

Neutron total and capture cross-section measurements of ^{nat}Er at ANNRI and resolved resonance analysis

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The neutron total and capture cross sections of ^{nat}Er were measured at the ANNRI beamline of J-PARC. The neutron capture cross section was determined using Ge and NaI(Tl) spectrometers, while the neutron total cross section was measured with Li-glass detectors. In the present work, the neutron total and capture cross-section results of ^{nat}Er are provided, together with the results of a resonance shape analysis to determine the resonance parameters of low energy resonances of $^{166,167}\text{Er}$.

Keywords: J-PARC, ANNRI, ^{nat}Er , $^{166,167}\text{Er}$, Neutron Total Cross Section, Neutron Capture Cross Section.

1. Introduction

The extension of the nuclear fuel life has always been seen as an effective method to improve the economic viability of nuclear reactors. Nonetheless, this has always been hampered by the limitation of ^{235}U 5 wt% due to criticality concerns[1]. Enrichment of ^{235}U above the 5 wt% threshold would mean a major reformulation of both reactor criticality and safety assessments for the present nuclear reactors. The Erbium-credit super high burnup (Er-SHB) fuel is an innovative configuration that allows for the fuel life to be extended by increasing the enrichment of $^{235}\text{U} > 5$ wt%, while treating the fuel as if the enrichment of ^{235}U were to be lower than 5 wt%, as in present LWR reactions. Er-SHB is also able to achieve this while providing several physical improvements (i.e., less downgrade of the flux distribution, improving the intrinsic reactor safety parameters, better control of the transient power phase) [1], [2]. Nonetheless, for this to be attainable, the accuracy of the nuclear data for the neutron capture cross section of Erbium needs to be improved. Sensitivity and uncertainty analyses have remarked the importance of improving the neutron capture cross section data of Erbium isotopes below 100 eV, with special emphasis on ^{167}Er , since it accounts for about 18% of the total criticality uncertainty[3].

2. Experimental Setup

The present experiments were performed in the Accurate Neutron-Nucleus Reaction Measurement Instrument (ANNRI) at the Materials and Life Science Facility (MLF) of the Japan Proton Accelerator Research Complex (J-PARC) using Li-glass detectors to measure the neutron total cross section; NaI(Tl) and Ge spectrometers to determine the neutron capture cross section, in separate measurements. In order to obtain high statistical accuracy at the neutron energy range targeted by each spectrometer, five ^{nat}Er samples with different conditions were prepared.

3. Cross Section Results

The neutrons capture cross section of ^{nat}Er was determined from the thermal energy to about 1 keV with the Ge spectrometers and from thermal energy to about 500 keV with the NaI(Tl) spectrometers using two 0.025-mm-thick sample. At the same time, the neutron total cross section of ^{nat}Er was measured using samples with 0.05, 0.175 and 1 mm in thickness, from thermal to about 1 keV with the Li-glass detectors. Moreover, since the neutron capture cross section of ^{167}Er accounts for about 95% of the capture events below 10 eV and there are no resonances of other isotopes, the neutron capture cross section of ^{167}Er was also derived with corrections using JENDL-5.

4. Resolved Resonance Analysis.

A resonance shape analysis was performed using the REFIT in order to derive the resonance parameters for the $^{166,167}\text{Er}$ resonances up to 65 eV. For this, 4 sets of data were employed: two capture data sets using two 0.025-mm-thick ^{nat}Er samples measured with the Ge and NaI(Tl) spectrometers, respectively; and two transmission data sets with ^{nat}Er samples with 99.9% purity and thicknesses of 1mm and 0.175 mm.

5. Conclusions

In this study, the results for the ^{nat}Er neutron total and capture cross sections measured with Li-glass, Ge and NaI(Tl) spectrometers are presented and compared. Moreover, the results of a resonance analysis using both capture and transmission data is also presented.

References

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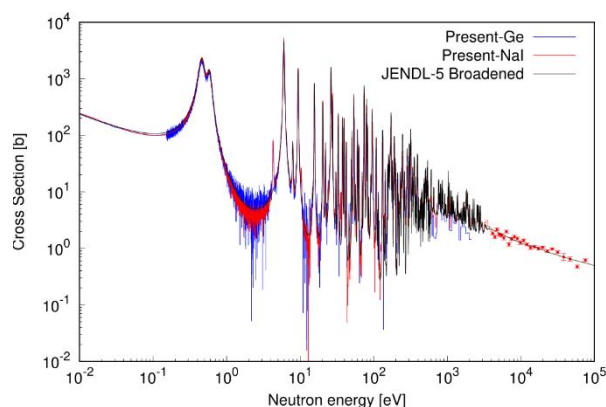


Figure 1 Neutron capture cross section results for ^{nat}Er measured with the NaI(Tl) and Ge spectrometers compared to JENDL-5