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Determination of Thermal Neutron Capture Cross Sections of Cerium Isotopes

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Abstract

The precise determination of thermal capture cross sections for cerium isotopes (^{138}Ce,^{140}Ce, and ^{142}Ce), along with detailed uncertainty analysis, is crucial for advancements in nuclear science and reactor technology. This thesis presents a comprehensive study focused on measuring these cross-sections and performing neutron spectrum unfolding at the irradiation location of an Am-Be neutron source. The research integrates experimental methods and advanced computational techniques to achieve accurate results.

In the experimental phase, Naturally occurring cerium oxide powdered samples were irradiated using an Am-Be neutron source, and the resulting gamma emissions were analysed using a High Pure Germanium Detector. The thermal capture cross sections for ^{138}Ce,^{140}Ce, and ^{142}Ce were derived from the acquired data, employing correction factors for neutron self-shielding and other experimental conditions.

To complement the experimental findings, neutron spectrum unfolding was performed at the irradiation site. This involved utilising the SAND-II code and the iterative maximum-likelihood Bayesian approach to reconstruct the neutron energy spectrum. The neutron flux and spectrum characterisation were validated through Monte Carlo simulations and multi-foil activation, ensuring robustness in the methodology and results.

The outcomes of this research provide accurate thermal capture cross-section values for ^{138}Ce,^{140}Ce, and ^{142}Ce along with detailed covariance analysis, contributing significantly to updating the nuclear data libraries. Moreover, the refined neutron spectrum at the Am-Be source location enhances our understanding of neutron interactions in mixed-field environments. This work lays a foundation for future studies in neutron capture processes and supports advancements in nuclear reactor design and safety analysis.

Keywords: Am-Be Neutron Source, Neutron Spectrum Unfolding, Monte-Carlo Simulations, Multi-Foil Activation, Thermal Neutron Capture Cross Sections, Neutron Activation