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Anti-neutrino Nuclear Responses by High Energy-Resolution Gamma-ray Studies Following Ordinary Muon Capture on Molybdenum

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Ordinary Muon Capture (OMC) provides a unique experimental avenue to probe the β^+ type nuclear responses essential for understanding double beta decays (DBDs) and astrophysical neutrino interactions. This study leverages high energy-resolution gamma-ray spectroscopy to meticulously identify transition channels in enriched and natural molybdenum. By utilizing high-purity germanium (HPGe) detectors, we resolve complex spectra to determine precise branching ratios for $(\mu, \text{x}\nu)$, and $(\mu, \text{x}\nu\bar{\nu})$ particle emission channels. These high-resolution datasets enable the identification of ppb-level elemental impurities for extracting the spin states involved during OMC. Within the framework of the Proton Neutron Emission Model (PNEM), the μ capture strength distribution across the Giant Resonance (GR) region (0–70 MeV) were mapped. In this region, nuclear transitions are predominantly driven by low multipole states ($0^\pm$, $1^\pm$, $2^\pm$), with only minor contributions originating from higher multipole states ($5^\pm$, and $6^\pm$). These high-resolution observations serve as crucial benchmarks for theoretical pn-QRPA calculations, and aid in understanding nuclear structure deformations relevant to hypothetical $0\nu\beta\beta$ decay, providing the critical experimental constraints needed to refine theoretical Nuclear Matrix Elements (NMEs).

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