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Radiation Fields, Effects and Risks in Human Space Missions (5)

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CALCULATED DOSES AND SPECTRA OF ENERGY AND ANGLE OF ALBEDO PARTICLES EMITTED BY THE LUNAR SURFACE

Abstract

When high energy galactic cosmic ray (GCR) particles collide with the lunar regolith, they eject "albedo" particles from the surface. The albedo particles could either be scattered incident ions or secondary ions and neutrons produced by the collisions of incident ions with the lunar regolith. Because Earth's moon has no protective atmosphere or magnetic field, these albedo particles, along with primary GCR ions, present a radiation exposure challenge for both astronauts and electronics. A previous study [1] used GEANT4 computer model simulations to estimate total absorbed dose at the altitude of the Cosmic Ray Telescope for the Effects of Radiation (CRaTER) instrument aboard the Lunar Reconnaissance Orbiter spacecraft, and showed that GCR contributed 91.4% of the dose, while albedo protons, neutrons, gammas, electrons, and positrons contributed the remaining 8.62%. In this study, we use the Monte Carlo N-Particle Transport Code (MCNP) to model interactions of incident GCR particles with lunar regolith. In a recent study of particle spectra and doses on the surface of Mars [2], it was demonstrated that there are differences in these types of predictions among various radiation transport codes. Hence, we use the MCNP code to estimate the angular and energy distribution of albedo particles, and to compare the resulting dose rates at CRaTER from the same albedo particles used in the GEANT4 study, as well as possible additional contributions from other light ions (deuterons, tritium ions, helium-3 ions, and alphas). In addition, since recent studies have indicated the presence of hydrated layers in the regolith, we also report on differences in the energy and angular spectra, and the radiation doses from dry regolith compared to regolith with a thin, top layer containing 10% hydrogen in atomic mass fraction.

[1] Spence, H. E., M. J. Golightly, C. J. Joyce, M. D. Looper, N. A. Schwadron, S. S. Smith, L. W.

Townsend, J. Wilson, and C. Zeitlin (2013), Relative contributions of galactic cosmic rays and lunar proton "albedo" to dose and dose rates near the Moon, Space Weather, 11, 643–650, doi:10.1002/2013SW000995.

[2] Matthia, D., et al. (2017), The radiation environment on the surface of Mars - Summary of model calculations and comparison to RAD data, Life Sci Space Res (Amst), 14, 18-28, doi:10.1016/j.lssr.2017.06.003.