PLANETARY REGOLITH MICROSTRUCTURE: AN UNEXPECTED OPPOSITION EFFECT RESULT

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Introduction: The Opposition Effect (OE) is the non-linear increase in the intensity of light scattered from a surface as phase angle approaches 0^o. It is seen in laboratory experiments and in remote sensing observations of planetary surfaces. Understanding the OE is a requirement to fitting photometric models which will produce meaningful results about regolith texture. Our previous laboratory studies are consistent with the hypothesis that the OE in particulate materials is due to two processes, Shadow Hiding (SHOE) and Coherent Backscattering (CBOE)(Hapke et al., 1993; Nelson, et al. 2000; 2002). SHOE arises because, as phase angle approaches zero, shadows cast by regolith grains on other grains become invisible to the observer. CBOE results from constructive interference between rays traveling the same path but in opposite directions.

The Experiment: . In this study we measured the angular scattering properties of 9 mixtures of Aluminum Oxide and Boron Carbide powders of the same particle diameter (25 microns). The reflectance of the materials ranged from 7% (pure B_4C) to 91% (pure Al_2O_3). Along with the reflectance phase curve we measured the circular polarization ratio (CPR)-the ratio of the intensity of the light returned with the same helicity as the incident light to that with the opposite helicity. An increase in CPR with decreasing phase angle indicates increased multiple scattering and is consistent with CBOE (Hapke, 1993). Popular conceptions of CBOE (Belskaya et al, 2003) hold that materials of higher albedo would exhibit increased multiple scattering and that the contribution of CBOE to the OE would increase as albedo increases. Remarkably, we find the highest albedo samples did not have the strongest CBOE opposition peaks. Instead, the maximum CBOE contribution is observed in samples with reflectance between 15 and 40%.

Interpretation: We derived a theoretical model which reproduces the data quite satisfactorily. Consider Hapke's approximate expression for diffusive reflectance Eq 8.26, Hapke 1993)

$r_o= (1-\gamma) / (1+\gamma)$ where $\gamma=(1-w)^{1/2}$

expanded as a Taylor series:

$r_o(w)= w/4 + w^2/8 + 5w^3/64 + \ldots$ where w is the single scattering albedo

Then:

$w/4$ is the contribution of first order scattering
$w^2/8$ is the contribution of second order scattering
$5w^3/64$ is the contribution of third order scattering

The contribution of each order to the totally scattered component is shown as lines in the figure along with size of the CBOE opposition surge for each of the 9 samples, which are shown as the '*' symbol. Our model shows that the reflectance where we find the CBOE amplitude to be a maximum is where the contribution of second order scattering is largest relative to the other orders.

Conclusion: Hence, we conclude that for closely packed media the maximum contribution of CBOE does not occur in materials of highest albedo but where the relative contribution of second order scattering is largest.

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References:

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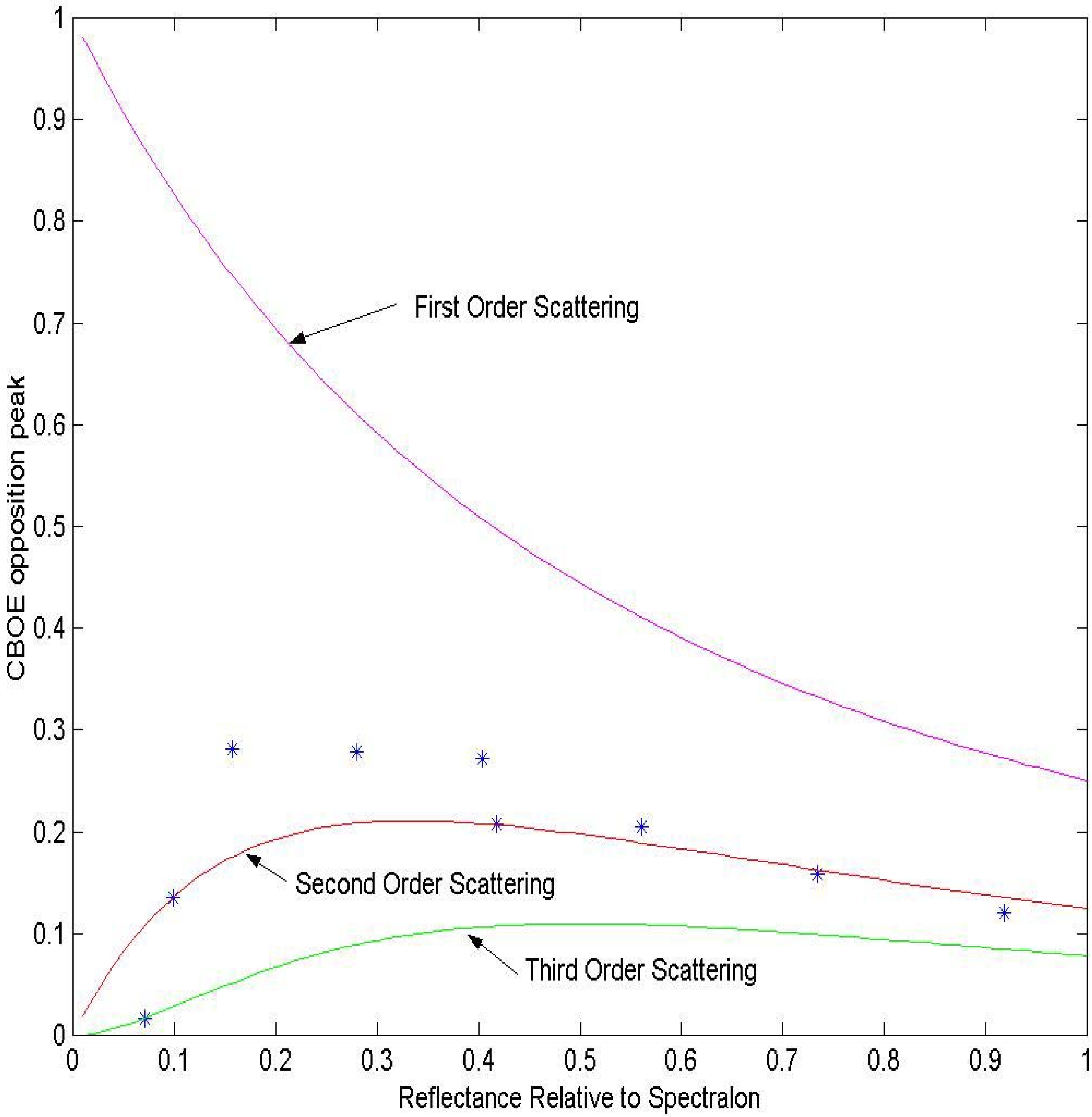

First Order Scattering
Second Order Scattering
Third Order Scattering
CBOE opposition peak
Reflectance Relative to Spectralon
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1