Bi-directional Reflectance Measurement of Pulse-Laser Irradiated Airless Body Analog Materials

Te Jiang[1], Hao Zhang[1], Yazhou Yang[1], Pei Ma[1], Xiaoyi Hu[1], and Yuxue Sun[1], Daniel Britt[2]

[1]School of Earch Sciences, China University of Geosciences (tejiang@cug.edu.cn), [2]University of Central Florida

Introduction

Space weathering processes including solar wind irradiation and micrometeorite bombardment produce nano-phase iron (***npFe⁰***) and amorphous layers that redden and darken the visible and near-infrared (VNIR) reflectance spectra of the surface of airless bodies. The ability that how a surface would reflect light into different directions can be quantitatively described by the bi-directional reflectance distribution function (**BRDF**) [1]. The BRDF of an airless body is closely related to the physical properties of the surface regolith such as particle size distribution, refractive indices, and porosity [1, 2].

Samples & Experiments

To understand how Space weathering may change the directional reflectance properties of regolith layers, we carried out pulsed laser irradiation experiments [3] on olivine (**OL**), ilmenite (**ILM**), and **JSC-1A** Lunar Regolith Simulant (**LRS**) with two size distributions (**<45 μm and <1 mm**), and measured (**Fig. 2, [4]**) their BRDF.

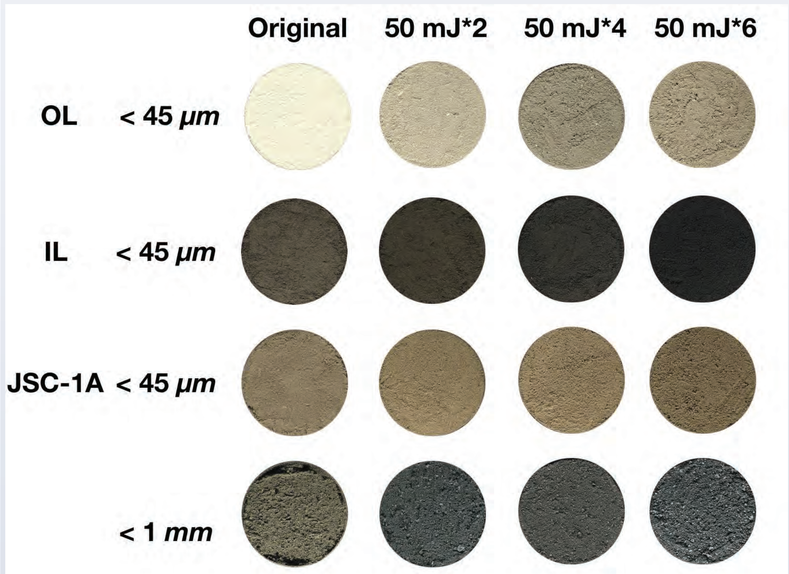

Fig. 1 Photos of the original and pulse-laser irradiated samples.

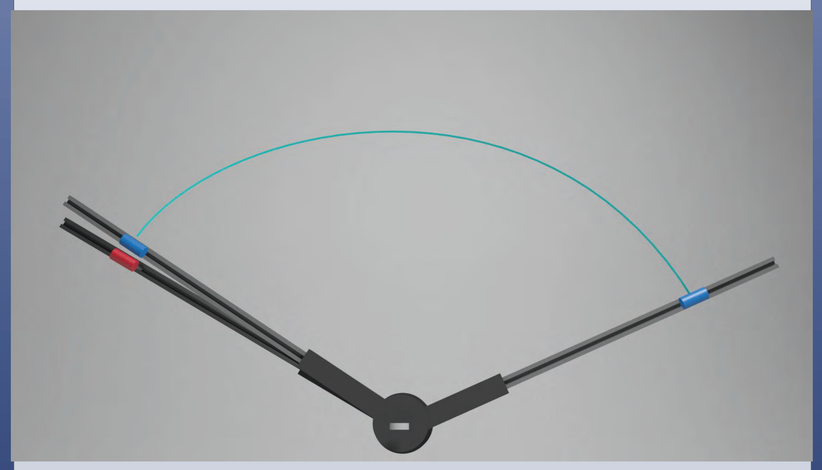

Fig. 2 The schematic of the BRDF Goniometer.
Light source: He-Ne laser 633 nm (i=60° α=[2.7°-130°])

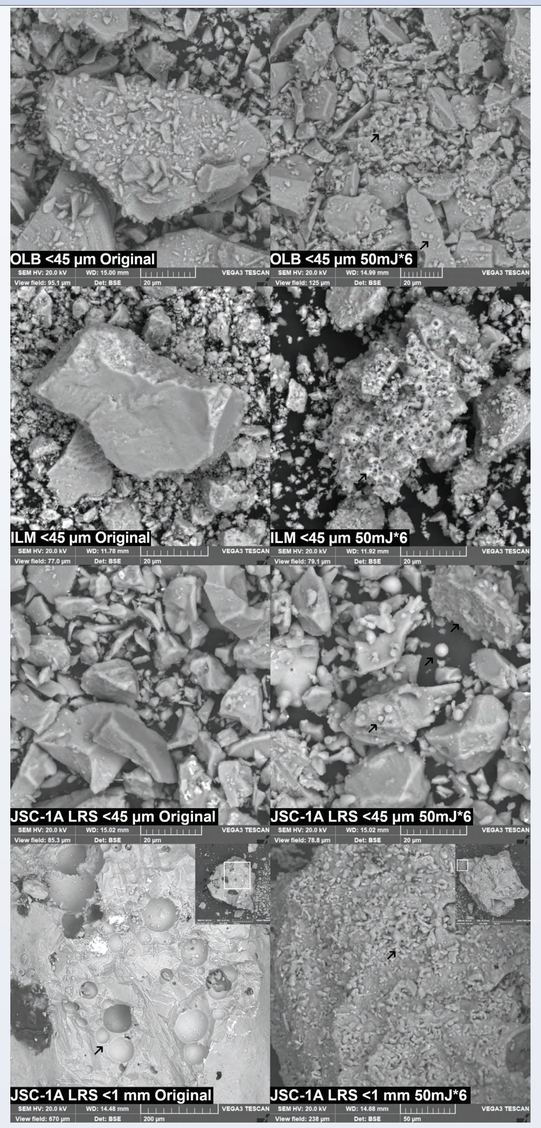

Fig. 3 SEM images of the samples.

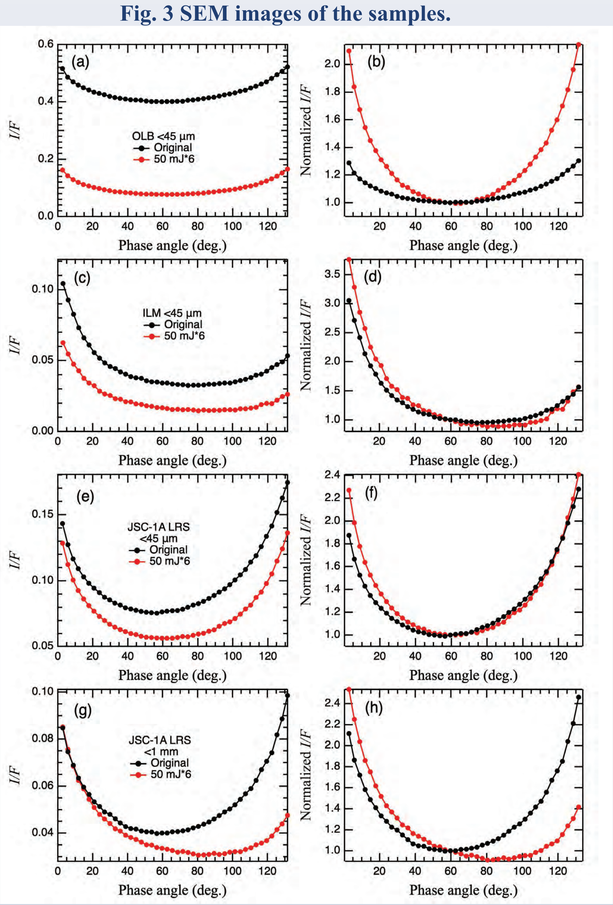

Fig. 4 Radiance Factor (I/F) (a, c, e, g) and normalized (at 60° phase angle) I/F (b, d, f, h) of OL, ILM, JSC-1A LRS <45 μm and <1 mm.

Results: SEM &BRDF

In SEM images (**Fig. 3**), original sampes have sharpe eadges and clean surfaces while the irradiated samples have small spherical melts, agglutinate of melts or very porous melts.

The absolute BRDF of all irradiated samples decrease. For the normalized ones, all samples have enhanced backscattering but various forward scattering (**Fig. 4**).

Results: Numerical Modeling

Numerical radiative transfer computations [5] were used to calculate the BRDF of OL grains with *npFe⁰* (vol: 0%, 0.01%, 0.1%, 1%) uniformly distributed inside the grains. OL with higher fractions of *npFe⁰* have lower absolute BRDF values (**Fig.5a**) and enhanced back- and forward scattering components (**Fig. 5b**), consistent with **Figs. 4a-b**.

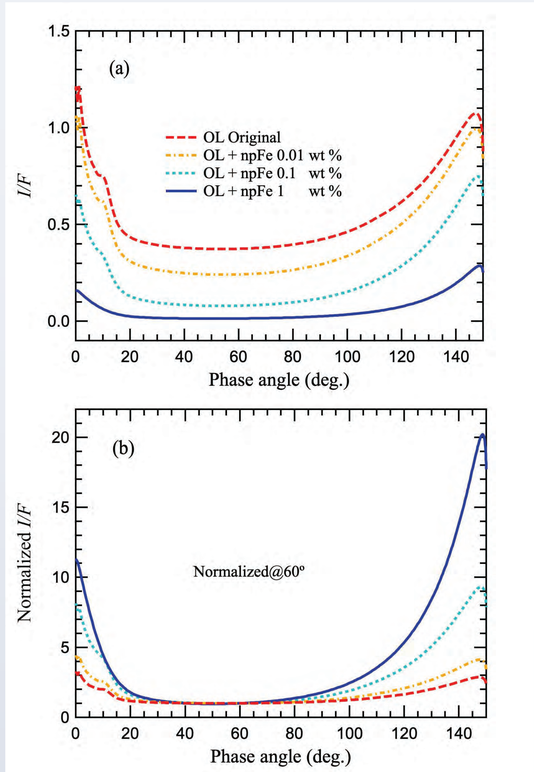

Fig. 5 *I/F* (a) and normalized *I/F* (b) of the original OL and varied fractions of *npFe⁰* uniformly distributed inside the grains.

Conclusion

1. SEM images show spherical and very porous melts.
2. The directional reflectance properties of space weathered regolith grains may be more backscattering.
3. The decreased forward scattering for ILM and JSC-1A <1 mm remains unexplained.
4. Measurements and modeling on more samples with different size distributions and mineral mixtures are expected in future.

References

[1] Hapke B. (2012), Theory of Refl. & Emitt. Spectroscopy. [2] Shkuratov Y. et al. (2011) PSS, 59, 1326-1371. [3] Yang Y. et al. (2017) A&A 597, A50. [4] Zhang H. et al. (2014) 45th LPSC abstract#1777. [5] Mishchenko M. I. et al. (2015) JQSRT, 156, 97-108.