THORIUM S-WAVE NEUTRON WIDTHS FROM 21 TO 2006 eV*

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A ^{232}Th total cross section measurement in the resolved resonance region has been requested with a 2% accuracy in order to obtain resonance parameters with a 5% accuracy.[1] These data are required for both fast and light-water breeder reactor studies. Inspection of the prior ^{232}Th differential data base shows several problems: the thermal cross sections seem inconsistent; the measured capture widths have large uncertainties; the two rather complete sets of measured[2,3] neutron widths are systematically discrepant; and the differential data appear to give Cd capture ratios and shielded-capture resonance integrals smaller than those required by integral measurements. In order to improve the differential data base we have measured neutron transmission spectra through eight samples of ^{232}Th. Resonance parameters have been obtained from these data using the computer code SIOB.[4,5] Fits to these data up to 440 eV, which concentrated on the capture widths, have been previously reported.[6] In this paper we report the results of extending these fits to 2.0 keV and discuss the result in terms of the s-wave strength function and the dilute-capture resonance integral.

Transmission spectra as a function of neutron flight time were measured at 40 m from the ORELA tantalum-target-moderator assembly employing an 88.9-mm diameter, 1.0-mm thick Li glass disk viewed edge on by two RCA-8575 phototubes. The summed fast signals, in coincidence with biased slow signals, produced 23,522 channel flight-time spectra stored in a large-capacity, rapid, random-access disk attached to a SEL 810 computer which automatically updated various scalars and cycled up to 20 filters and sample combinations in and out of the beam. Table I lists some of the experimental parameters. More details of the measurement can be found in Ref. 7 along with a description of the data reduction. In particular, the transmission normalizations are believed to be accurate to within ±0.5% and less than a 1% time-dependent background, as determined from black ^{238}U, Al and ^{232}Th resonances, was subtracted from the spectra.

The eight transmission spectra were simultaneously least-squares shape fitted using the computer code SIOB[4,5] which employees the multi-level Breit-Wigner approximation. In addition, considerable care was taken to account for distant levels so that the accurately measured transmission normalizations could be exploited in the fits. In particular, the data were divided into the 15 regions listed in Table II. The cross section for each region was calculated with the s-wave contribution from resonances extending $\sim$ 250 eV beyond the fitted region explicitly included. Even more distant levels were accounted for with "picket fence" terms. These cross sections were Gaussian Doppler broadened giving eight transmissions which were resolution broadened with an asymmetric resolution function[5] and least-squares fitted to the data by varying the resonance parameters, effective radius, and the resolution-width.

Several iterations of this procedure resulted in the effective radii "a" and equivalent moderator distances "d" of Table II which are satisfyingly energy independent. These average the appropriate values of 97.2 fm and 25.4 mm, respectively. More importantly, Fig. 1 summarizes the s-wave neutron widths for the ENDF/B-V[8] population where local strength functions for 0.5-keV intervals are plotted as percent differences from the ENDF/B-V evaluation. Also shown are the Rahn et. al.[2] and Ribon[3] measured values and the Derrien[9] and LASL[10] evaluated values. The ORELA measurement and analysis give the largest s-wave strength function above 0.5 keV which has been reported. The direct comparisons of the ORELA transmissions to ENDF/B-V calculated transmissions in Ref. 7 indicates that the trend shown in Fig. 1 continues to 4 keV.

The neutron and capture widths described in this paper and Ref. 6 increase the agreement between calculated and integrally measured dilute capture resonance integrals I_γ. Greneche[11] reports an evaluated I_γ = 85.8 ±0.9b (experiment) ±1.6b (normalization) from a review of the available integral measurements. Both the ENDF/B-V[8] and Derrien[7] evaluation give I_γ = 83.7b; whereas, the ORELA widths would give I_γ = 86.2b.

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TABLE I. Experimental Parameters

Flight path	40.015
Pulse rate	150 pps
Pulse width	12 nsec
Beam power	∿ 3.5 kW
γ-filter	Pb-1.9 cm
Time filter	B-1.1 kg/m^2
Bgd. filters	Al-0/2663 b^{-1}
	^{238}U-0.0188 b^{-1}
^{232}Th samples	0.19308 b^{-1}
	0.11588 b^{-1}
	0.03868 b^{-1}
	0.012566 b^{-1}
	0.004080 b^{-1}
	0.0013949 b^{-1}
	0.0004537 b^{-1}
	0.0001608 b^{-1}

TABLE II. LSF Effective Radii and Resolution FWHM

Region(eV)	a(fm)	d(mm)
9 - 89	96.4	26.4
89 - 186	97.4	25.5
186 - 295	97.4	24.2
295 - 440	96.4	23.4
440 - 551	97.4	23.6
551 - 636	98.0	23.0
636 - 759	97.5	23.7
759 - 881	97.2	23.9
881 - 1001	96.0	23.3
1001 - 1170	96.8	23.6
1170 - 1319	96.3	24.1
1319 - 1496	96.9	22.9
1496 - 1690	97.4	23.8
1690 - 1880	96.9	23.9
1880 - 2030	98.2	24.0

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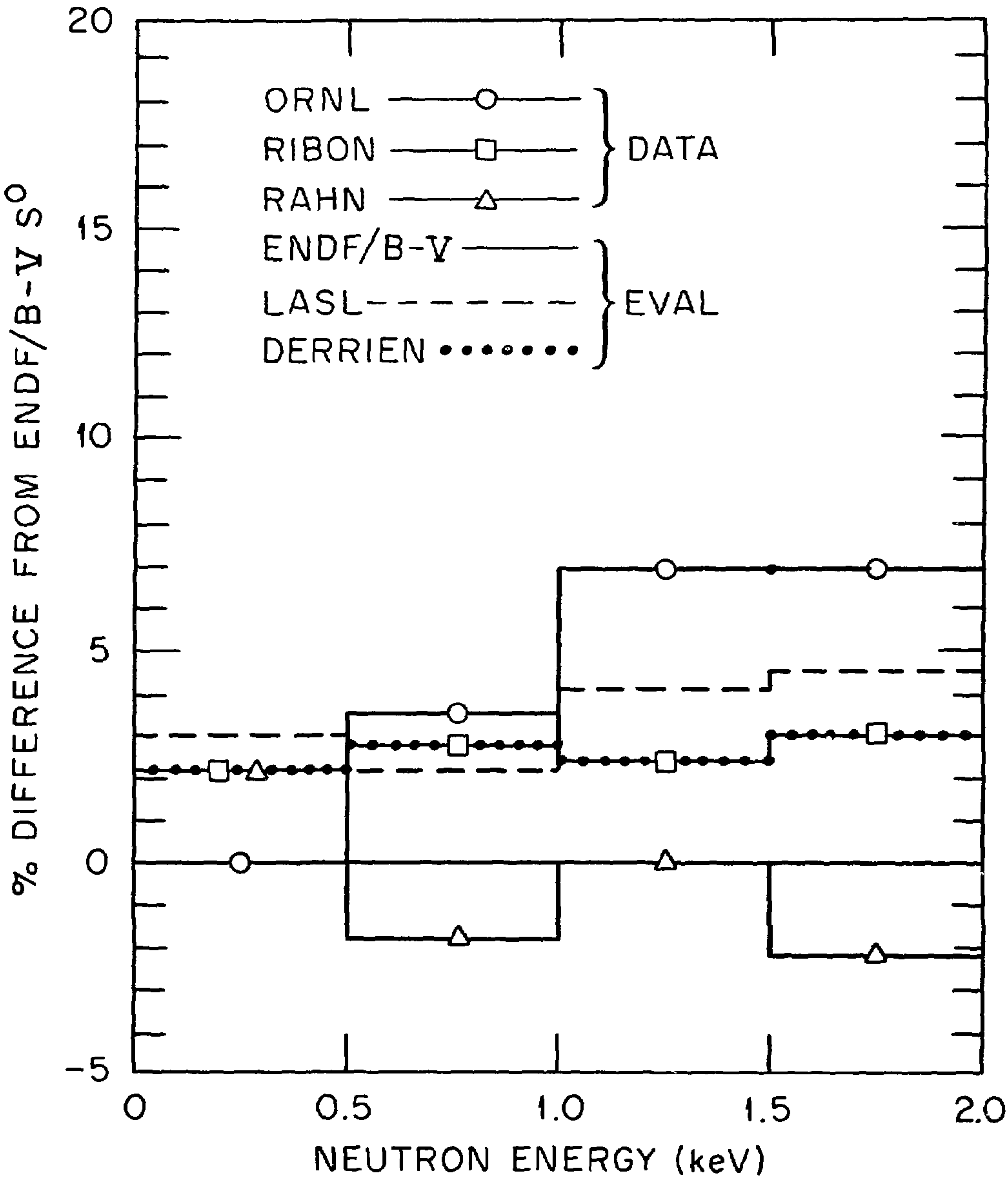

FIGURE CAPTION

Fig. 1. Comparison of ^{232}Th local s-wave strength functions for 0.5 keV intervals. The local strength functions, all assuming the ENDF/B-V s-wave population, are plotted as percent differences from the ENDF/B-V values. Above 0.5 keV the ORNL results give the largest strength function which has been measured.