SCATTERING PROPERTIES OF LUNAR REGOLITH SAMPLES DETERMINED BY MIMSA FITS. J. L. Piatek[1] B. W. Hapke[2], and R.M. Nelson[3] [1] Dept. of Geological Sciences, Central Connecticut State University, New Britain, CT (piatekjel@ccsu.edu), [2] University of Pittsburgh, Pittsburgh, PA, [3] Planetary Science Institute.

Introduction: Lab characterization of the scattering properties of particulate samples using goniometric photopolarimeters (GPP) is a valuable tool for understanding reflectance data returned from telescopes and planetary spacecraft. A GPP measures the reflectance of a sample at different angles and different senses of polarization (both linear and circular). Many of these studies focus on planetary regolith analogs, such as aluminum oxide [e.g. 1,2], which can be used as a proxy for high albedo surface materials such as ices that would be difficult to study otherwise. In this case, however, we report measurements not from analog materials, but from 8 Apollo soil samples. These results should be useful in interpretation of data returned from current and future missions to the Moon.

Method: Eight samples of lunar soil were used in this study: these are referred to using their 5 digit sample number (see Table 1). Samples were poured into a sample cup so the sample surface was generally level with the edge of the cup and then gently shaken to level the surface and settle particles.

The instruments used to collect scattering data were the long and short arm GPP then housed at the Jet Propulsion Laboratory [1,2].The long arm GPP measures phase angles from 0.05° to 5° with a minimum phase angle (g) increment of 0.01° (a reconstructed version of this instrument is now in operation at Mount San Antonio College [3]). The short arm GPP measured phase angles from 4° to 140° with a minimum phase angle increment of 0.5°. This is accomplished by setting the incidence angle (i) to 60°, giving a wider range of available phase angles for the full range of possible emission angles.

Table 1: Sample normal albedos (long arm GPP).

Sample #	Albedo
A10084	0.0866
A15041	0.1033
A15271	0.1374
A15601	0.1131
A61221	0.3785
A65701	0.1682
A75121	0.0883
A79221	0.0854

Both instruments measured the intensity of laser light reflected from a sample in 8 senses of polarization (4 linear and 4 circular). Linear polarization states were parallel and perpendicular to the scattering plane, while circular polarization was achieved by using the same senses of linear polarization but including a quarter wave plate in the optical path. Emitted light was analyzed in both the same and opposite sense of polarization, giving four possible combinations for each type of polarization. Samples were analyzed in only linear or circular polarization: no mixed data were collected (e.g. circular incident/linear return).

For each data run, a 99% reflectance standard was measured in addition to the sample at a 5° phase angle (i=0°, e=5°) and in all eight polarizations. The purpose of this measurement was to allow for calibration and as a calculation of sample normal albedo. A calibrated phase curve was determined by summing results from all eight polarizations at each phase angle and dividing the result by the summed reflectances from the standard in all polarizations.

The resulting phase curves were subjected to a series of theoretical fits to attempt to determine various scattering properties. These were fit using the modified isotropic multiple-scattering approximation (MIMSA) model [4] both without and with corrections for the opposition effect. The parameters varied are the single scattering albedo (w), single scattering function (p(g)) and the amplitude and half-width of both the shadow-hiding and coherent backscatter opposition effects.. The single scattering function was represented as a symmetric double Henyey-Greenstein function, which produced the best fit to the dat and is commonly used in this type of modeling. Data from the long arm goniometer will include contributions from both opposition effects, while it is likely that the short arm data contain only effects from coherent backscatter and then only at the smallest phase angles.

Results: Phase curves from both the long arm (Figure 1) and short arm (Figure 2) are fairly similar for all samples except soil A61221, which also has the highest normal albedo (see Table 1) and strongest apparent opposition surge in long arm data. The remaining samples, regardless of relative albedo, have similar phase curves that suggest backscattering samples with coherent backscatter opposition surges that extend a bit past 5 degrees phase (and thus are apparent in the short arm phase curves). Initial model fits are consistent with observations, with single scattering functions suggesting backscattering samples and coherent backscatter opposition surges reaching slightly beyond 5° phase.

References: [1] Nelson, R. M. et al, Icarus **147**, 545, 2000. [2] Piatek, J.L. et al., Icarus, 171, 531, 2004. [3] Nelson, R.M. et al, LPSC 46, #2584. [4] Hapke, B. W. Theory of Reflectance and Emittance Spectroscopy, Cambridge University Press ISBN 978-0-521-88349-8 2012.

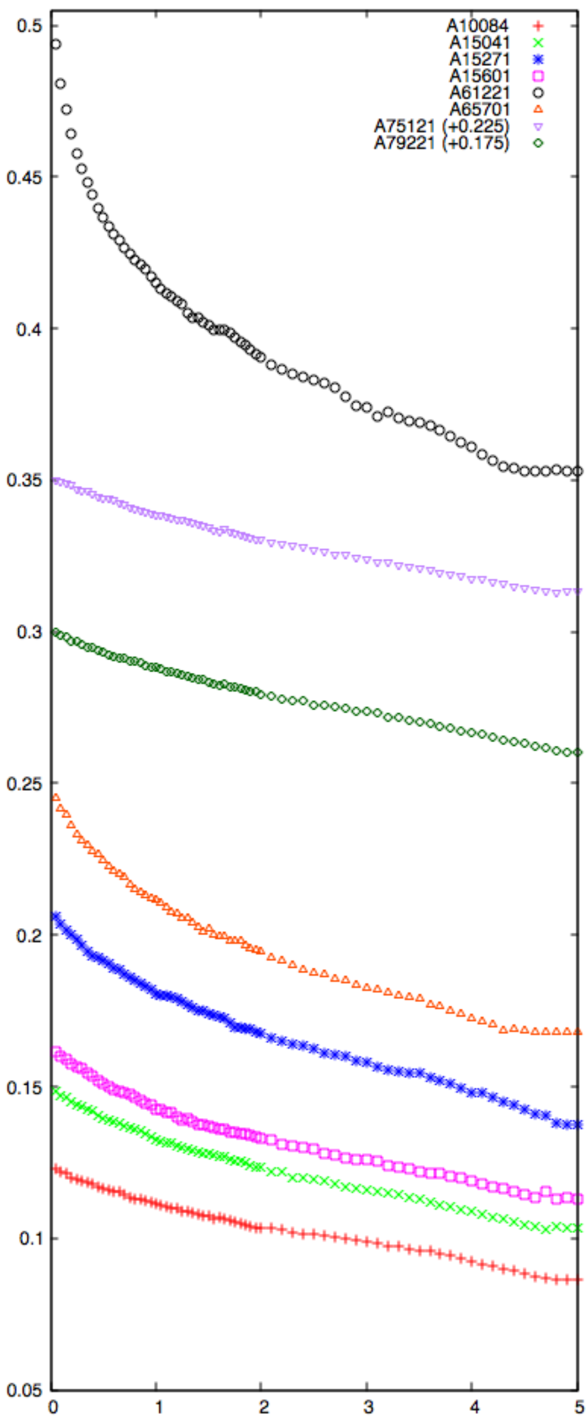

Figure 1: Long arm phase curves (reflectance vs. phase angle). Some curves are offset for clarity (amount noted in the legend). Symbol colors and shapes for each sample are the same as Figure 2.

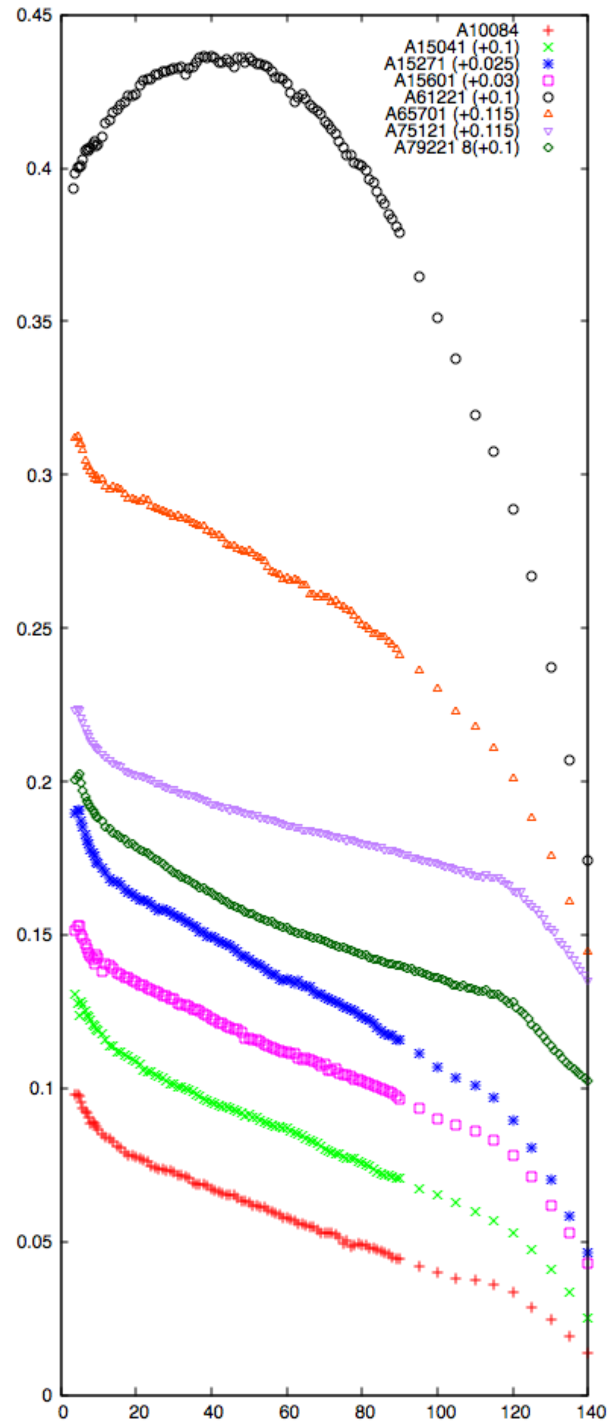

Figure 2: Short arm phase curves (reflectance vs. phase angle). Some curves are offset for clarity (amount noted in the legend). Symbol colors and shapes for each sample are the same as Figure 1.