SECONDARY NEUTRON PRODUCTION FROM SPACE RADIATION INTERACTIONS: ADVANCES IN MODEL AND EXPERIMENTAL DATA BASE DEVELOPMENT

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For humans engaged in long-duration missions in deep space or near-Earth orbit, the risk from exposure to galactic and solar cosmic rays is an important factor in the design of spacecraft, spacesuits, and planetary bases. As cosmic rays are transported through shielding materials and human tissue components, a secondary radiation field is produced. Neutrons are an important component of that secondary field, especially in thickly-shielded environments. Calculations predict that 50% of the dose-equivalent in a lunar or Martian base comes from neutrons, and a recent workshop held at the Johnson Space Center concluded that as much as 30% of the dose in the International Space Station may come from secondary neutrons. Accelerator facilities provide a means for measuring the effectiveness of various materials in their ability to limit neutron production, using beams and energies that are present in cosmic radiation. The nearly limitless range of beams, energies, and target materials that are present in space, however, means that accelerator-based experiments will not provide a complete database of cross sections and thick-target yields that are necessary to plan and design long-duration missions. As such, accurate nuclear models of neutron production are needed, as well as data sets that can be used to compare with, and verify, the predictions from such models. Improvements in a model of secondary neutron production from heavy-ion interactions are presented here, along with the results from recent accelerator-based measurements of neutron-production cross sections.

An analytical knockout-ablation model capable of predicting neutron production from high-energy hadron-hadron interactions (both nucleon-nucleus and nucleus-nucleus collisions) has been previously developed. In the knockout stage, the collision between two nuclei result in the emission of one or more nucleons from the projectile and/or target. The resulting projectile and target remnants, referred to as prefragments, then decay by the emission of nucleons, composites, and gamma rays. Recent improvements to the model have incorporated coalescence effects, which effectively tie up single nucleons in the formation of composites during final-state interactions. Comparison of the improved model's predictions with neutron production data near 0º in the ^{40}Ca + H reaction at 357 and 565 MeV/nucleon show marked improvement.

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