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REPRESENTATION OF THE NEUTRON CROSS SECTIONS OF SEVERAL FERTILE AND FISSILE NUCLEI IN THE RESONANCE REGIONS*

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In this critical review we discuss some problems associated with the measurement and representation of the neutron cross sections of the fertile and fissile nuclei in the resolved and unresolved resonance regions. We restrict our attention to the heavy nuclei most important for nuclear reactor applications: the resonance structure of the light- and medium-weight nuclei (moderators and structural materials) has different characteristics and requires a different approach. In fact, we concentrate on five specific nuclei: the fertile ^{232}Th and ^{238}U and the fissile ^{233}U, ^{235}U and ^{239}Pu which play a major role in practical applications and have resonance structures somewhat typical of the actinides.

We discuss some of the experimental problems in neutron cross-section measurements and some of the ambiguities in the resonance analysis resulting from the use of different resonance formalisms and different treatments of the effect of "far-away" levels.

The evaluator must review several data sets and the resonance parameters obtained from their analysis and determine an appropriate set of parameters for inclusion in the ENDF/B evaluation. Since the cross sections are often analyzed with different formalisms and almost always with procedures different from those of ENDF/B, this evaluation process has often led to unfortunate results such as the ENDF/B specification of "negative cross sections" or of a "smooth" File-3 contribution with considerable structure. Much progress has been accomplished recently toward understanding and resolving such problems, but the representation of the resolved region in ENDF/B-V is still inadequate.

In the unresolved resonance region the ENDF/B does not specify cross sections but defines statistical distributions of fictitious unresolved resonance parameters. These distributions can be used to obtain most probable values and associated probability distributions for average dilute or self-shielded group cross sections as a function of temperature. The methods used by evaluators to generate the average value and distribution of the unresolved resonance parameters are largely arbitrary and ambiguous. Several authors have recently discussed the problems and inconsistencies of such a probabilistic representation of the cross sections and suggested other approaches. We feel that what is most needed are precise self-indication and Doppler-effect measurements to test the several possible representations of the cross sections in the unresolved resonance region.

In recent years much effort has been spent into generating covariance files to specify the uncertainties in the ENDF/B cross sections. These covariance files are needed to adjust cross sections so as to take into account both differential and integral measurements in generating a cross section library. At the present time no satisfactory method to specify a covariance file for the resolved and unresolved resonance parameters has been found, but several recent developments appear promising.

In summary, in spite of much progress in the accuracy of cross-section measurements and their analysis, many problems remain with the ENDF/B-V representation of the cross sections of the fertile and fissile nuclei in the resolved and unresolved resonance regions. Some of the important tasks remaining are: (1) A better evaluation of the resolved resonance parameters using the best data presently available, particularly for ^{235}U, (2) a better definition of the logical and theoretical basis for the unresolved resonance region representation, (3) the collection and use of good and simple self-indication measurements and Doppler-effect benchmarks to test the resonance representations, and (4) the development of reliable uncertainty covariance matrices for the resolved and unresolved resonance parameters.