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The Effect of the Decay Data on Activation Cross Section

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【abstract】 *The effect of the decay data on evaluation of activation cross section is investigated. Present work shows that these effects must be considered carefully when activation cross section is evaluated. Sometime they are main reason for causing the discrepancies among the experimental data.*

Introduction

The neutron activation cross sections are very useful in nuclear engineering applications especially in fission and fusion reactors, and nuclear physics studies. They are also used to confirm predictions of nuclear reaction theory. As developing of nuclear technology and nuclear engineering, more accurate evaluated data are required.

Up to now, a lot of neutron activation cross sections have been measured by activation method. And there are large discrepancies among some reactions.

There are many factors, which affects the accuracy of the experimental data. According to the principle of activation method, the decay data of product is one of the factors which will affect the measured data. In order to provide more reliable and accurate evaluated nuclear data, evaluation is necessary for decay data.

In this work, the effect of the decay data on activation cross section is investigated. Some examples are given to show these effects.

1 The Effect of Decay Data

According to the principle of activation method, the decay data of residual nucleus will affect the result of measured data. Usually the decay data include the half-life of the residual nucleus, γ branching ratio of the residual nucleus. On the other hand, the decay scheme of the product will play an important role in selecting the γ rays which were used to determine the radioactivity of the reaction products.

In the following paragraph, the effect of the decay data will be discussed briefly.

1.1 Half-life

Generally speaking, the half-life of the residual nucleus doesn't cause the large discrepancies among the measured data. But the value of half-life changed largely, it will cause the conflict among the measured data. Sometime this is a main reason for the discrepancies.

Here we selected the ^{109}Ag(n,2n)^{108m}Ag reaction as an example, showing in Fig. 1. Obviously the measured data can be divided into two groups. The experimental data measured by half-life of 127 year before 1993 are much lower than those of 418 year after 1993. We investigated the experimental conditions carefully and found that the half-life was the main reason for causing the discrepancies. If the experimental data were rough adjusted by

$$\sigma_{\text{new}} = \sigma_{\text{old}} T_{1/2}^{\text{new}} / T_{1/2}^{\text{old}} \tag{1}$$

the experimental data measured by half-life of 127 years would be in agreement with those of 418 years (see Table 1 in detail).

Table 1 Comparison of the measurements for ^{109}Ag(n,2n) ^{108m}Ag reaction with different $T_{1/2}$

E_n/MeV	$T_{1/2}$(127 a)		
	Wang92[1] (mb)	Ikeda91[2] (mb)	Csikai91[3] (mb)
13.64	223		
13.79	223		
14.03	227		
14.33	224		
14.5			263
14.6	232		
14.8	236	191	

E_n/MeV	$T_{1/2}$(418 a)		
	Wang92 (mb)	Ikeda91 (mb)	Csikai91 (mb)
13.64	759/734*		
13.79	759/734*		
14.03	774/747*		
14.33	763/737*		
14.5			716/865*
14.6	790/764*		
14.8	805/777*	671/629*	

* Adjusted measurements by Eq.(1).

1.2 γ Branching Ratio

The collected experimental data will be normalized with the newest γ branching ratio by evaluators firstly when evaluating the activation cross sections. This is because the value of the measured data will be changed when the new γ branching ratio is different from the old one. Of course this is the advantage of the activation method.

Usually the corrected factor is calculated by

$$\sigma_{\text{new}} = \sigma_{\text{exp}} I_{\gamma,\text{old}} / I_{\gamma,\text{new}} \tag{2}$$

where σ_{new} and $\sigma_{\text{exp.}}$ is the adjusted cross section and measured cross section, respectively. I_γ is the branching ratio of measured gamma ray.

Sometime the effect of γ branching ratio on measured data is very large. A typical example is the ^{187}Re(n,2n)^{186g}Re reaction, as shown in Fig. 2. For the ^{187}Re(n,2n)^{186g}Re reaction, the experimental data of FAN Tieshuan et al.[16] are obviously higher than other measurements. The I_γ value of 137 keV γ ray they used is 8.5%, which is much lower than the newest value, 9.22%[17]. After normalized with the new value, their measurements are in agreement with other measured data within the error.

1.3 Decay Scheme

The ^{181}Ta(n,2n)^{180g}Ta reaction (see Fig. 3 in detail) will be an example to show the effect of the decay scheme on activation cross sections.

In the energy range above 12 MeV, the available data can be divided into two groups according to their values. The data of ZHAO Wenrong et al.[22] are higher than that of R. J. Prestwood et al.[18] and M. Bormann et al[19]. These discrepancies were caused by using different decay scheme. The different decay scheme and relevant parameters of the product ^{180g}Ta is listed in Table 2. The decay scheme of the product ^{180g}Ta is shown in Fig. 4.

Table 2 Different decay schemes and data for ^{180g}Ta product

	Brown[25]	Gallagher[26]	Ryves[24]
a/%	11	3.2	3.5
b/%	10	9.8	14.6
c/%	79	27	24.3
d/%		60	57.6
$I_\gamma(E_\gamma$=93 keV)		4.682	4.274
$I_\gamma(E_\gamma$=104 keV)		0.715	0.793

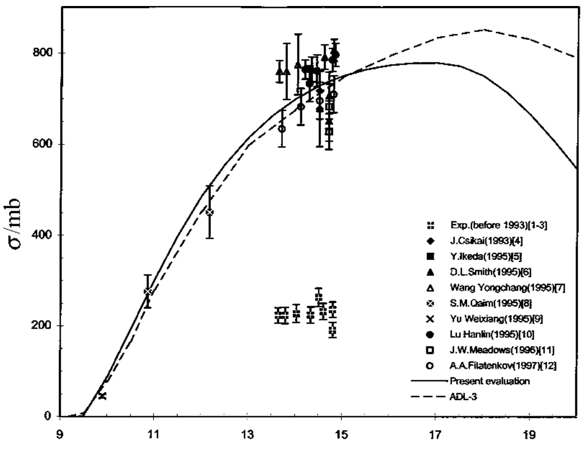

Fig.1 The cross section for ^{109}Ag(n,2n) ^{108m}Ag reaction

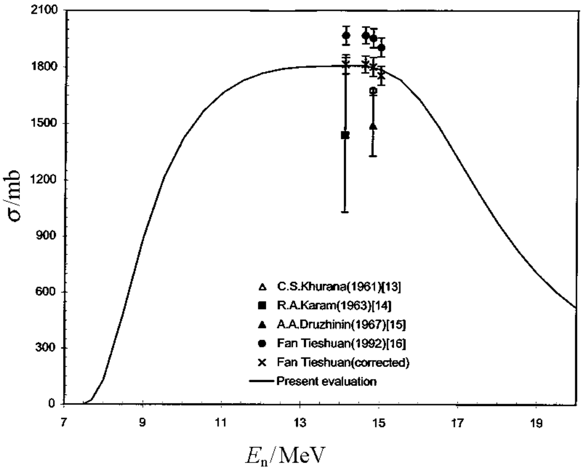

Fig.2 The cross section for ^{187}Re(n,2n) ^{186g}Re reaction

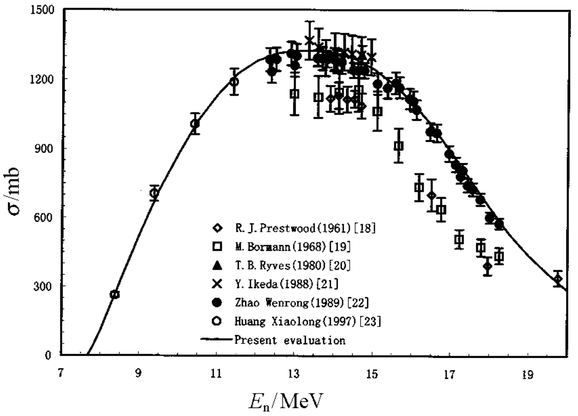

Fig.3 The cross section for ^{181}Ta(n,2n) ^{180g}Ta reaction

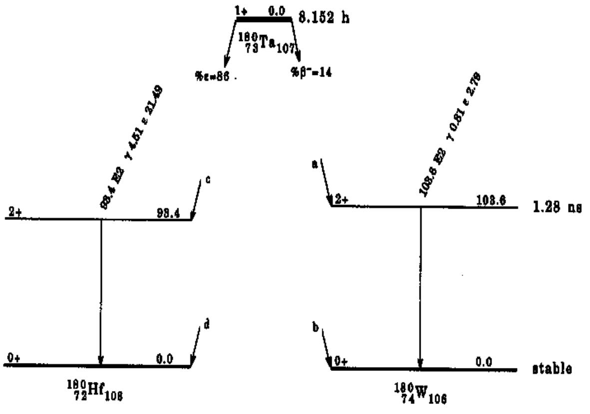

Fig.4 Decay scheme of ^{180g}Ta

In order to check the effect of decay scheme on activation cross sections, the results measured by Zhao, Prestwood, Bormann and Ryves were deduced and discrimined at 14.5 MeV with different decay schemes (see Table 3 in detail).

Tbale 3 Comparison of the ^{181}Ta(n,2n)^{180g}Ta cross section deduced with different decay schemes at 14.5 MeV

Author	Brown[25] (mb)	Gallagher[26] (mb)	Ryves[24] (mb)	Method
Prestwood[18]	1116	1802	1288	β
Bormann[19]	1157	1869	1335	β
Ryves[20]		1178	1307	γ(93 keV)
ZHAO[22]		1351	1269	γ(93+104 keV)

It's obvious that good agreement was obtained among these measurements after normalization with decay scheme of Ryves.

This example shows that the effect of decay scheme on activation cross sections is very large. And this effect must be considered carefully when evaluated.

2 Conclusions

The effect of the decay data on activation cross section is investigated carefully and testified by several examples. These decay data include the half-life, γ branching ratio of the product and its decay scheme.

Present work shows that these effects must be considered carefully when evaluating the activation cross section. Sometime they are main reason for causing the discrepancies among the experimental data.

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A Testing of RIPL with UNF Code Calculation in Energy Region 0.1~20 MeV

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Introduction

For general testing and validation of the RIPL[1] database, a nuclear model code UNF[2] was used to perform the testing with RIPL database. The testing was done in the incident energy region of 0.1~20 MeV for 103 nuclei and mass region from 69 to 160.

1 The Information of Nuclei and Model Parameters

Nuclear data model calculations need two important kinds of information. One is nuclear character, including mass, spin and nuclear discrete level for the target, compound and residual nuclei. This kind of information can be obtained from the nuclear experimental measurements. Other one is the information about the nuclear reaction model code used, which contains the related model parameters. These parameters can be adjusted in a reasonable range according to the experimental data for an individual reaction calculation.

In this work all nuclear character of target, compound, residual nuclei and model parameters are taken from RIPL database.