Capture Cross Sections for Ag-109, Xe-131 and Cs-131

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1. Introduction

The current evaluation of the neutron induced capture cross section data was from an unresolved energy to 20 MeV. The evaluation work has been performed under a joint work with the National Nuclear Data Center of Brookhaven National Laboratory. The results complement the evaluation of the resonance region. Neutron induced nuclear reaction data is important for the burn-up performance prediction and the design of a spent fuel storage. Neutron capture cross section in a fission reactor is a significant factor to estimate the loss of neutrons.

Ag-109, Xe-131 and Cs-133 are stable isotopes and mainly produced by a nuclear fission and an accumulation from the parent nuclides. ENDF/B-VI was formed from the ENDF/B-V by converting it to an ENDF-6 format. ENDF/B-V had an evaluation for Ag-109, Xe-131 and Cs-133 in 1983, 1978 and 1978, respectively.

The evaluations consisted of an optical model potential search followed by a complete nuclear reaction model calculation and a validation for the experimental data. Nuclear reaction cross sections were calculated using the recently released Empire-II code[1]. The direct capture model enhances the capture cross section in the pre-equilibrium energy region, and the width fluctuation correction influences on the capture and inelastic scattering cross sections in the equilibrium energy region. The calculated cross sections are graphically compared with the experimental data and the evaluated files (ENDF/B-VI, JENDL-3.2, JEF-2.2, BROND-2 and CENDL-2). The evaluated results are compiled in an ENDF-6 format and finally, they are merged with the resonance results to make the full data file.

2. Models

The optical model is used to provide the total, elastic scattering and reaction cross sections. The potential form in the optical model and the corresponding parameters, as a function of the incident neutron energy, were searched based on the reference experimental data. To the obtain proper potential parameters, the Woods-Saxon well is used for the real part potential in the optical model:

$$V(r) = -V/(1+\exp((r-R_v)/a_v)) \qquad (1)$$

where V and a_v are the strength and diffuseness of the potential. The nuclear radius R_v, related to the mass number A, is given by

$$R_v = r_v A^{1/3}. \qquad (2)$$

For the imaginary part potential, the derivative Woods-Saxon shape is used,

$$W(r) = -4W\exp((r-R_w)/a_w) / (1+ \exp((r-R_w)/a_w)^2 \qquad (3)$$

where W, R_w and a_w are the potential strength, radius and diffuseness, respectively.

Empire is a modularized code system. The main utilities include the masses, level densities and the discrete levels, the decay schemes, deformation parameters, γ-ray strength functions, RIPL, ENDF-6 formatting and the plotting capabilities. The main modules are: the Optical model, Multi-step Direct and compound, Pre-equilibrium exiton model (DEGAS) and Monte Carlo hybrid simulation (HMS) and a full featured Hauser-Feshbach including the width fluctuation correction.

3. Results and Discussions

Ag-109 and Xe-131 do not have experimental data for their total cross section. Therefore, natural element experimental data[2,4,5] was used instead in the optical model potential parameter search. In all the figures, the current evaluation results are nominated as an ENDF/B-VII. Fig. 1 shows the calculated capture cross section for Ag-109, using the searched parameters in Empire. The calculation and the ENDF/B-VI agree well with the experimental data[3]. However, the calculation shows a direct capture feature in the pre-equilibrium region, on the other hand, the ENDF/B-VI does not have such a feature. Fig. 2 is the capture cross section on Xe-131. The calculation shows a fast neutron capture in the pre-equilibrium. On the other hand, ENDF/B-VI decreases continuously after 6 MeV. For Cs-133, Fig. 4 shows the capture cross section for the calculation and the evaluated

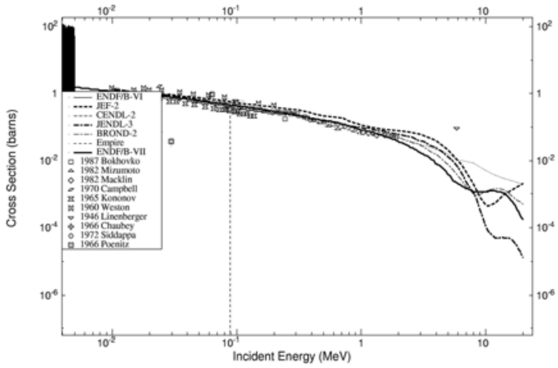

Figure 1. (n, γ) cross section of Ag-109.

files. The calculation and the ENDF/B-VI agree well with the experimental data[6]. Only the capture results are presented here, but the other threshold reaction cross sections are also calculated and evaluated. All the results are formatted and summarized in each file to make a full library.

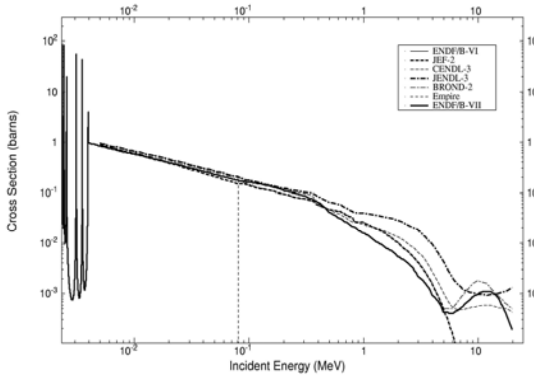

Figure 2. (n, γ) cross section of Xe-131.

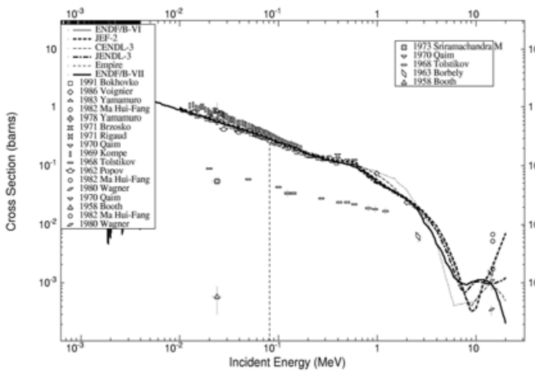

Figure 3. (n, γ) cross section of Cs-133.

4. Conclusion

The selected energy dependent optical model potential, based on the experimental data, was proper for producing the model calculated cross sections in the evaluation energy range. The capture cross sections were connected with the resonance smoothly and continuously in the unresolved energy region. If necessary, the background was inserted into the unresolved resonance region. Empire was successful in producing each reactions' cross sections. The capture calculated cross sections are in good agreement with the experimental data. They represent an improvement over the current ENDF/B-VI. At the pre-equilibrium energy region, the calculated capture cross section prominently shows the fast neutron direct capture phenomena. All the results are ready for ENDF/B-VII.

Acknowledgement

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