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CHARGING AND DIELECTRIC BREAKDOWN OF DUSTY SPACESUIT: IMPLICATIONS FOR ASTRONAUT SAFETY AT THE LUNAR TERMINATOR

Abstract

Lacking a global magnetic field and an atmosphere, the lunar surface is electrically charged due to direct exposure to space plasma and solar radiation. Charging was not a serious concern during the Apollo mission because astronauts always stayed under sunlit where the surface charging potential is typically slightly positive due to photoelectron emission. However, future lunar missions will explore the lunar terminator, and involve operations in the permanently shadowed regions, where the surface can be hundreds to thousands of volts negative due to the collection of hot ambient electrons. Moreover, the adhesion of lunar regolith on the extravehicular (EVA) spacesuit makes the suit surface a complex mixture of different dielectric and conducting materials, rendering the typical charging mitigation approach developed for spacecraft on orbit not applicable. Thus, charging induced risks will need to be re-evaluated for astronaut on the lunar surface.

In a recent study [1], we developed a multi-scale numerical simulation model which applies particle-in-cell (PIC) and molecular dynamics (MD) simulations to investigate charging of dusty EVA spacesuit under the lunar charging environment over 10 orders of magnitude of length scales (from nanometer to tens of meter). The results showed that charging at the dust-spacesuit interface can generate a microscale electric field exceeding the dielectric breakdown threshold of EVA suit material under certain space weather conditions. This paper extends the study in [1] to analyze a more realistic EVA suit model and more extensive space weather conditions. We find that, comparing to deep dielectric charging caused by radiation, dielectric breakdown of EVA suit can be induced more frequently and under much more moderate space weather conditions by charging at the dust-spacesuit interface. Thus, the combination of plasma charging and dust adhesion on spacesuit surface may pose a significant safety risk for astronauts on EVA at the lunar terminator. Potential mitigation options will also be discussed.

1. J. Wang and Z. Huang, Multiscale numerical simulations of plasma charging effects for astronaut at the lunar terminator, IEEE Trans. Plasma Sciences, 51(9), 2023.