Pion Absorption and Nuclear Fragmentation using the QMSFRG model

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Abstract:

Pions are produced as secondary radiation during galactic cosmic ray (GCR) traversal of spacecraft shielding and tissue. For describing pion transport using Monte-Carlo codes such as the GCR Event Based Risk Model code (GERMcode), pion production cross sections and multiplicity distributions, and pion absorption and nuclear fragmentation cross sections are required. Estimates of multiplicity distributions for pion production in pion (or nucleon) induced reactions have been evaluated previously by nuclear cascade models. Here we apply a quantum multiple scattering model of fragmentation (QMSFRG), developed for estimating proton and heavy ion fragmentation cross-sections, to pion absorption and nuclear fragmentation of ^{12}C, ^{16}O, ^{27}Al and ^{40}Ca target atoms. The key features of our calculations are:

1) Application of high-energy multiple scattering theory using the Impulse and Eikonal approximations.

2) Use of parameterized energy-dependent π^+, π^-, and π^0 two-body cross-sections for their interactions with protons and neutrons.

3) The use of Coulomb trajectories for distinguishing pion charge states in nuclear absorption, including the role of Coulomb trajectories in π^- capture at low energy.

4) Consideration of the quasi-elastic π-nucleus scattering distribution in estimating excitation energies to be used in the abrasion-ablation model of nuclear fragmentation.

Because the two-body cross sections for πN scattering contain resonances at intermediate energies, and the impulse approximation ignores the effects of the nucleon velocity distribution in the bound state, we also consider energy averaging of the two-body cross section to account for the Fermi distribution of protons and neutrons in the nucleus. Comparisons to experiments and the development of a data-base for GCR transport are described.