INTRODUCTION AND OBSERVATIONS

Multi-band polarimetry is a powerful tool for understanding the surface characteristics of airless planetary bodies such as those of the Moon. Polarized light scattered on an airless body contains information such as mean particle size, compositions, porosity, that can be estimated by analyzing the degree of polarization whose spectral behavior is not well known yet. We carried out multi-band (u, b, v, r, and i pass-bands) polarimetric observations toward the lunar surface from Lick observatory using 15cm reflecting telescope. We calculate the size parameter of the lunar regolith from our polarimetry data utilizing the albedo map from Clementine. Comparing the polarization maximum ratios and size parameters between adjacent band-passes, we found that different topography (maria and highlands) show different spectral behavior of the polarization properties. We anticipate that understanding of the spectral dependency of the polarization properties may help understand the different regolith properties between maria and highlands.

SIZE PARAMETERS

The relation between the polarization maximum $P_{\text{max}}$ and the albedo on the lunar surface is given by,

$$P_{\text{max}} = C_1(d)A^{-1.37},$$  

where $C_1(d)$, a size parameter, is dependent on the particle size of the regolith grains (Dollfus, 1998). The parameter $C_1(d)$ is expressed by

$$C_1(d) = (1.76 - 0.021) \times 10^{-5},$$

where $d$ is a mean particle size in μm and $\gamma$ and $\delta$ are coefficients. $\gamma$ and $\delta$ were determined to be 1.76 and 0.021, respectively, by experimental analysis on the lunar samples and artificial regolith at the wavelength 5800 Å from Dollfus.

We found that the $C_1(d)$ parameter has dependencies not only on the particle size but also on the observing wavelengths. Figure 2 shows discrepancies of the mean particle size of maria and highlands derived at u, b, r, and i bands when d in Eq. (2) is fixed to that at v bands, as Dollfus suggested. It is clearly seen that $\gamma$ and $\delta$, therefore $C_1(d)$, depend on the observing pass-bands.

OPTICAL MATURITY AND MEAN PARTICLE SIZE

- One of the most well-known maturity index is the optical maturity (OMAT) which is derived from the reflectances of 7500 Å and 9500 Å (Lucey, 2000).
- We compared the OMAT with the $C_1(d)$, the size parameter, calculated at the five optical pass-bands. Figure 3 shows that the OMAT and the mean particle size have strong correlation as a maturity index. However, the swirl, Reiner Gamma is separated from the other geographical features.

SPECTRAL PROPERTIES OF $P_{\text{max}}$ AND NANOPHASE Fe

- Figure 6 is a $P_{\text{max}}$ Versus $P_{\text{max}}$ ratio plot for the lunar surface. At the ratio between u and i bands, the $P_{\text{max}}$ ratio is almost the same for both maria and highlands. However, at longer wavelengths, the $P_{\text{max}}$ ratio at highlands tends to become smaller. Then, it makes the mean particle size to vary (Fig. 5).
- The degree of polarization is defined by

$$P = \frac{I_\parallel - I_\perp}{I_\parallel + I_\perp},$$  

where $I_\parallel$ and $I_\perp$ are the intensities of light scattered on the surface and on the inward side, respectively, of the individual regolith particle.
- According to Shkuratov et al. (2007), the $I_\parallel$ is not affected by nanophase Fe. The interacting depth of $I_\parallel$ increases along with the wavelength. Also, the distributions of the nanophase Fe particles are in a wide range of depth from a few nanometers up to several hundred nanometers (James et al., 2002). As the exposed time in space environments passes more and more, the nanophase Fe spreads deeper inside the regolith particle.
- Therefore, it is suggested that multi-band polarimetry can be a tool to estimate the depth of nanophase Fe inside the particle.

CONCLUSIONS

1. We show that the $\gamma$ and $\delta$ are different at u, b, v, r, and i bands.
2. The mean particle size is a more effective method to measure the exposed time in space environments, especially for a swirl-like region.
3. We suggest that the wavelength dependency of the $P_{\text{max}}$ ratio might be from nanophase Fe on the surface of the regolith particles.
4. The multi-band polarimetry can give a clue to understanding the distributions of nanophase Fe in the regolith particle.

FUTURE WORKS

We have plans to carry out computer simulations and laboratory experiments using lunar samples and artificial regolith to help analyses of the multi-band polarimetry in this work.