Paper ID: 41771
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SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations (IP)

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SURFACE STUDIES OF ICY REGOLITHS USING LIGHT SCATTERING AT SMALL PHASE ANGLES

Abstract

Several surfaces in the solar system such as the icy Galilean satellites of Jupiter and shadowed polar craters on Mercury return highly polarized radar signals as a result of coherent backscattering opposition effect (CBOE) from icy deposits. The physical cause of the effect is due to the enhancement of radar brightness by volume scattering within a low-loss medium. Interpretation of radar data from the Moon has implied the possibility of icy deposits in lunar polar craters. To understand the physical properties of lunar icy regoliths, optical analog measurements were conducted to analyze the effect of variables that can control the backscattering of electromagnetic radiation. The following aspects of the scatterers are pivotal: size, distribution, number density, and absorption properties of the host medium and scatterers themselves. Measuring reflectance at near-zero phase angles (0-10, step size of 0.5) determines the effects of these variables on the strength and polarization of the reflected signal as a function of phase angle. At small phase angles, it is expected that a narrow spike in brightness is observed and is negatively polarized, typical of icy regoliths. A setup was created on the goniometric altimeter to measure the change in reflectance and circular polarization ratio (CPR) with respect to phase angle for several highly reflective aluminum oxide powders and suspended polystyrene beads. The experiment utilizes a 1064nm wavelength, chopped laser beam. As it reflects off a mirror at 45, the incident beam becomes circularly polarized and hits the beam splitter before bifurcating to the sample surface. The scattered light is collected and sent to the analyzer section, consisting of a rotating quarter wave plate and a fixed linear polarizer, attached on the movable arm before being detected. The data was analyzed to compute the CPR, Stokes parameters, m-chi and three "decomposition" parameters (R, G and B) which differentiate the effects of single-bounce, double bounce and CBOE volume scattering. The reflectance is greatest when the particle size is within a few wavelengths of the incident radiation. A decreased scattering efficiency from small particle size results in a reduced reflectance for particle sizes smaller than the incident radiation wavelength. Plotting reflectance phase curves with CPR shows contribution of CBOE. The research will help to constrain purity of ice and the kind, abundance and size distribution of scatterers responsible for coherent effects. Understanding lunar ice regions will allow us to re-interpret published radar data for Mercurian deposits.