

Integral Quantities

which may be included in evaluation process in SAMMY

(1) Thermal cross section

$$\sigma_{0x} = \sigma_x(E_0) \quad \text{for } E_0 = 0.0253\text{eV}$$

(2) Maxwellian average at thermal energy

$$\bar{\sigma}_x = \frac{\int_{E_1}^{E_2} \sigma_x(E) \frac{E}{E_0} e^{-E/E_0} dE}{\int_{E_1}^{E_2} \frac{E}{E_0} e^{-E/E_0} dE}$$

where $E_1 = 10^{-5}$ eV and $E_2 = 3$ eV

(3) Westcott's g -factor

$$g_x = \frac{2}{\sqrt{\pi}} \frac{\bar{\sigma}_x}{\sigma_{0x}}$$

(4) Resonance integral

$$I_x = \int_{E_3}^{E_4} \sigma_x(E) \frac{dE}{E} + X_{4x}$$

(5) Average integral

$$\hat{\sigma}_x = \int_{E_5}^{E_6} \sigma_x(E) dE / (E_6 - E_5)$$

(6) Watt spectrum average

$$\bar{\sigma}_{Wf} = \frac{\int_{E_1}^{E_7} \sigma_f(E) \Phi(E) dE}{\int_{E_1}^{E_7} \Phi(E) dE}$$

with $E_7 = 20 \text{ MeV}$

and $\Phi(E) = \text{Watt fission spectrum}$

$$\begin{aligned}\Phi(E) &= e^{-E/a} \sinh(\sqrt{bE}) \\ &= e^{-E/a} (e^{\sqrt{bE}} - e^{-\sqrt{bE}}) / 2\end{aligned}$$

(7) $K1$ (indicative of K_{eff} for thermal benchmarks)

$$K1 = \nu \sigma_{0f} g_f - \sigma_{0a} g_a = (\nu \bar{\sigma}_f - \bar{\sigma}_a) \frac{2}{\sqrt{\pi}}$$

(8) Alpha

$$\alpha = I_c / I_f$$

(9) Thermal alpha integral (NJOY's α),

$$\alpha_{NJOY} = \frac{\int_{E_1}^{E_2} \frac{\sigma_c(E)}{\sigma_f(E)} \frac{E}{E_0} e^{-E/E_0} dE}{\int_{E_1}^{E_2} \frac{E}{E_0} e^{-E/E_0} dE}$$

(10) Thermal eta integral (NJOY's η),

$$\eta_{NJOY} = \frac{\int_{E_1}^{E_2} \frac{v \sigma_f(E)}{\sigma_a(E)} \frac{E}{E_0} e^{-E/E_0} dE}{\int_{E_1}^{E_2} \frac{E}{E_0} e^{-E/E_0} dE}$$

Recent Addition to SAMMY

Flux-weighted group cross sections:

$$\bar{\sigma}_g = \frac{\int_{E_g}^{E_{g+1}} \sigma(E) \Phi(E) dE}{\int_{E_g}^{E_{g+1}} \Phi(E) dE}$$

with several options for $\Phi(E)$ —

Option 1: Bondarenko narrow-resonance weighting scheme,

$$\Phi(E) = \frac{C(E)}{\sigma_0 + \sigma_t(E, T)}$$

where

$C(E)$ = smooth function of energy

σ_0 = dilution

$\sigma_t(E, T)$ = Doppler-broadened total cross section

Option 2: flux is given numerically on energy grid (for intermediate spectrum, useful in criticality predictability) (not yet included in SAMMY, but “on the drawing board”)

Covariances are calculated for the group cross sections. (However, fitting is not permitted, only calculations.)

Example: ^{235}U

Differential measurements: 14 data sets analyzed via SAMMY

Details for ^{235}U can be found in

L. C. Leal, H. Derrien, N. M. Larson, and R. Q. Wright, *R-Matrix Analysis of ^{235}U Neutron Transmission and Cross Sections in the Energy Range 0 to 2.25 keV*, ORNL/TM-13516, Martin Marietta Energy Systems, Inc., Oak Ridge National Laboratory (November 1997). Also *Nucl. Sci. and Eng.* **131** 230 (February 1999).

Integral Standards: six quantities
have been included in analysis

Details can be found in

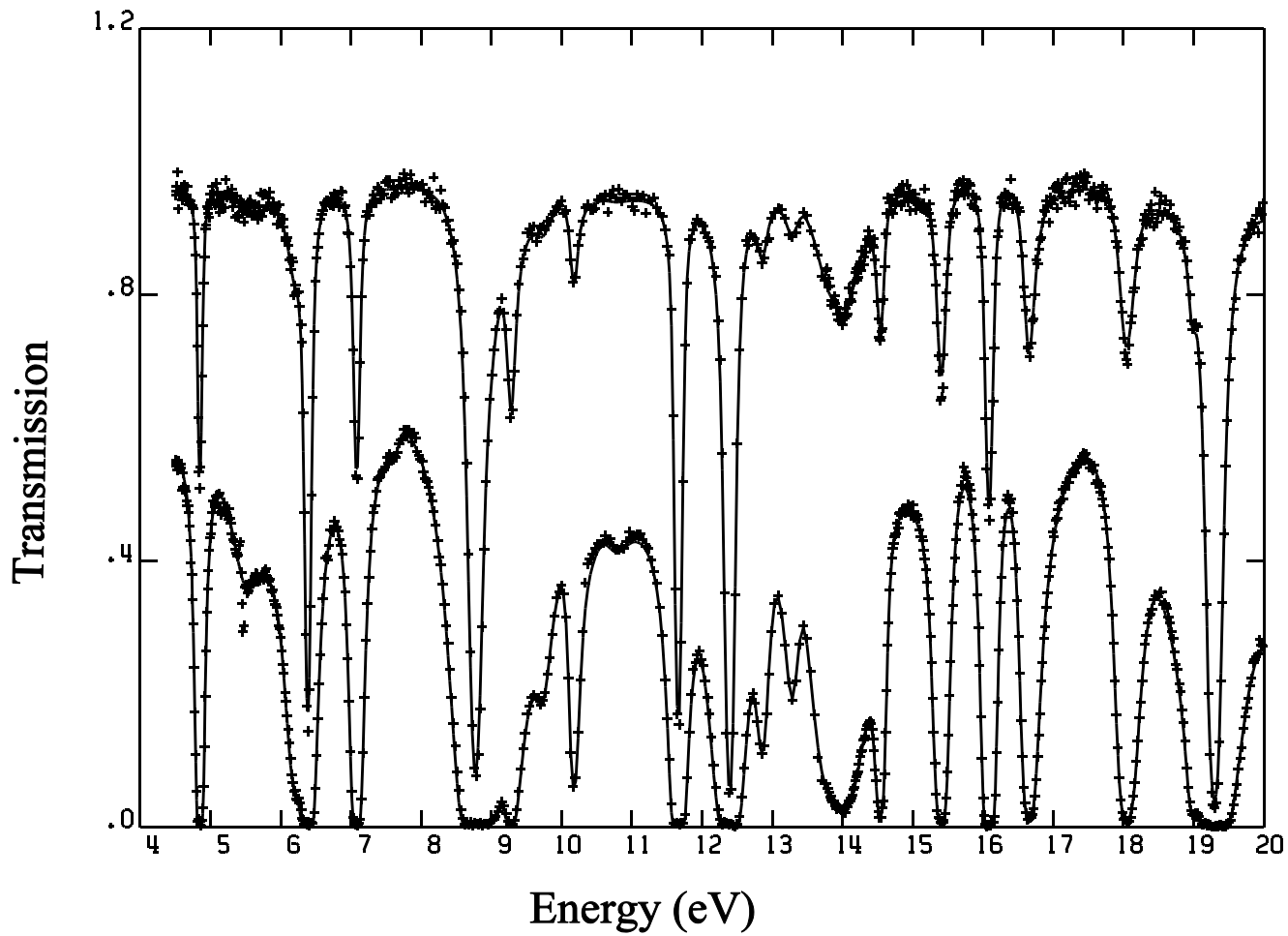
N. M. Larson, L. C. Leal, and H. Derrien, "Integral Data Analysis for Resonance Parameters Determination," ORNL-TM-13495, Oak Ridge National Laboratory, Lockheed Martin Energy Research, Inc. (1997). Also *Nucl. Sci. and Eng.* **131** 254 (February 1999).

Selected Measurements for ^{235}U

Reference	Energy range (eV)	Data set #	Data
de Saussure (RPI/1967) ¹⁰	0.01 - 2250.0	5,6	Fission & capture at 25.2 m
Perez (ORNL/1972) ¹¹	0.01 - 100.0	7,8	Fission & capture at 39.7 m
Weston (ORNL/1984) ²⁸	14.0 - 2250.0	14	Fission at 18.9 meters
Gwin (ORNL/1984) ⁴⁷	0.01 - 20.0	9	Fission at 25.6 meters
Spencer (ORNL/1984) ³	0.01 - 1.0	10	Transmission at 18 meters and sample thickness of 0.001468 atom/barn
Harvey (ORNL/1986) ²	0.4 - 68.0	1	Transmission at 18 meters. Sample thickness of 0.03269 atom/barn cooled to 77 K
Harvey (ORNL/1986) ²	4.0 - 2250.0	2	Transmission at 80 meters. Sample thickness of 0.00233 atom/barn cooled to 77 K
Harvey (ORNL/1986) ²	4.0 - 2250.0	3	Transmission at 80 meters. Sample thickness of 0.03269 atom/barn cooled to 77 K
Wartena (Geel/1987) ²⁴	0.0018 - 1.0		Eta at 8 meters
Wagemans (Geel/1988) ³¹	0.001 - 0.4	11	Fission at 18 meters
Schrack (RPI/1988) ³²	0.02 - 20	4	Fission at 8.4 meters
Weigmann (ILL/1990) ²⁵	0.0015 - 0.15		Eta (Chopper)
Weston (ORNL/1992) ⁴	100.0 - 2000.		Fission at 86.5 meters
Moxon (ORNL/1992) ²⁶	0.01- 50.0		Fission Yield
Gwin (ORNL/1996) ²⁷	0.01- 4.0	12,13	Absorption and fission

References for “Selected Measurements for ^{235}U ”

2. J. A. Harvey, N. W. Hill, F. G. Perey, G. L. Tweed, and L. C. Leal, *Proc. Int. Conf. On Nuclear Data for Science and Technology*, Mito, Japan (May 30-June 3, 1988).
3. R. R. Spencer, J. A. Harvey, N. W. Hill, and L. Weston, *Nucl. Sci. Eng.* **96**, 318 (1987).
4. L. W. Weston and J. H. Todd, *Nucl. Sci. Eng.* **111**, 415 (1992).
10. G. de Saussure, R. Gwin, L. W. Weston, and R. W. Ingle, *Simultaneous Measurements of the Neutron Fission and Capture Cross Section for ^{235}U for incident neutron energy from 0.4 eV to 3 keV*, ORNL/TM-1804, Martin Marietta Energy Systems, Inc., Oak Ridge National Laboratory, Oak Ridge, TN (1967).
11. R. B. Perez, G. de Saussure, and E. G. Silver, *Nucl. Sci. Eng.* **52**, 46 (1973).
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^{235}U Transmission data of Harvey et al. for two sample thicknesses (0.03269 barns and 0.00233 barns)

Comparison between experimental and calculated thermal values and integral quantities for ^{235}U

Quantity	Measured, recommended, and standard values	Fit to differential data	Fit to differential plus integral data
σ_{0f} (barn)	584.25 ± 1.11	584.28	584.88
$\sigma_{0\gamma}$ (barn)	98.96 ± 0.74	99.18	98.66
σ_{0s} (barn)	15.46 ± 1.06	15.44	15.67
$K1$ (barn)	722.7 ± 3.90	717.48	722.43
g_f	0.9771 ± 0.0008	0.9743	0.9764
g_a	0.9790 ± 0.0008	0.9774	0.9785