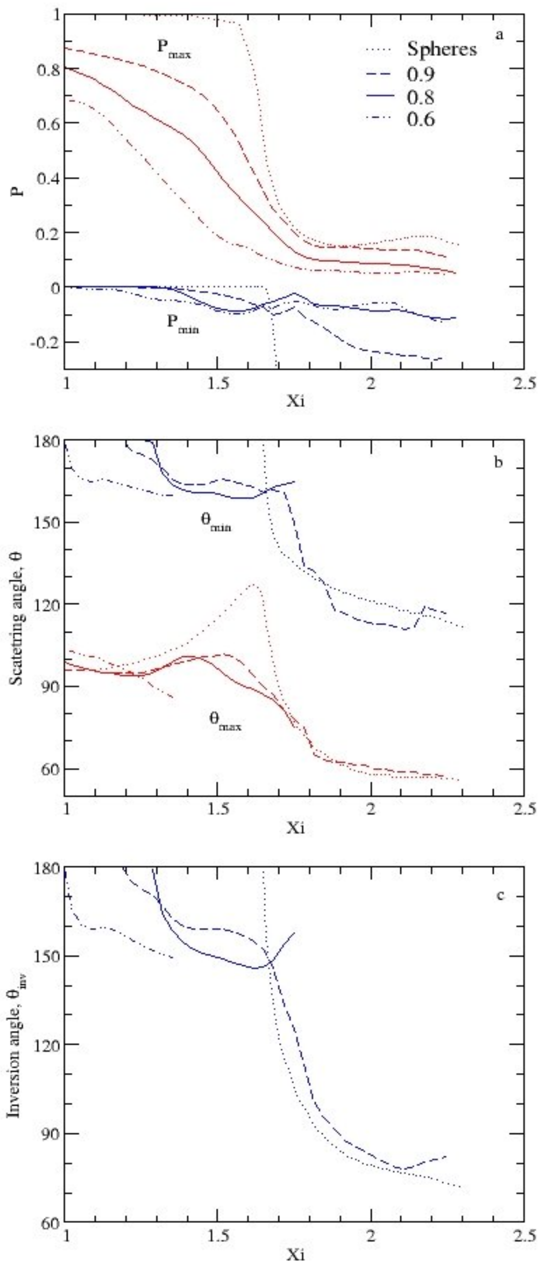

Figure 3: Characteristics of the linear polarization (P) phase curves of aggregates as a function of X : (a) P_{min} and P_{max} the maximum and minumum of P, (b) θ_{min} and θ_{max} the angles at which P_{min} and P_{max} are realized, and (c) θ_{inv}, the angle at which the polarization curve changes sign. In (b) and (c) curves are plotted only for the range of X for which a single NPB exist.