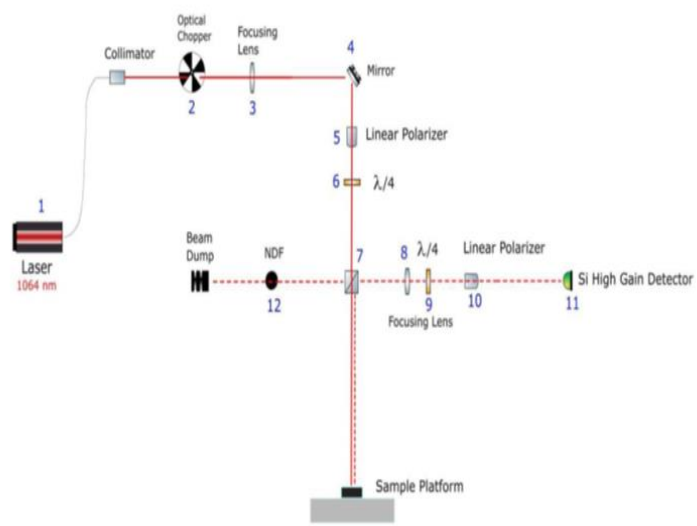
OPTICAL POLARIZATION STUDIES OF SUSPENDED BEADS IN AQUEOUS SOLUTION: AN ANALOG FOR RADAR SCATTERING IN ICY REGOLITHS. Antoine V. Bourget[1], Michael Daly[1], Parvathy Prem[2], and David T. Blewett[2], [1]Dept. of Physics, 4700 Keele St, Toronto, ON M3J 1P, [2]Planetary Exploration Group, Johns Hopkins University Applied Physics Laboratory, Laurel, Md., USA. (antoine1@yorku.ca)

Introduction: We present a study of icy regolith analogs at low phase angle, with the aim of improving our understanding of radar scattering in planetary icy regolith in the solar system. We study low phase angle measurements of same-sense circular polarization (SC), opposite opposite-sense circular polarization (OC), and circular polarization ratio (CPR) of spherical latex beads in aqueous solution at 0.8 µm (wavelength in water), and of alumina powder at 1.064 µm (in air) using a custom Multi-Axis-Goniometer-Instrument (MAGI); with the aim of improving our understanding of radar measurements for icy planetary regolith. Alumina is an excellent analogue due to its hexagonal crystal structure, which matches that of water ice. Crystals of H_2O tend to form platelets that are highly reflective this is also true for our powders of Al_2O_3 [1]. Suspended latex beads in aqueous solution act as a highly reflective material (water ice) in a transparent medium (water) and can be used to model a variety of icy regolith geophysical configuration by changing the size, concentration, and absorption of the beads.

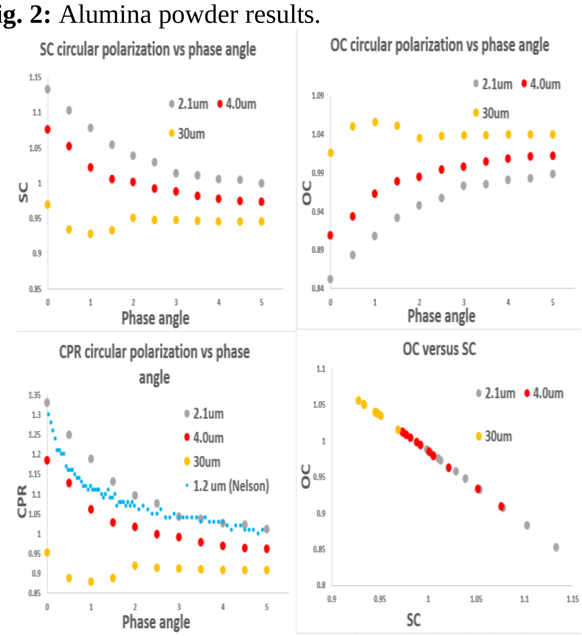
Experiment: The measurements presented here were acquired using the MAGI facility at York University. One advantage of our goniometer is that we can do polarimetric measurements at zero phase angle using a 45° beam-splitter. Other goniometers have a simpler configuration where both detector and source are on separate vertical axes, but due to obstruction they cannot observe at zero phase angle (direct backscatter conditions), this enables us to have a physical understanding of the backscatter conditions of our samples and thus of the icy regolith. Our experiment (Fig. 1) consists of measuring the SC and OC, as well as circular polarization ratio (CPR) at small phase angles (0-5-degree), at 0.5-degree intervals. We measure the reflected intensity for several depths of latex beads solution to determine the influence of reflections from the bottom of the sample cup. The depth that minimizes reflections is 7 mm+/-0.5 mm. Using a combination of a Linear polarizer (LP labelled 5 in Fig. 1), and quarter wave plate (QWP labelled 6 in Fig. 1), and square mirror we generate an incident right-circular polarized signal defined by Stokes vector $S_i = [S_0, S_1, S_2, S_3]=[1,0.2,0,-0.91]$. The incident signal is split by the beam splitter (BS labelled 7 in Fig. 1), and the second half is sent through a neutral density filter plate (ND-plate) to prevent unwanted scattered light from reaching the detector. The output Stokes vector is calculated by sending the scattered light from sample through a second quarter-waveplate (QWP labelled 9 in Fig. 1), and a second linear polarizer (LP labelled 10 in Fig. 1), and to a photo-diode detector (labelled 11 in Fig. 1). Depending on the size, concentration, and absorption properties of the scattering medium (sample), the amount of scattered signal in the same sense (right circular) or in the opposite sense (left circular) will vary; the CPR is calculated by measuring the SC/OC ratio. To test the reliability of the instrument, low phase angle measurements of circular polarization and CPR of standardized WCA Micro Abrasives Corp. Al_2O_3 powders are collected at 1.064 μm (air), and compared to the results from Nelson [2] with similar d/λ.

Fig. 1: MAGI set-up.



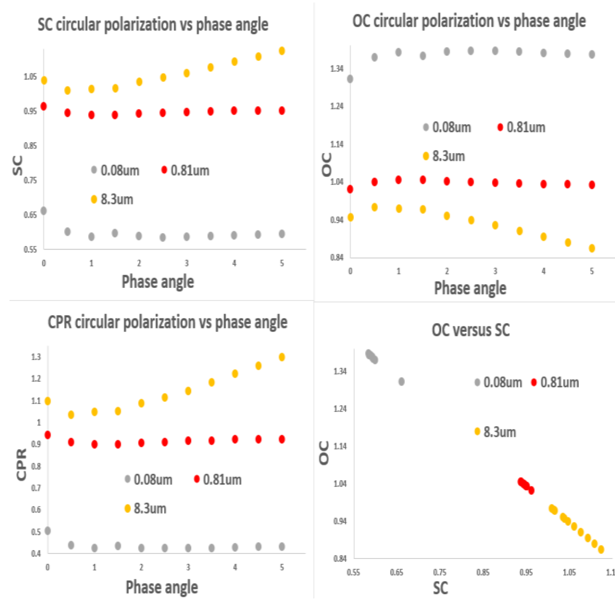
Primary results: Alumina scatterers (Fig. 2) in the Mie regime (4.0 µm and 2.1 µm size powders) have high CPR curves (CPR>1) and have a SC and CPR minimum and OC maximum occurring at 5-degree phase angle. Alumina scatterers in the geometric regime have a low CPR curve (CPR<1) where the shape of the CPR, SC and OC curves are different from the Mie scattering regime and are characterized by a SC and CPR minimum and OC maximum at 1-degree phase angle. Our 2.1-µm alumina sample has a similar *d*/λ to Nelson's 1.2 µm, and both CPR curves are within 5% of each other indicating reliable measurement.

Fig. 2: Alumina powder results.



Latex beads in aqueous solution are presented in the Rayleigh, Mie, and Geometric scattering regimes (Fig. 3). Beads in the Mie and Rayleigh scattering regime have low CPR curves (CPR<1) and the shape of the CPR, SC and OC curves are very similar and are characterized by a SC and CPR minimum and OC maximum at 2.5-degree and 1.5-degree respectively. Beads in the geometric scattering regime are the most interesting, the CPR curve is high (CPR>1) and the shape of the SC, OC and CPR curves differ greatly from the Rayleigh and Mie scattering regime, where the SC and CPR minimum and OC maximum occurs at 0.5-degree phase angle.

Fig 3: Suspended latex beads in aqueous solution results.



Conclusions: Our results clearly outline the difference between each scattering regime (Rayleigh, Mie and Geometric), suggesting different analog surface (alumina) and subsurface (beads) scattering conditions that indicate a variety of geophysical conditions in planetary icy regoliths, such that the size and the spatial distribution of the reflective scatterers. Future work will focus on how the volume concentration and absorption properties of the scatterers affect the SC, OC, and CPR curves. We will also explore the mixing of different size populations of scatterers with the aim of modeling non-uniform population distribution of reflective scatterers (water-ice).

References: [1] R. M. Nelson et al. (2018), *Icarus* 30, 483-498. [2] R.M. Nelson et al. (2000), *Icarus 147*, 545–558.