THE OPPOSITION PHASE CURVE IN LOW ALBEDO MEDIA

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Introduction: We report the results of an investigation into the opposition surge of
circular polarization ratio with
low albedo particulate materials of varying particle size and packing density. These
very low albedo materials exhibit nearly constant circular polarization ratio with
degressing phase angle consistent with the elimination of shadows being the
overwhelming contributor to the phase curve.

The Experiment: The measurements were made on the long arm goniometer at NASA's Jet Propulsion Laboratory. The samples were presented with linearly and circularly polarized light from a laser of wavelength 0.633 μm. The samples (SiC, B4C, Fe3O4 and Co2O3) differed in reflectance from 13% to 1.6%. The reflectance of each sample measured at 5° phase angle relative to Spectralon™ was, 13%, 5%, 2.3%, and 1.7% for the SiC, B4C, Fe3O4 and Co2O3 respectively. They were presented with light that was polarized in and perpendicular to the scattering plane. A quarter wave plate was inserted into the optical train at appropriate places to permit the samples to be presented with both senses of circular polarization. The scattered beam was analyzed in both senses of linear and circular polarization. We combined the data from all of the polarization configurations and these are shown as integrated phase curves.

The Results: The phase curves all exhibit an increase in reflectance as phase angle decreases. From 5 to 0°, SiC exhibits a non-linear increase in circular polarization ratio (CPR) compared to the more absorbing media. The increase in CPR with decreasing phase angle can only be caused by significant multiple scattering in the medium. This is consistent with coherent backscattering.

Discussion: We have previously shown that significant multiple scattering is observed in materials of high reflectance (70-90%). We found the result for SiC to be unusual given that is so much more absorbing. However, if the reflectance of a material decreases still further (below 10%) the contribution of multiply scattered light to the reflectance phase curve diminishes significantly. This causes the phase curve to become nearly linear as in the case of B4C, Fe3O4 and Co2O3.

Conclusion: We find a significant contribution of multiply scattered radiation in the reflectance phase curve of materials of fairly low albedo even for some materials as with reflectance as low as 13%. The contribution of multiple scattering only becomes insignificant (although still measurable) when the reflectance approaches 5%. Low albedo planetary regoliths such as the Moon and Mercury can be expected to exhibit appreciable multiple scattering.