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Subject: Lexfor, resonance integrals

There is a Budapest-Ghent co-operation on thermal cross-sections and resonance-integrals for activation analysis, using with good success an improved formalism for resonance-integrals by which previous discrepancies between directly measured resonance-integrals and those derived from cross-section curves, can be resolved. As an Exfor compiler must know this formalism, I submit a proposed addendum to the Lexfor entry on Resonance-Integrals.

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Effective Resonance-Energies

The "ideal" resonance-integral is defined for an epithermal flux assumed to be proportional to 1/E. This is an approximation which may be sufficiently accurate in certain cases only. Directly measured resonance-intgrals and those computed from cross-section curves assuming a 1/E flux are often discrepant due to the fact that realistic epithermal fluxes deviate from the 1/E shape.

T.B. Ryves [Metrologia 5, 119, (1969)] has developed a better approximation which is sufficiently accurate for most applications. Ryves shows that the epithermal part of a reactor neutron spectrum is proportional to $1/E^{1+\alpha}$ where α is a constant close to zero (either positive or negative), which can be determined for each realistic reactor spectrum. Accordingly, the realistic resonance-integral is defined as:

$$I(\alpha) = \int_{E_c}^{\infty} \frac{\sigma(E)\ dE/eV}{(E/eV)^{1+\alpha}}$$

with E_c = cut-off energy (Cd cut-off near 0.5 eV). For $\alpha=0$ this formula goes over to the "ideal" infinite dilute resonance-integral

$$I_0 = \int_{E_c}^{\infty} \frac{\sigma(E)\ dE}{E}$$

The realistic resonance integral ($\alpha \neq 0$) and the ideal resonance integral ($\alpha = 0$) are related by the formula:

$$I(\alpha) = \frac{I_0 - 0.429\ \sigma_0}{(\bar{E}_r/eV)^{\alpha}} + \frac{0.429\ \sigma_0}{(2\alpha + 1)\ (E_c/eV)^{\alpha}}$$

where σ_0 = 2200 m/s cross-section

$\bar{E}_r$ = "effective resonance-energy" [reference: A. Simonits, F. de Corte, L. Moens, J. Hoste, J. of Radioanal. Chem. 72 (1982) 209, see p. 215].

The "effective resonance-energy" is a microscopic nuclear constant representing a kind of average over the major resonances. It is tabulated in the literature for various nuclides and can be determined by experiment and evaluation. For (n,γ) activation analysis it is needed as a correction factor of similar importance as the resonance integral. Its value need not be known with high accuracy. A 50% uncertainty in the effective resonance-energy may lead to a 1% uncertainty in activation analysis measurements, whereas ignoring the parameter α may lead to a 25% error in activation analysis measurements.
[reference: S. Jovanovic, F. de Corte, L. Moens, A. Simonits, J. Hoste, J. of Radioanal and Nucl. Chem. 82/2 (1984) 379].

Conclusion for Exfor compilation:

When directly measured resonance-integral data are compiled in Exfor it is essential

- to give all available information on the epithermal neutron spectrum; if given, to quote the α parameter;
- and to state whether the value given is $I(\alpha)$ for the realistic epithermal neutron spectrum, or whether appropriate corrections have been applied so that the value given is meant to be I_0 for an ideal epithermal 1/E spectrum.