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Evaluation of Neutron Cross Section for Fission Products in the ENDF/B-VII Library

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1. Introduction

Neutron cross sections up to 20 MeV for 32 fission products have been evaluated by the KAERI-BNL collaboration. Resonance regions were based on the recent evaluation of resonance parameters [1]. In the fast neutron energy range, a modular system of nuclear reaction codes EMPIRE-2.19 [2] was used to produce physical observables. Experimental data were taken into account wherever available. The two regions were matched and merged. The evaluated file will be included in the evaluated nuclear data library ENDF/B-VII, to be released in the middle of 2006.

2. Scope of evaluations

2.1 Evaluated Nuclides

The KAERI and BNL have been performing evaluation of fission products with high priority for several years. The preliminary version of the new evaluated nuclear data library ENDF/B-VII was released in middle of 2005. Several problems in the fission product evaluations, such as photon production, irregularities in inelastic cross sections, and consistency among the isotopes have been identified. In order to resolve these problems, new evaluations for total 32 fission products had to be performed. Table 1 shows all nuclides considered by KAERI-BNL collaboration.

Table 1 Nuclides evaluated by KAERI-BNL collaboration

	Nuclei
Isolated nuclei(8)	^{95}Mo, ^{101}Ru, ^{103}Rh, ^{105}Pd, ^{109}Ag, ^{131}Xe, ^{133}Cs, ^{141}Pr,
Neodymium isotopes(8)	^{142,143,144,145,146,147,148,150}Nd
Samarium isotopes(9)	^{144,147,148,149,150,151,152,153,154}Sm
Dysprosium isotopes(7)	^{156,158,160,161,162,163,164}Dy

2.2 Physical observables

Evaluated were cross sections, spectra, angular distributions and double-differential cross sections in the resonance and fast neutron regions. Figure 1 shows elastic angular distribution of 7.0 MeV incident neutrons on ^{144}Nd, which was important to determine optical model parameters.

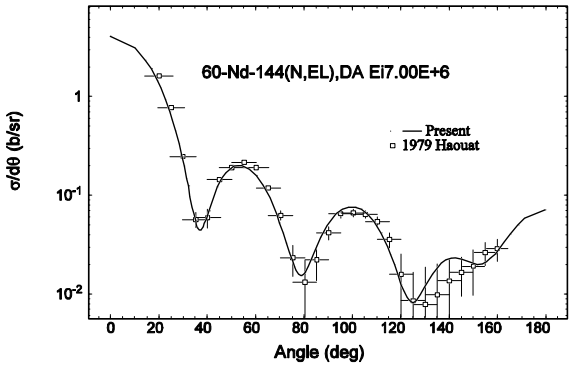

Figure 1 Elastic angular distribution for ^{144}Nd

3. Nuclear reactions

3.1 Resonance region

The resonance parameters were carefully evaluated using all available experimental information [1]. The unresolved region is based on systematics and was adjusted to reproduce available capture cross sections.

3.2 Fast neutron region

3.2.1 Direct reaction

Generally, we used the Coupled Channels to calculate incident channel and inelastic scattering to collective discrete levels. Only in case of nuclei with very small deformation, the spherical OMP was employed.

3.2.2 Equilibrium reaction

Nuclear reactions processing through the equilibrated Compound Nucleus are well described by the Hauser-Feshbach theory [3]. The necessary input parameters are optical model parameters, nuclear level densities and gamma strength functions.

Many OMP parameters are available in the literature and RIPL-2 [4] database. The OMP parameters reproduced well physical observables if enough experimental data exist, otherwise the OMP parameters need to be adjusted in order to produce reasonable physical observables. The OMPs used in this work are based on those published in RILP-2 [4], and adjusted to reproduce available measurements.

Figure 2 shows the total cross sections for all Neodymium isotopes.

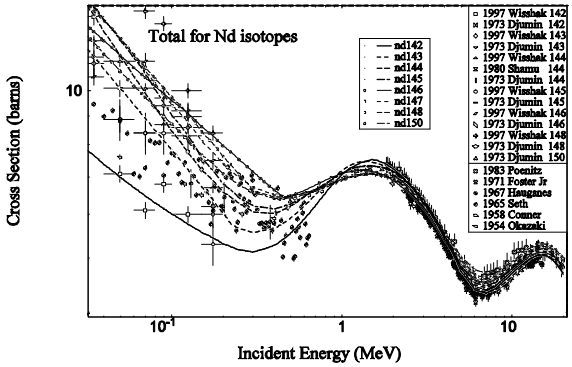

Figure 2 Total cross sections for Neodymium isotopes

Nuclear level densities are another critical input parameters in statistical model calculations. Three different types of level densities can be used in EMPIRE-2.19. The optimal formulation was selected by comparing predictions of the capture cross sections with experimental results. The same procedure was used to choose between various options for the gamma-ray strength function.

3.2.3 Pre-equilibrium reaction

The nuclear reactions in pre-equilibrium region were described employing three different models. In order to describe neutron emission we have used quantum mechanical approach MSD/MSC. Standard exciton model with Iwamoto-Harada cluster emission (PCROSS code) was used for protons and alphas. The exciton model with angular momentum coupling (code DEGAS) was employed for gammas to simulate direct semi-direct model.

4. Conclusion

As the results of the KAERI-BNL collaboration, evaluations for total of 32 nuclides have been performed. The simultaneous evaluation of three full rare earth isotopic chains ensures consistency within each chain and allows for a better constrain of cases with insufficient experimental information. This method is expected to be used for future evaluations.

The newly evaluated nuclear data library ENDF/B-VII including the results of this work is expected to be released in the middle of 2006.

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