Color polarimetry of the Moon at large phase angles as a tool to study regolith properties

Y. Shkuratov (1), C. Pieters (2), N. Opanasenko (1)

(1) Astronomical Institute of Kharkov Univ., 61022, Ukraine, (2) Dept. of Geosciences, Brown University, Providence, RI 02912, USA. (e-mail: shkuratov@vk.kh.ua / Phone: +38-057-700-5349)

The degree of polarization has been considered non-informative for remote sensing of the lunar surface. We suggested two approaches to make this parameter informative: (1) To use the deviation from the regression line of the correlation between the polarization degree maximum P_{max} and albedo A, i.e. we proposed to use the parameter $(P_{max})A$. It bears significant information on the particle characteristic size and microporosity of the lunar regolith. Analysis of telescope images presenting a distribution of $(P_{max})A$ shows rayed young craters and pyroclastic regions. Laboratory measurements of lunar samples and glass size-particle separates have shown that the variations of $(P_{max})A$ correlate with the particle size. (2) To use a polarization filter orienting it parallel and perpendicular to the scattering plane to retrieve the color-ratios $C_{||}(\lambda_1/\lambda_2) = A_{||}(\lambda_1)/A_{||}(\lambda_2)$ and $C_{\perp}(\lambda_1/\lambda_2) = A_{\perp}(\lambda_1)/A_{\perp}(\lambda_2)$, where λ is a wavelength. We studied the ratios $C_{||}$(0.65/0.42μm) and $C_{\perp}$(0.65/0.42μm) at a phase angle near 88˚. There is not resemblance between the $C_{||}$ and $C_{\perp}$ images. The $C_{||}$ image clearly shows the ray systems of young craters. The maria/highlands contrast is different for the $C_{||}$ and $C_{\perp}$ images. We suggest an interpretation of $C_{||}$ and $C_{\perp}$ images. The perpendicular polarization component is mainly produced with small scatterers and Fresnel reflection from smooth facets of lunar grains. In the latter case a thin slab of the grain surface is responsible for the reflection. This may produce large positive polarization. The parallel polarization component is primarily formed by internal scatter in rather large particles and depends on their absorbing properties. Thus the $C_{\perp}$ image acquired at large phase angles gives us information on the composition of superficial layers of regolith grains. These layers usually contain a surplus of nano-phase metallic iron (npFe^0) that is an indicator of the maturity of the lunar regolith. Agglutinate particles of the mature lunar regolith include the npFe^0 in the surface layers as well as in their volume; whereas, particles of immature regolith contain npFe^0 mainly in superficial zones. This means that the parameter $C_{\perp}$ should be not as sensitive to the mature effects as the $C_{||}$. Thus color-ratio images obtained with a polarization filter suggest an effective tool to study the lunar surface, since the $C_{||}$ and $C_{\perp}$ images are sensitive to different thicknesses of the regolith grain surfaces. This approach can be applied to lunar observations with spacecrafts, in particular, the HST.