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Space weathering on the Moon, Mercury and airless silicate bodies

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Space weathering is the process to change surface optical property of airless silicate bodies such as the Moon, Mercury and asteroids. Typical changes are darkening, spectral reddening, and attenuation of absorption bands in reflectance spectra. The space weathering is caused by the formation of nanophase metallic iron particles in amorphous surface coatings of regolith grains, which was formed by high velocity dust impacts as well as irradiation of the solar wind ions. Those nanophase iron particles were discovered in lunar soils, Kapoeta meteorite, and recently in dust grains of asteroid Itokawa brought by Hayabusa spacecraft. Experimental studies using nano-second pulse laser showed the formation of nanophase ion particles on the surface of iron-bearing silicate should control the spectral darkening and reddening.

Mariner 10 and MESSENGER showed that Mercury is dark in albedo but has more impact craters associated with bright rays than the Moon. Space weathering rate on Mercury's surface might be slower than that of the lunar surface, although dust flux and solar wind flux causing the weathering should be one order of magnitude of greater on Mercury than on the Moon. This could be explained by compositional difference. MESSENGER showed low surface Fe abundance (less than 4 wt%). On the Moon, weathering degree of mare region is usually higher than that of the highland. This would be also ascribed to the difference of Fe abundance.

Increase in the size of nanophase iron particles should affect space weathering. The size might increase under high temperature of several 100 C, which could suggest latitude dependency of the space weathering degree: less optical change at lower latitude. Simulation experiments of laser irradiation showed apparent growth of nanophase iron particles after repetitive irradiation. The repetitive heating by high velocity dust impacts will cause the saturation of space weathering on Mercury.

From KAGUYA SP data of the Moon, estimated global reflectance map after solar phase angle correction shows that the both high latitude (over 75deg) regions have anomalously low color ratio (1547.7 nm/752.8 nm), which suggests lower degree (immature) space weathering. This could be caused by small cross section for solar wind proton supply. On Mercury, observed asymmetry of magnetic field might change the influx of solar wind particles, which would cause different current space weathering rate, although most of dark area of Mercury would be mature in weathering.

Dust grains of Itokawa contain not only nanophase iron but also nanophase FeS particles on the surface deposited amorphous layer. Probably nanophase FeS might also contribute the space weathering. MESSENGER discovered the surface concentration of sulfur. Probably FeS nanoparticles may exist and contribute in space weathering on the surface of Mercury.

Keywords: Moon, Mercury, Itokawa, reflectance spectrum, space weathering, age