Measurement of neutron total cross-sections for ^{nat}Dy at Pohang Neutron Facility

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1. Introduction

The accurate data on neutron total cross-sections of Dy (Dysprosium) is very important because of its large neutron total cross-sections in the thermal neutron energy region. There are few measurements for Dy below 100 eV [1-3]. Moreover, there exist discrepancies among the measurements.

In the present work, the total neutron cross-sections for ^{nat}Dy were measured by using the time-of-flight (TOF) method at the Pohang Neutron Facility (PNF) as shown in Fig. 1. The PNF consists of an electron linac, a water-cooled Ta target, and an 11-m-long TOF path. The characteristics of PNF are described elsewhere [4]. We also briefly discuss the future plan to verify our experimental result.

Figure.1: A photo of PLS-PNF electron Linac tunnel.

2. Experimental Method

The experimental arrangement for the transmission measurements is similar to the previous one [5]. A natural Dy plate, 10 cm x 10 cm in area by 0.5 mm in thickness, was used as a transmission sample. A set of notch filters of Co, In, and Cd plates with 0.5 mm in thickness was used for the background measurement and the energy calibration. Samples are placed on the sample changer at the midpoint of the flight path as shown in Fig. 2. The positions of the samples were chosen in the following sequence: Dy sample and open. The exposure time for each position was 5 minutes. A ^{6}Li-ZnS(Ag) scintillator (BC702) for neutron detection is placed at the endpoint of the tube. During the experiment, the electron linac was operated with a pulse repetition rate of 15 Hz, a pulse width of 1.6 μs and the beam energy and current of electron linac are 60 MeV and 200 mA, respectively. Total data taking times for the sample in and the open beam are about 290 and 200 hours, respectively.

The time and the shape of signal from the BC702 scintillator were fed into a flash ADC (NFADC 100, Notice Korea).

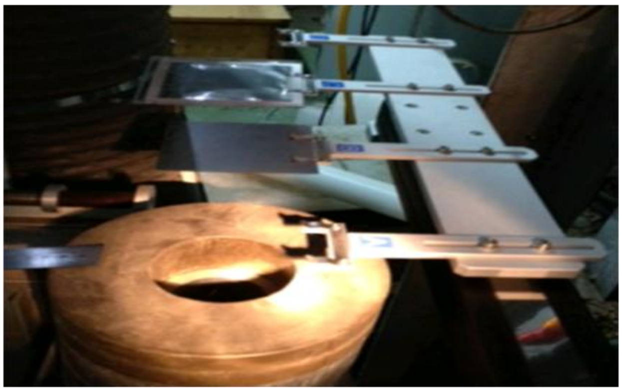

Figure.2: A photo of a motorized linear sample changer.

The neutron TOF spectra for the Dy sample, open beam, and the notch filter are shown in Fig. 3, together with the background level obtained by using the fitting function. The background fitting level was interpolated between the black resonances of a notch filter by using the fitting function $y = \exp(A + B \cdot x + C \cdot x^2)$, where *A*, *B*, and *C* are constants and *x* is the channel number.

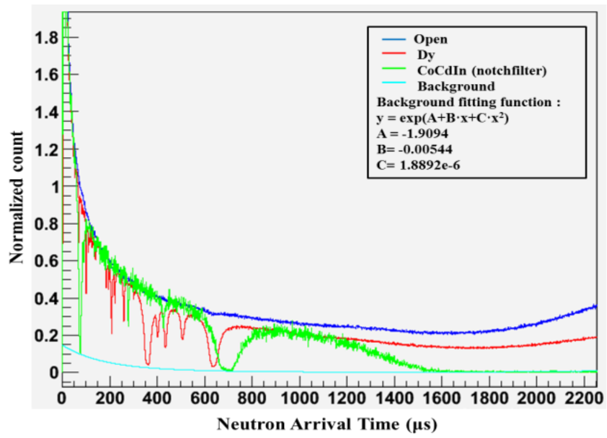

Figure.3: Neutron TOF spectra for Dy, notch filter, and open beam together with background fitting function.

3. Data Analysis and Result

The neutron energy E in eV corresponding to each timing channel T [μs] in the TOF spectrum is derived as follows:

$$E[eV] = \left[\frac{72.3 \times L[m]}{T[\mu s] - T_0[\mu s]} \right]^2, \qquad (1)$$

where L is the neutron flight path length in meters, T is the arrival time of neutron, and T_0 is the time difference between the start time and the real time zero when the neutron burst was produced. Using the known energies and the arrival times of four resonance peaks for the notch filter listed in Table 1, we found L=11.46±0.01 [m] and T_0= 3.74±0.19 [us].

Table.1: The values of energy and arrival time of four resonance peaks of notch filter.

Resonance Energy [eV]	Arrival time [μs]
132	76.01
9.04	279.11
3.85	426.04
1.457	690.89

The total neutron cross-section is determined by measuring the transmission of neutron through the sample. The total neutron cross-section is related to the neutron transmission rate as follows;

$$\sigma(E_i) = -\frac{1}{N} \ln\left(\frac{\Phi_{sample}(E_i)/M_{sample}}{\Phi_{open}(E_i)/M_{open}}\right), \qquad (2)$$

where *N* is the atomic density of the sample, $\phi_{sample}(E_i)$ and $\phi_{open}(E_i)$ are the neutron flux for the sample-in and the open beam, and M_{sample} and M_{open} are their monitor counts, respectively.

The total neutron cross-sections of the ^{nat}Dy sample as a function of neutron energy were obtained by using Eq. (2). The present result is compared with other data [1-3] and the evaluated data in ENDF/B-VII [6]. The present measurement is generally in good agreement with other data and the evaluated one as shown in Fig. 4.

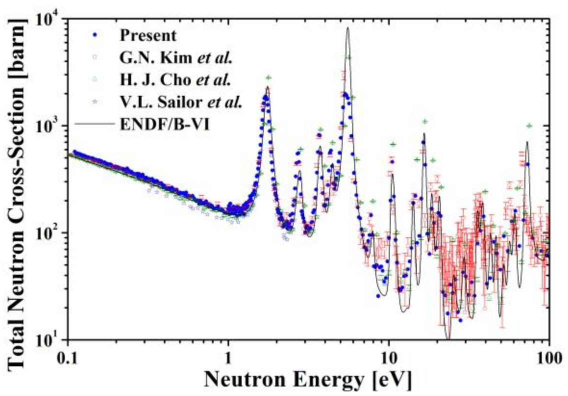

Figure.4: Comparison of the measured data with the evaluated data in the neutron energy region between 0.01 and 100 eV.

4. Conclusion

We have measured the total neutron cross-sections of ^{nat}Dy in the neutron energy region from 0.1 eV to 100 eV with the TOF method at the Pohang Neutron Facility. The present result is in good agreement with the previous data and the evaluated data in ENDF/B-VI. We would like to get resonance parameters by using SAMMY or REFIT codes.

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