Experimental investigations on dust grain charging within a dust layer and its effects on spacecraft charging

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While spacecraft charging for "clean" surfaces has been a subject of extensive research over the past decades, few studies have been made on how dust contamination may affect spacecraft surface charging. This paper presents an investigation on the effects of dust accumulation on surface charging due to a dusty environment and compares experimental results with numerical models.

Spacecraft surfaces can be covered by a layer of dust in various environments, such as around a comet, on the surface of the Moon, or near an asteroid. Previous studies on dust grain charging and dust interactions with charged surfaces have mostly considered single, isolated dust grains ("dust-in-plasma" condition), where the dust grain is electrically isolated from neighboring grains. When a dust layer accumulates on spacecraft surfaces ("dusty surface" condition), however, the charge on individual dust grains is strongly affected by that of neighboring grains as well as the spacecraft surface, and a single sheath forms over the surface. As a result, the spacecraft surface potential is dependent on both current balance as well as the dust layer capacitance. This paper considers the charging of dust grains within a dusty surface.

Previously, we presented results of dusty surface charging under ambient plasma conditions found at the lunar terminator and investigated the effects of dust coverage using a commercial Trek non-contacting electrostatic voltmeter. We also showed the current-voltage characteristics of a dusty surface as dust accumulation increased. In the present paper, a dust layer covers the surface of a conducting plate entirely and is charged in an environment similar to the solar wind, and the floating potentials of 15 evenly spaced wires embedded within the dust layer are used to infer the charge on dust grains. By maintaining a constant dust layer thickness and varying the depth of the embedded wires with respect to the dust surface, it will be possible to investigate the effects of leakage current and charge transfer as a function of depth through the dust layer. The effects of dust layer thickness and dust grain size on the charging process will also be investigated. Most importantly, it will be necessary to determine the relation between dust layer thickness and the charging of spacecraft surfaces.