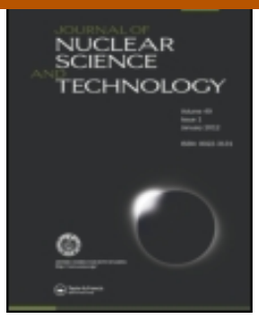

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Measurement of Neutron Total Cross Section of Silicon at 146-and 53.5-keV Windows

Yoshiaki FUJITA , Katsuhei KOBAYASHI , Itsuro KIMURA & Saim SELVI

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stream with high efficiency in the presence of NO_2. In practice, DOG contains water. Maeck *et al.*[3] and Wilhelm[4] have reported that zeolite 13X loses iodine removal efficiency, when co-adsorption of water occurs in large amounts. A counterplan for water, which is compatible with the total off-gas treatment system, remains to be established.

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SHORT NOTE

Measurement of Neutron Total Cross Section of Silicon at 146- and 53.5-keV Windows

Yoshiaki FUJITA, Katsuhei KOBAYASHI, Itsuro KIMURA and Saim SELVI†

*Research Reactor Institute, Kyoto University**

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KEYWORDS: neutron total cross section, silicon, filtered neutrons, neutron window, time-of-flight method, transmission measurement, keV range

Silicon has a marked minimum in the total cross section of neutrons at 146 keV, and is used as a filter material providing quasi-monoenergetic neutrons of 143 keV in the average energy. The authors measured[1] the total cross section near the minimum and the result was markedly different from an old measurement[2]. They found another minimum near 53.5 keV, which can also be used for providing filtered neutrons.

The experiment reported here is a refined measurement for these minima after making several improvements of experimental conditions and apparatuses. The cross section and energy values at the minima are more precisely determined in the present measurement.

1. Experiment

The present experiment has been carried out with a 22 m time-of-flight spectrometer at the electron linac facility of the Research Reactor Institute of Kyoto University, which is described in a literature[3]. The improvements in the experiment are itemized as follows:

(1) A higher energy resolution 0.5 ns/m, by more than three times, was employed using 15 and 10 ns for the widths of the pulsed linac-beam and the channel of a time analyzer, respectively.
(2) Higher counts by more than ten times were taken to reduce statistical errors.
(3) As a new neutron monitor, a 1-mm thick ^{6}Li glass scintillator was installed in the flight path instead of an old BF_3 counter placed in the target room.
(4) The Si-samples were 10.7, 27.2, 52.1 and 77.7 cm in thickness, while they

* *Kumatori-cho, Osaka 590-04.*
† Permanent address: Visiting Research Fellow from Faculty of Science, Ege University, *Bornova, Izumir, TURKEY.*

were 20.0 and 40.0 cm in the previous experiment. A thicker sample is better in a transmission measurement of a small total cross section. An employment of various thicknesses reduces the systematic error in the experiment.

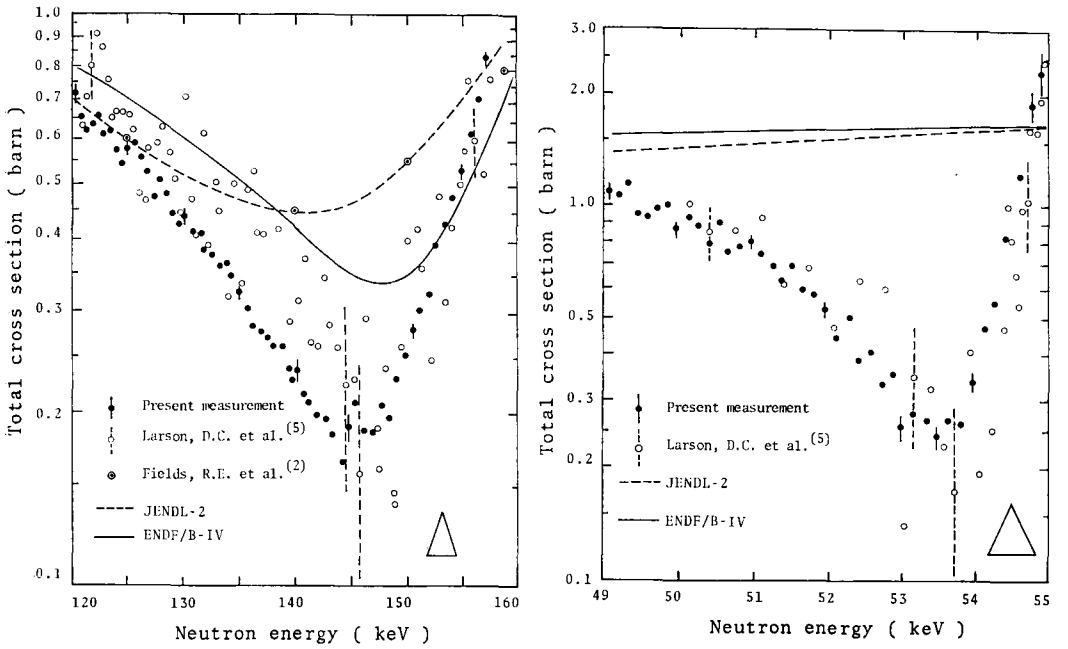
(5) The energy scale was more carefully determined and confirmed within a 0.4-% precision by making a transmission measurement with an Al-sample at resonance energies of 5.9035±0.0015 and 119.75±0.04 keV[4].

A ^{6}Li glass scintillator of 12.7 cm in diameter and 1.27 cm in thickness was used as the transmission detector. As a notch filter, a pile of Si-blocks of about 10 cm in effective thickness was placed at the entrance of the flight path in the target room. The background in the time-of-flight spectrum was determined with the counts in the regions blocked-out by the notch filter. The Si-sample was a transistor grade and the correction for the impurities was so small that it was neglected.

2. Results and Discussion

The total cross section is deduced from the five time-of-flight spectra for one sample-out run and four sample-in runs after subtracting the background and correcting for the dead time. The results are shown in **Fig. 1**(a) around the 146-keV window and in Fig. 1(b) around the 53.5-keV. The error bars typically shown for a few data points in the figures are of counting statistics, the predominant component of the errors near the minima of the cross section. The data points of open circles in Fig. 1 are the experimental results obtained by Larson *et al.*[5] Their experiment was of high energy resolution and of high intensity of the neutron beam. However, the sample used was only about 1.5 cm thick and thus the counting statistics in the cross section at the windows was rather poor, because the transmission of neutrons through the sample was higher than about 98% at the windows.

In Fig. 1(a) are also shown the experiment



(a) Near 146-keV (b) Near 53.5-keV

The triangle shows the energy resolution of this experiment. The curves are eye-guide interpolations of the evaluated values at discrete energy points.

Fig. 1 Total cross section of Si near 146- and 53.5-keV minima

of Fields *et al.*[2] and cross section curves evaluated for JENDL-2 (MAT=2,140) and ENDF/B-IV (MAT=1,194). The data points of Fields *et al.* are higher than the other data. The discrepancy may be attributed to the poorer energy resolution in Fields *et al.*'s experiment. The minimum value near 146 keV of the present experiment, 0.187±0.006 b, agrees with 0.17±0.05 b of Larson *et al.*'s. However, there is a systematic discrepancy between these two experiments in the other energies. Both of the evaluated curves are considerably higher than the present and Larson *et al.*'s experiments.

As for the 53.5-keV window, these experiments agree within the errors. The minimum value of the present data is 0.265±0.008 b, while that of Larson *et al.*'s is 0.2±0.08 b. This sharp window is smeared out in both of the evaluations which provide the gross structure of the total cross section.

The energies 146.0 and 53.5 keV may be attributed to the minima with the experimental precision 0.4%. The average energies of the filtered neutrons differ from these values depending on experimental conditions such as the length of the filter, the energy spectrum of the source neutrons and the secondary filter used. For an example, according to present estimation, the average energies of filtered neutrons from a $1/E$ source are 143 and 53.3 keV in case of Si-block with 2-m thickness, and the energy widths of 11 and 1.6 keV respectively. These widths correspond to two times of the root mean square of the spectrum spread.

The sum of potential scattering cross sections of the other isotopes than ^{28}Si in natural Si is estimated to be 0.16±0.016 b at the energies of the windows. The magnitudes of effective scattering radius used for the estimation, 4.0±0.2 fm for ^{29}Si and 4.3±0.2 fm for ^{30}Si, are taken from Ref. (4). Another estimation of the remaining cross section is given by Koester *et al.*[6] to be 0.208±0.007 b using the result of their scattering length measurement. These comparison show that the main part of minimum cross sections at the windows may be attributed to the potential scattering of other isotopes than ^{28}Si and the cross section of ^{28}Si is considered to be very small as expected from the Breit-Wigner cross section formula for an even-even nucleus.

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