DISK-INTEGRATED POLARIZATION OF THE MOON IN THE ULTRAVIOLET. Gregory M. Holsclaw[1], Martin Snow[1], and Willliam E. McClintock[1], [1]University of Colorado, Laboratory for Atmospheric and Space Physics, 1234 Innovation Dr., Boulder, CO 80303 (holsclaw@colorado.edu).

Introduction: We have obtained the first disk-integrated measurement of the lunar polarization at ultraviolet wavelengths and only the second polarization measurement of the Moon to date. We present the results of these measurements, compare with previous and related results, and explore their scientific value.

Background: Sunlight scattered from the Moon's surface is known to be partially linearly polarized [1]. The degree of polarization is a strong function of phase angle (measured at the Moon between the Sun and observer): zero at full Moon (0 degrees), a small negative minimum at ~15 degrees, a positive maximum at ~100 degrees, and declining toward zero approaching the new Moon (180 degrees). Volume and multiple scattering, which dominate for bright surfaces, has the effect of randomizing the polarization of incident light resulting in scattered light which is unpolarized. Single scattering (first surface reflectance) dominates for low-albedo surfaces, and the light scattered is linearly polarized. These properties are used to explain the observed "Umov" effect that the polarization of the Moon increases toward shorter visible wavelengths proportional to the decrease in reflectance [2, 3]. The degree of polarization has been determined to also be a function of grain size [2].

Instrumentation: The SOLar Stellar Irradiance Comparison Experiment (SOLSTICE) [4] is one instrument onboard the Solar Radiation and Climate Experiment (SORCE) spacecraft [5]. The primary objective of SOLSTICE is to measure the solar spectral irradiance in the wavelength range 115-320 nm by directly observing the full disk of the Sun. In order to characterize expected declines in sensitivity over time, this instrument has the ability to measure the irradiance of a set of photometrically stable stars. The required dynamic range of $\sim 10^9$ is accomodated by changes in entrance aperture, spectral resolution and integration time. This unique ability of SOLSTICE allows for its use to observe both the Sun and Moon, resulting in an accurate measure of the lunar reflectance [6].

SOLSTICE operates as a scanning-grating monochromator, and thus it exhibits a wavelength-dependent linear polarization sensitivity (~60% for the range 250-300 nm). The linear polarization response of the instrument was measured prior to launch [4].

Dataset: We have acquired reflectance spectra of the Moon across a wide range of phase angles (-170 to +170 degrees) using the entire wavelength coverage of SOLSTICE [6]. For the current analysis, we limit the wavelength interval to 220-300 nm of the Middle-UltraViolet (MUV) channel. Pointing contraints of the SORCE spacecraft result in the acquisition of spectra at a variety of roll angles (Fig 1). Roll angle refers to the angle between the cross-dispersion axis of the instrument and the normal to the scattering plane, (defined by the Sun, Moon, and spacecraft).

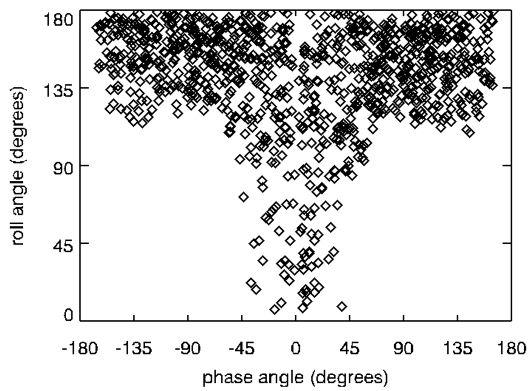

Figure 1 – Plot of roll angle (measured between the cross-dispersion axis of the instrument and the normal to the scattering plane) versus phase angle for all MUV spectra.

Derivation of lunar polarization: The serendipitous sampling of roll angle space as a function of phase angle is what allows for the derivation of the lunar polarization. By representing the partially polarizing effects of the Moon and SOLSTICE as Mueller matrices, the observed lunar irradiance can be found to be proportional to roll angle, r, in the form A+Bcos(2r) where A and B are constants empirically determined for any one wavelength and phase angle. The lunar polarization is proportional to the ratio of B to A divided by the instrument polarization at the same wavelength.

Preliminary Results: Figure 2 shows an example of the disk-integrated polarization of the Moon as measured by SOLSTICE at a wavelength of 260 nm as a function of phase angle. Error bars are calculated from the goodness of fit between the model described above and the data. Also shown in Fig 2 are similar curves at a wavelength of 336 nm and 534 nm [7]. The functional form of the SOLTICE measurement is consistent with the curves representing the near-ultraviolet and visible wavelengths. Negative phase angles refer to the waxing phase of the Moon (prior to full) while positive phase angles refer to the waning phase. Because the western portion of the nearside Moon exhibits a greater relative abundance of dark, mare material the polarization is higher at positive phase angles. This effect is still observable at 260 nm in the SOLSTICE data.

This dataset will allow us to determine the phase-dependent polarization of the Moon across a range of ultraviolet wavelengths. Further comparisons will be made to similar results at visible wavelengths [7] and to resolved measurements from the only other polarization measurement of the Moon in the ultraviolet [8].

We expect that continued improvements to the data processing will allow for more accurate determinations of the polarization, which will allow us to explore the full range of measured phase angles.

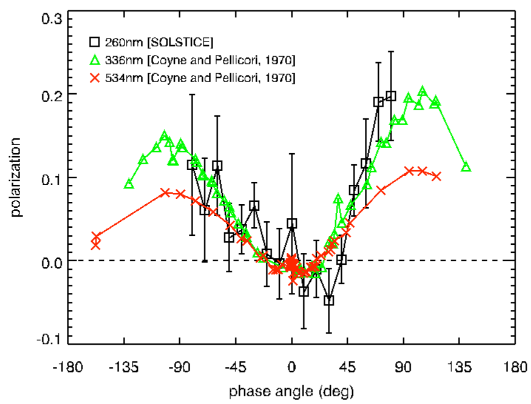

Figure 2 – Disk-integrated polarization of the Moon vs phase angle as measured by SOLSTICE (wavelength of 260 nm), and by Coyne and Pellicori (336 and 534 nm) [7].

References: [1] Lyot, B. (1929). *Annales de l'Observatoire de Paris 8.* [2] Dollfus, A. (1998) *Icarus 136*:69–103. [3] Shkuratov, Y. et al. (2011) *Planet. Sp. Sci 59*, 1326-1371. [4] McClintock, W. E., Rottman, G. J., and Woods, T. N. (2005) *Solar Phys., 230*:225–258. [5] Rottman, G. (2005) *Solar Phys., 230*:7–25. [6] Snow, M., Holsclaw, G., McClintock, W. E., and Woods, T.. (2007) *Proc. of the SPIE,* Vol. 6677. [7] Coyne, G. V., and Pellicori, S. F. (1970) *Astron. J. 75*:54. [8] Fox, G. K. et al. (1998) *Moon 309*:303-309.