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SENSITIVITY COEFFICIENTS FOR THE ^{238}U NEUTRON-CAPTURE SHIELDED-GROUP CROSS SECTIONS*

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In the unresolved resonance region cross sections are represented with statistical resonance parameters. The average values of these parameters are chosen in order to fit evaluated infinitely dilute group cross sections[1]. This procedure is not unique: several equally reasonable sets of average resonance parameters will fit well the evaluated infinitely dilute group cross sections.[2] The sensitivity of the shielded group cross sections to the choice of mean resonance data has recently been investigated for the case of ^{235}U and ^{239}Pu by Ganesan[3] and by Antsipov et al.[4] In this paper we report on similar sensitivity studies for ^{238}U. These sensitivities are important in evaluating uncertainties in computed Doppler coefficients of reactivity and central worth due to the parameterization of the unresolved resonance range[3] and in adjusting group cross sections with integral experiments.[5,6]

For this study the computer program PAPIN was developed, which constructs cross section probability tables and shielded group cross sections for several dilutions and for several temperatures. The shielded cross sections are calculated using the Bondarenko formula and averaged by a Lebesgue integral over the probability table.[7]

Several studies were performed. As an example, in Fig. 1 we show the quantity,

$$F_1(T,E,\sigma_o) = \frac{\delta\langle\sigma_{n\gamma}\rangle}{\langle\sigma_{n\gamma}\rangle} \frac{\langle\Gamma_n'\rangle}{\delta\langle\Gamma_n'\rangle}$$

where $\delta\langle\sigma_{n\gamma}\rangle / \langle\sigma_{n\gamma}\rangle$ represents the relative change in the shielded average capture cross section at temperature T, energy E, and dilution σ_o corresponding to a

a relative change $\delta\langle\Gamma_n'\rangle / \langle\Gamma_n'\rangle$ in the average p-wave neutron width. For the data shown in Fig. 1 the capture widths were kept constant and the average s-wave neutron width was readjusted in order to keep the infinitely dilute capture cross section constant and equal to the ENDF/B-V value. The data of Fig. 1 are for 3 typical energies with T = 300°k.

If we assume a 5% uncertainity in the value of the average p-wave neutron width at 20 keV, the sensitivity coefficients of Fig. 1 suggest a corresponding 4% uncertainty in the shielded average capture cross section for a dilution σ_o = 10b. Hence realistic estimates of the uncertainties in the average resonance parameters and of the covariance between them are required to assess properly the uncertainties in shielded group cross sections and thus in the calculations of the Doppler coefficient of reactivity. As was pointed out by several authors, similar sensitivity studies and uncertainty estimates are also required for any meaningful adjustment study in the unresolved resonance region.[5,6] Clearly the effect shown in this work, is of relevance to the adjustment process as it affords an extra degree of freedom, in that the group cross sections can be readjusted, within certain limits, without alteration of the differential data.[3]

In summary a technique is presented to study the sensitivity of shielded group cross sections to the parameterization of the unresolved resonance region, using the probability table approach. This technique is illustrated with a study of the sensitivity of the shielded ^{238}U capture cross section to the assumed value of the average s-wave and p-wave neutron widths.

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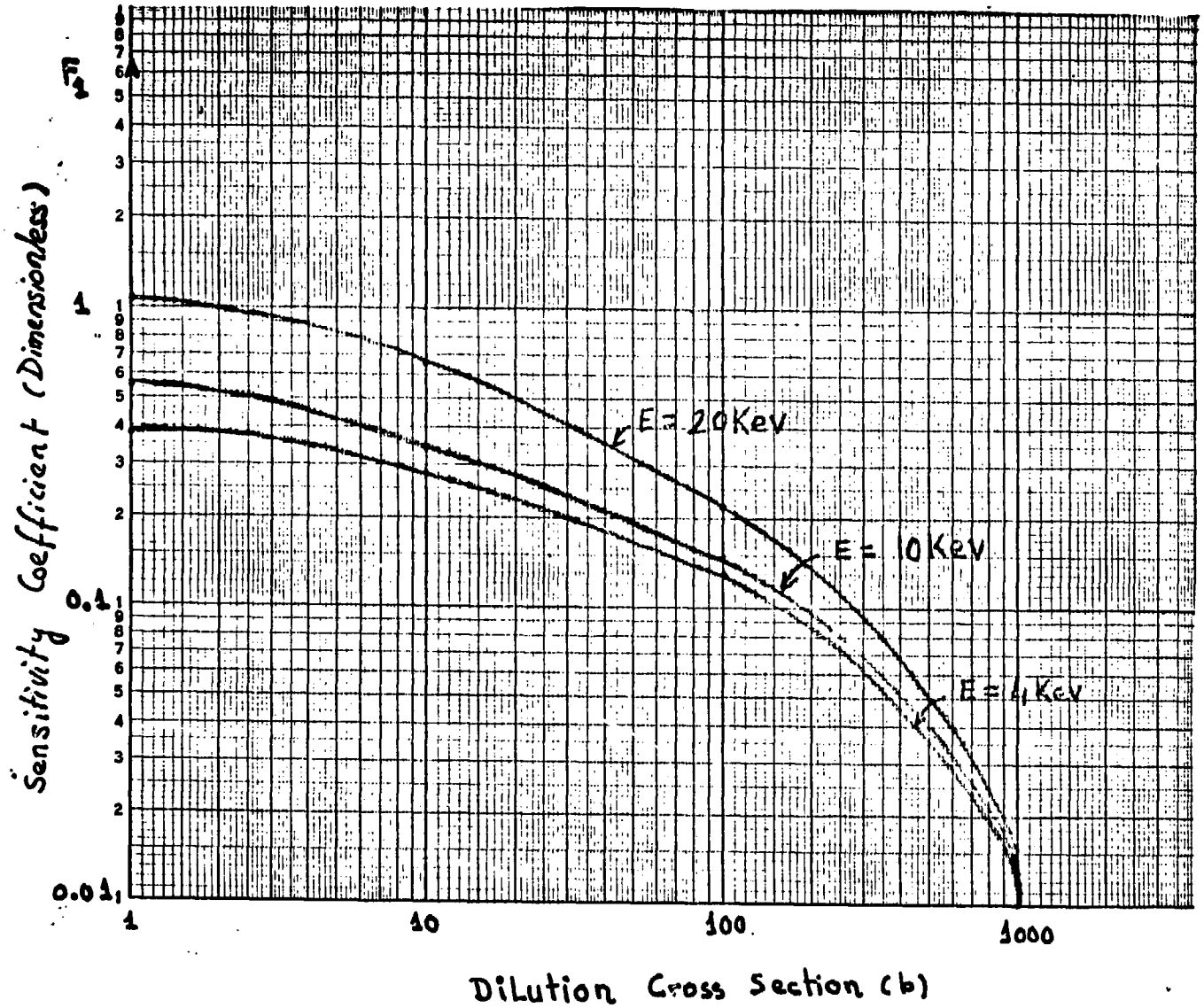
Sensitivity Coefficient (Dimensionless)
10
1
0.1
0.01
1
10
100
1000
Dilution Cross Section (b)
E = 20Kev
E = 10Kev
E = 4Kev

FIGURE CAPTION

Fig. 1. The sensitivity coefficient (see definition in text), versus the dilution cross section (b) for ^{238}U neutron capture shielded group cross sections at 300°k for 4 keV, 10 keV and 20 keV neutron energies.