IN HOUSE-DEVELOPED GONIOMETER TO SUPPORT MEASUREMENTS OF THE BIDIRECTIONAL REFLECTANCE DISTRIBUTION FUNCTION (BRDF) OF CO_2 ICE MADE IN AN ENVIRONMENTAL CHAMBER THAT SIMULATES MARTIAN POLAR CONDITIONS. Jamie A. Isen[1] and Isaac B. Smith[2], [1]York University Lassonde School of Engineering

Introduction: Mars has a South Polar Residual Cap (SPRC) that persists throughout the warmest months on the planet. When Mars' southern hemisphere enters the coldest months CO_2 ice deposits from the atmosphere to form seasonal caps.

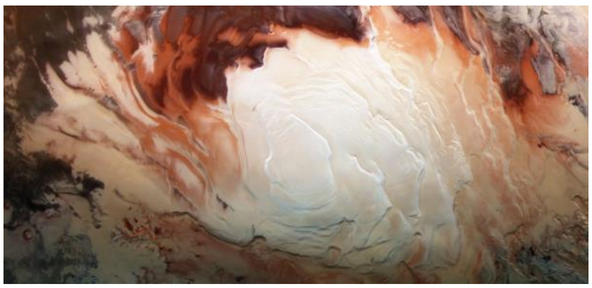

Figure 1. Image of SPRC (Mars Express 2012) [4].

Hyperspectral images recorded from planetary mission spectrometers provide various illumination and observation angles of planetary surfaces [1]. These instruments provide us with data that allows us to study the properties of surface materials.

Remote-sensing spectrometers such as the Compact Reconnaissance Imaging Spectrometer (CRISM) flown on Mars Reconnaissance Orbiter (MRO) provides hyperspectral images of the seasonal cap and the SPRC.

However, both surface and atmospheric characteristics taken from orbit cannot be fully explained without obtaining a reference from laboratory experiments.

One such measurement that has not been made in any lab before is the bidirectional reflectance distribution function (BRDF) [1] of CO_2 ice. This motivates us to use the MARs Volatile and Ice evolution (MARVIN) chamber at York University to make these novel measurements.

With MARVIN we can control various pressure and temperature regimes to simulate environments that are analogous to the seasonal changes of Mars and then with our goniometer perform spectral BRDF measurements to compliment CRISM observations, similar to Fig 2.

Mars Polar Environment Chamber: Our environmental chamber is a 1-meter-long cylindrical stainless steel vacuum chamber with an outer diameter of 71 cm. Inside the chamber, we have three cooling zones: a platen that acts as a base for all measurements, a cold plate where we make and control samples, and a

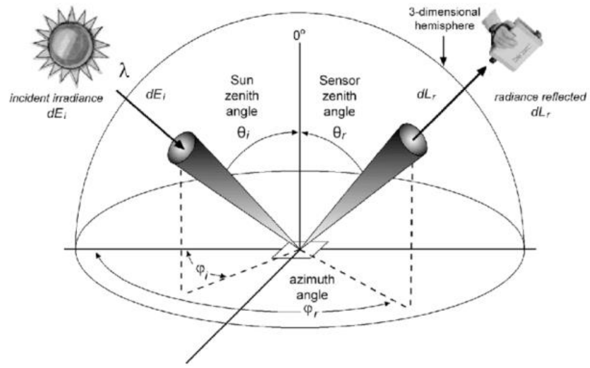

Figure 2. Example Concept and Parameters of BRDF Measurement.

shroud. To cool each zone liquid N_2 (LN_2) is fed through the walls of the chamber at three ports (Fig 3).

The purpose of the shroud, which is covered with space-black, high-emissivity paint, is to create a cold sky that does not emit radiation towards our sample, allowing it to behave more consistently with conditions on Mars. Further the shroud supports cooling of the internal atmosphere to lower the surface temperature and the thermal gradient with samples that are primarily cooled from the bottom. The platen is cooled for the same reasons.

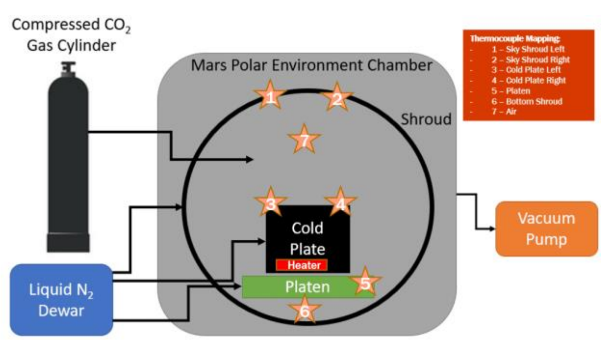

Figure 3. Polar Environment Chamber Schematic

Goniometer: In past experiments using MARVIN, spectral measurements were made with 0° phase angle only. We built a goniometer in house to vary both incidence and detector angles individually along the principal plane, giving us the phase information needed to make the BRDF measurements.

Our goniometer consists of two fiber optics cables on two separate robotic arms. One arm hosts the incidence light, and the other carries the detector with a collimating lens. The robotic arms are designed to vary the angles of each probe between +/- 60° from the 0° nadir position.

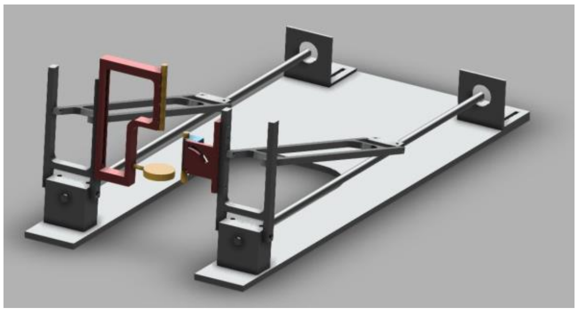

Figure 4. AutoCAD Design of Goniometer.

The collimating lens has a focal distance of 4 cm that serves to redirect more light into the detector. The detector cable is linked to an Avantes Avaspec-NIR spectrometer that records NIR spectra between 1-2.5 μm with a minimum resolution of 12.9 nm. The illuminating source fiber optic cable is connected to an Avantes Avalight-HAL-S-Mini source light with a wavelength range of 360-2500 nm.

Figure 5 shows results from a trial run of our goniometer where we have various levels of reflectance when changing incidence and detector angles. Calibration and optimization of the goniometer and chamber are nearly finished development.

Special Calibration: Reflectance calibration is performed with Spectralon Diffuse Reflectance Standards. The standards consist of a variety of highly Lambertian pucks (reflectance is constant regardless of the view angle) that represent various percentages of reflectance.

Preliminary Results and Interpretation: In previous work we have successfully grown CO_2 ice under Martian conditions [2]. We measured the albedo of ice we have grown using an infrared camera and its reflectance with our spectrometer. Using Spectralon reflectance standard pucks as a reference we can determine the albedo of the ice. This is done by normalizing to the standard pucks thus obtaining a 0° phase albedo.

We have also observed CO_2 ice textures under various pressure and temperature regimes [2]. When CO_2 ice deposits on our cold plate it forms in one of two modes: transparent slab ice, or fine-grained frost [2]. These modes were expected as they have been observed in previous laboratory experiments [7] and are believed to be found on Mars [6].

We observed fracturing and healing in every experiment that resulted in slab ice. However, to simulate basal warming and the formation of "Cryptic Terrain" (with surface features including "Spiders") on Mars SPRC, we use a heater located beneath our cold plate. This is analogous to what is expected from the Keiffer model [6].

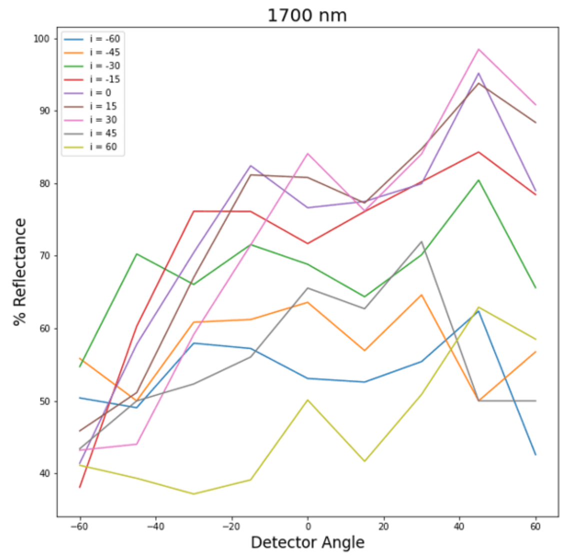

Figure 5. BRDF Measurement using goniometer.

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