The Porosity and Composition of Dust in Different Cosmic Environments Studied Through Its Spectral Dependence of Polarization.

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For a long time the main polarimetric characteristic used for remote sensing of cosmic dust was the dependence of polarization on scattering/phase angle. This so-called phase curve appeared to have a very similar shape for a variety of dust types: cometary and interplanetary dust, asteroidal regolith and even the dust in debris disks. Numerous laboratory and theoretical simulations showed that the polarimetric phase curve of this shape is typical for fluffy materials, e.g., porous, aggregated particles. The positions and values of the minimum and maximum of the curve have been found sensitive to the size of constituent particles (monomers) in the aggregates and their composition. One more polarimetric characteristic, spectral gradient of polarization, was found different for different objects: positive for comets and negative for asteroids and interplanetary dust, indicating some important difference in the dust properties. More so, it was found that there are some comets for which the spectral gradient of polarization is negative or changes from positive to negative at long wavelengths. Both positive and negative gradients were observed in debris disks.

In this paper we show that the spectral dependence of polarization is sensitive to the porosity of the aggregated particles or regolith material as it is defined by the electromagnetic interaction between the monomers. The strength of the interaction mainly depends on how many monomers the electromagnetic wave covers at a single period (on the light path equal to one wavelength). Since the electromagnetic interaction depolarizes the light, the more particles a single wavelength covers the smaller is the polarization of the scattered light. Thus, the polarization should decrease with wavelength resulting in the negative spectral gradient of polarization. However, this tendency occurs only for rather compact particles. For very porous particles, the increase of wavelength may not increase the number of the covered monomers and in this case polarization increases with wavelength (typical case of cometary dust). We show that for each porosity a critical wavelength exists at which the spectral gradient of polarization changes from positive to negative. We also show that the electromagnetic interaction is stronger for more transparent materials that affects the value of the critical wavelength. Thus, measurements of polarization in a broad range of wavelength can be a powerful tool to study porosity and composition of the dust in a variety of cosmic environments.

Keywords: Dust; comet; debris disks; regolith; aggregates; electromagnetic interaction; polarization; wavelength.