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SPACE LIFE SCIENCES SYMPOSIUM (A1)
Radiation Fields, Effects and Risks in Human Space Missions (5)

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PHITS MODELING OF MARTIAN RADIATION ENVIRONMENT

Abstract

Mars has a thin atmosphere and no magnetic field, which prevents effective shielding against primary radiation from space and secondary radiation from atmospheric showering. Both solar energetic particles (SEPs) and galactic cosmic rays (GCRs) are known to cause these showering events and have been measured at the planet's surface. Shielding against these sources of radiation is critical to protecting electronic equipment, and to minimizing cancer risk for future astronauts. To simulate the effects of these events, the Particle and Heavy Ion Transport code System (PHITS) is used. This Monte-Carlo program has been shown to accurately simulate the radiation transport of heavy charged particles comprising the space radiation environment, including protons, alphas, and heavier charged nuclei.

The simulation geometry for this work consists of concentric spheres representing the Martian atmosphere at various altitudes, with appropriate densities. The inner-most sphere consists of Martian regolith, and is included to simulate albedo effects, which are not appropriately accounted for in straight-ahead approximation solutions. The regolith areal density was set to 300 $\frac{g}{cm^2}$, and the composition was taken from the On-Line Tool for the Assessment of Radiation in Space (OLTARIS). The density profile for the atmosphere was based off based off data from the Mars Climate Database, and the composition of the atmosphere has values of 95.4%CO_2, 2.7%N_2, 1.6% Ar, and small amounts of O_2 and CO, from the most recent OLTARIS model. The tally surfaces are specified to record particle-specific flux density as a function of energy and angle, and are placed at altitudes separated by 1 $\frac{g}{cm^2}$ of atmosphere, and on the surface. The source term consists of mono-energetic protons, individually simulated over the range of proton energies.

The unique aspect of this research separating it from previous studies is that particle-specific flux densities for virtually any SEP proton spectrum can be calculated using the response function approach, allowing flexibility that will enable mission designers to understand, in a statistical sense, the effectiveness of shielding against the historical record of SEP events, or even allow astronauts to understand how their radiation risk is accruing in real-time during an event. Protons are also the primary constituent of the GCR spectrum, allowing the use of the response functions for evaluation of shielded GCR flux density.