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The Calculation of True Total Cross Section for Tantalum using SAMMY Code

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1. Introduction

The transmission is measured using the Time-Of-Flight method and includes the Doppler broadening and self-shielding effect. The total cross section is calculated using the measured transmission. So, we can only get the broadened cross section. However the true total cross section is needed for analysis of reactor physics and other cases. In this study, we calculate the true total cross section using the resonance parameters that are evaluated using transmissions for three thicknesses samples of Ta (1, 2, 4 mm) and the SAMMY code. The SAMMY code analyzes the transmission data with multilevel R-Matrix fits to neutron data using Bayes' Equations. The calculated true total cross section is compared to the value of ENDF/B-VI.8.

2. Evaluation Procedure

1. Analysis using SAMMY Code

The measured transmission can be analyzed with a computer code such as SAMMY to obtain the resonance parameters that represent the data. For the methodologies used in SAMMY Code, refer to the reference 1, where scattering matrix U, Reich-Moore approximation to multilevel R-Matrix, Bayes' equations, covariance matrix, spin and angular momentum conventions, and resolution function are described. Because the fitting procedure in SAMMY is Bayes' method rather than ordinary least-squares, SAMMY may be used for general evaluation purposes: that is, for determining a set of parameters which simultaneously describe a large number of different types of experimental data taken at different times and/or at different laboratories.

The transmission of Ta was measured in Pohang TOF facility [3]. For natural Ta, the atomic weight is 180.9479962 ±0.0000031 amu. The sample thickness in unit of atoms/barn is 0.005525 for 1 mm, 0.0110509 for 2 mm and 0.022102 for 4 mm. The spin group is divided into two by total spin values, 3 and 4. Initial parameter file is generated based on the resonance data such as resonance energy, gamma widths and neutron widths given in ENDF file.

2. *Calculation of True Total Cross Section*

The measured transmission T is as follows:

$$T = e^{-n\sigma}$$

Here n is the sample thickness, measured independently and expressed in units of atoms/barn. The "cross section" extracted directly form the measured transmission using the relationship.

$$"\sigma" = -\frac{1}{n}\ln(T_{measured})$$

The distinction is made between "effective cross section" σ_{effect} and "true cross section" σ_{true}. The effective cross section is defined by first resolution-broadening the transmission.

$$Tr(D) = \int e^{-n\sigma_D(E')} R(E-E')dE'$$

Where σ_D is the Doppler-broadened total cross section and *R(E-E')*is the resolution function, and then converting to cross section. The so-called true cross section, on the other hand, is defined by resolution-broadening the Doppler-broadened total cross section directly (that is, by omitting the conversion to-and-from transmission):

$$\sigma_{true}(E) = \int \sigma_D(E')R(E-E')dE'$$

The difference between σ_{effect} and σ_{true} corresponds to the "self-shielding effect" in transmission measurements.

3. Results and Discussions

The resonance parameters of Ta in the energy from 0 to 30 eV were evaluated simultaneously using the measured transmission data of three samples that have different thicknesses. As shown in the figure 1, the effective total cross sections were fitted and χ^2/N was 2.30, 3.33 and 2.79 for the thicknesses of 1, 2, and 4 mm. We calculated the true total cross section using the resonance parameters. The averages of difference between effective and true total cross section were 31.2, 32.3 and 23.5 barns for 1, 2, and 4 mm. The calculated true total cross section was compared to the value of ENDF/B-VI.8 in the figure 2. The peaks of present results are lower and more broadened than those of ENDF/B-VI.8. It is believed we can get better result if the resonance parameters are evaluated more accurately.

In the future, a simultaneous analysis of the capture cross section and transmission data of natural Ta will be

performed in order to obtain better values for the resonance parameters if good capture cross section data is available because the SAMMY prediction in this study was made using transmission data only.

4. Conclusion

For the calculation of true total cross section, we evaluated the resonance parameters using the measured transmissions of three samples that have different thickness and SAMMY code. The calculated true total cross section was compared to the calculated value using the ENDF/B-VI.8. The true total cross section should be calculated using the accurately evaluated resonance parameters without any other procedure for the self shielding correction.

Acknowledgement

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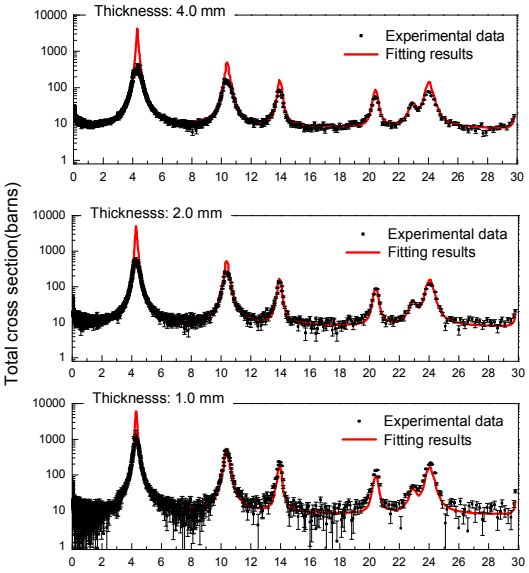

Fig 1. The fitting results using the SAMMY Code

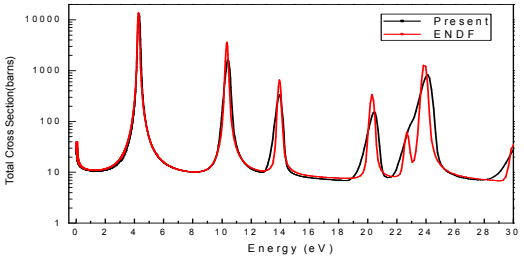

Fig 2. Comparison of the calculated true total cross section using the resonance parameters from present results and ENDF/B-VI.8