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The grain size dependence of the lunar opposition spike

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1. Abstract

The Moon surface shows the brightening at small phase angles. This phenomenon is known as the opposition effect. The brightness opposition effect is affected by various physical properties of the surface such as roughness, albedo, wavelength, and grain size. The lunar opposition effect is caused by the shadow-hiding effect weakened by incoherent multiple scattering. The coherent backscattering may also contribute to the brightening, especially, for high albedo surface. In this paper, we focused on the coherent backscattering component. Using experimental and theoretical analyses several researches have shown that the grain size significantly effect on the opposition effect [1-3]. However, the grain size effect is not well-studied with observational methods. To understand the dependence on the grain size, we analyze the data with phase angles of less than 6 degrees from Lunar Reconnaissance Orbiter Wide Angle Camera (LRO WAC) and the grain size data from polarimetry. All the data include reflectances at phase angles less than 1.5°. We find that there are no correlation between the grain size and the brightness opposition effect. This is in agreement with the conclusion suggested in [11] that the coherent backscattering of the Moon is fairly small because of low albedo of the lunar regolith.

2. Data

We collect and analyze LROC WAC data that satisfy the following conditions, which are photometric conditions such as an incident, emission, and phase angle. The ranges of the incident and emission angle are from -10° to 10°. The range of phase angles is less than 10°. In addition, the data are limited to near-side because we have a grain size map only for the near-side. We analyze 1284 images from LROC WAC. The grain size map was constructed by using polarimetric and photometric observation data by [4],

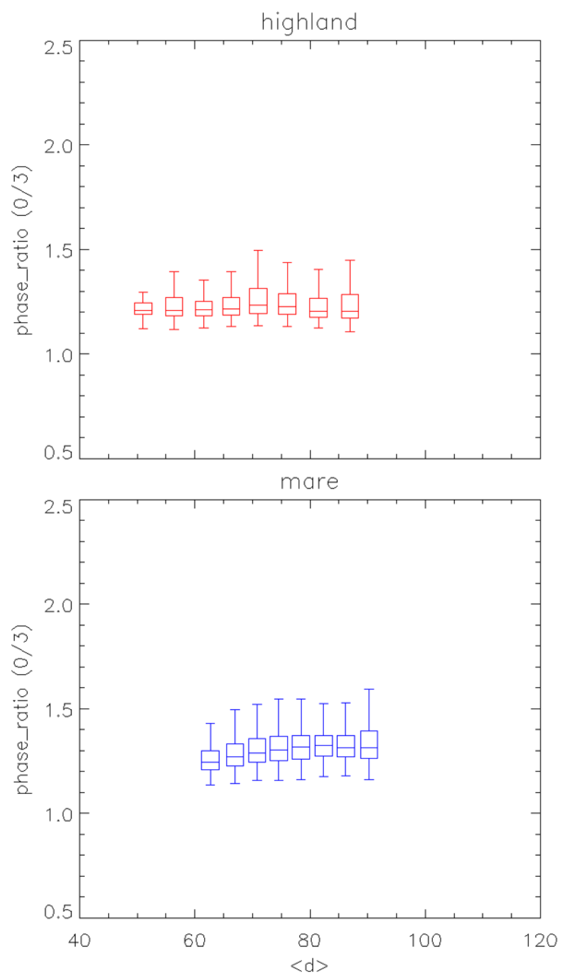

Figure 1: Phase ratios ($R_{0°}/R_{3°}$, y-axis) depending on regolith grain size (x-axis). The upper and bottom figures show highlands (red) and maria (blue) regions, respectively.

which map was derived by an empirical method developed by [5]. To remove the photometric effect by incident and emission angle, we apply a disk function derived by [6, 7]. The data are analyzed quantitatively for every single location (image scale: 2 km/pixel) by fitting a lunar phase curve model derived by [8].

3. Results and discussions

We construct the phase ratio Π map to analyze the grain size dependence of lunar phase curve; i.e., $\Pi = R_{\theta 1} / R_{\theta 2}$, where R_{θ} is a reflectance at phase angle of θ. We analyze the Π maps at $R_{0°}/R_{3°}$, $R_{3°}/R_{6°}$, and $R_{6°}/R_{15°}$. **Figure 1** shows $\Pi_{0°/3°}$ distributions depending on the grain size for the highlands (upper red) and maria (bottom blue) at 604 nm passband. According to the theoretical [2] and experimental [1] predictions, the lunar phase curve has a correlation with the grain size. The phase curve slope is expected to be steeper when the grain size increases at the phase angle range from 0° to 3°. However, **Figure 1** shows no correlation between the phase curve and grain size.

One of the possible causes is that the lunar opposition effect is not dominated by coherent backscattering even the phase angle range from 0° to 3°. The coherent backscattering requires multiple scattering but lunar regolith is very dark. Therefore, the multiple scattering is relatively weak in lunar regolith. Thus, the relative contribution of coherent backscattering on the lunar opposition effect can be not important [11].

In this paper, the spatial resolutions are very different between the reflectance (100 m) and grain size data (2000 m) and the observation methods are also different each other. LROC WAC data are from orbiter and the grain size data are from ground-based telescope. Wide-Angle Polarimetric Camera which is an instrument of Korea Pathfinder Lunar Orbiter, will provide more detailed data.

References

[1] Ovcharenko et al., Particle size effect on the opposition spike and negative polarization, JQSRT, 101, 394-403, 2006.

[2] Akkermans et al., Theoretical study of the coherent backscattering of light by disordered media, J.Phys.France, 49, 77-98, 1988

[3] Marks et al., Light scattering in strongly scattering media: Multiple scattering and weak localization, Phys. Review, 37, 7, 1988

[4] Jeong et al., Multi-band polarimetry of the lunar surface. I. global properties, APJS, 2015, 221, 16

[5] Shkuratov and Opanasenko, Polarimetic and photometric properties of the Moon: Telescope observation and laboratory simulation, 1992, Icarus, 99, 468-484

[6] Akimov et al., Dependence of lunar highland brightness on photometric latitude, Kinem.Phys.Celest.Bodies, 15, 232–236, 1999.

[7] Akimov et al., Dependence of latitudinal brightness distribution over the lunar disk on albedo and surface roughness., Kinem. Phys. Celest. Bodies, 16, 137–141, 2000.

[8] Velikodsky et al., New Earth-based absolute photometry of the Moon., Icarus, 10, 1016, 2011

[9] Nelson et al., Planetary regolith microstructure: An unexpected opposition effect result, paper presented at 35th Lunar and Planetary Science Conference, Lunar and Planet. Inst., Houston, Tex.

[10] Hapke et al., The wavelength dependence of the lunar phase curve as seen by the Lunar Reconnaissance Orbiter wide-angle camera., JGR, 117, E00H15, 2012

[11] Kaydash V.G., Pieters C.M., Shkuratov Y.G., Korokhin V.V. Lunar opposition effect as inferred from the Chandrayaan-1 M^3 data. JGR, 2013. 118(6), 1221-1232, doi:10.1002/jgre.20098.