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RESOLVED-RESONANCE NEUTRON WIDTHS FROM A CONSISTENT REANALYSIS OF THE MOST RECENT ^{238}U TRANSMISSION DATA

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RESOLVED-RESONANCE NEUTRON WIDTHS FROM A CONSISTENT REANALYSIS OF THE MOST RECENT ^{238}U TRANSMISSION DATA*

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The ^{238}U neutron differential capture cross sections are one of the most important nuclear data for reactor physics calculations. Nevertheless, differential data have persistently over-predicted the ratio of the ^{238}U capture rate relative to the ^{239}Pu fission rate in fast-reactor spectra as measured by integral experiments. One of the possible ways of perhaps reducing this discrepancy is to extend the theoretically sound resolved-resonance range upwards in energy from the present 4 keV to 10 keV. Such a development would eliminate the need to treat the 4- to 10-keV capture region with the much more ambiguous unresolved resonance theory. More of the self-shielding effects would be accounted for in a logically consistent fashion, directly based on differential data.

One of the major obstacles to such an extension is the published discrepancies among the resolved-resonance region neutron widths from 1 to 4 keV from the three most recent transmission measurements and analysis: the 1978 results of Olsen et al.[1] from Oak Ridge National Laboratory (ORNL); the 1975 results of Poortmans et al.[2] from the Central Bureau of Nuclear Measurements (CBNM) in Belgium; and the 1975 results of Nakajima et al.[3] from the Japan Atomic Energy Research Institute (JAERI). These measurements and analyses give neutron widths which are increasingly discrepant (up to 10 or 15%) with increasing energy. Clearly, higher energy resonance parameters could be obtained with considerably more

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confidence if the discrepancies in the existing resolved-resonance region were understood and eliminated.

In this paper, the results of a detailed reanalysis of the three recent transmission measurements over three narrow energy regions are reported: region 1, 3820 to 4000 eV, six large resonances; region 2, 2470 to 2740 eV, ten large resonances; and region 3, 1460 to 1820 eV, twelve large resonances. This reanalysis was done in order to determine whether the systematic resolved-resonance neutron-width discrepancies are caused by systematic differences between the reduced transmission data or whether the neutron-width discrepancies are introduced in the data-analysis procedure. These calculations were done, in part, in response to the work of the Nuclear Energy Agency Nuclear Data Committee ad hoc task force on discrepancies in ^{238}U differential data. Details of the measurements can be found in refs. 1, 2, and 3.

The three data sets over the three energy regions were least squares shape-fitted with the computer code SIOB[1,4] which was written specifically for the ^{238}U resolved resonances. SIOB employs the MLBW approximation and uses cross-section equations identical to those used in processing codes. Several sample thicknesses can be fit simultaneously, and global parameters such as data normalizations and excess-background corrections can be varied in order to search for possible errors in the data reduction. In addition, the instrumental resolution function can be determined from the transmission data itself by means of variable width parameters, etc., in mathematical forms describing the resolution.[5]

Figure 1 summarizes the results of this reanalysis in terms of average neutron-width deviations from the ENDF/B-V evaluation.[6] Results for the three energy regions are connected by straight lines: solid lines show the original published neutron widths, dashed lines show the neutron widths from the present

reanalysis, and the dotted lines show neutron widths from calculations in which possible background subtraction errors are also sought. The resolution functions from these fits are highly asymmetric as one would expect and are perhaps broader than one would have initially assumed. More importantly, this reanalysis gives neutron widths which, as shown in Fig. 1, systematically agree within 2 to 4% except for the 4-keV JAERI data in which there may exist a background subtraction error. In any event, most of the discrepancy is removed and seems to have been introduced in the data-analysis procedure. The ORNL neutron widths are increased by 2 to 4% because of the more sophisticated treatment of the resolution function employed in the present study. The CBNM and JAERI neutron widths tend to increase by larger amounts. These data were initially analyzed by the much simpler area analysis technique with symmetric resolution functions. This technique does not seem valid at the higher energies for these complicated spectra and resolution functions.

The dotted lines in Fig. 1 show results with variable excess-background corrections. With the CBNM data and JAERI data, these corrections converge to unrealistically large values giving unbelievable neutron widths. With the ORNL data, these corrections converge to zero, a very pleasing result that verifies the essential goodness of the fits and correctness of the original experimentally determined background subtractions.

The results of this study eliminate the resolved-resonance region neutron-width discrepancy, indicate that these neutron widths are on the average 4 to 8% larger than those contained in the ENDF/B-V evaluation,[6] and give confidence that resolved-resonance parameters can be obtained up to 10 keV. The previously published ORNL 4- to 6-keV resonance parameters[7] were analyzed in a consistent fashion with the present reanalysis as well as preliminary parameters which cover the 6- to 10-keV region.

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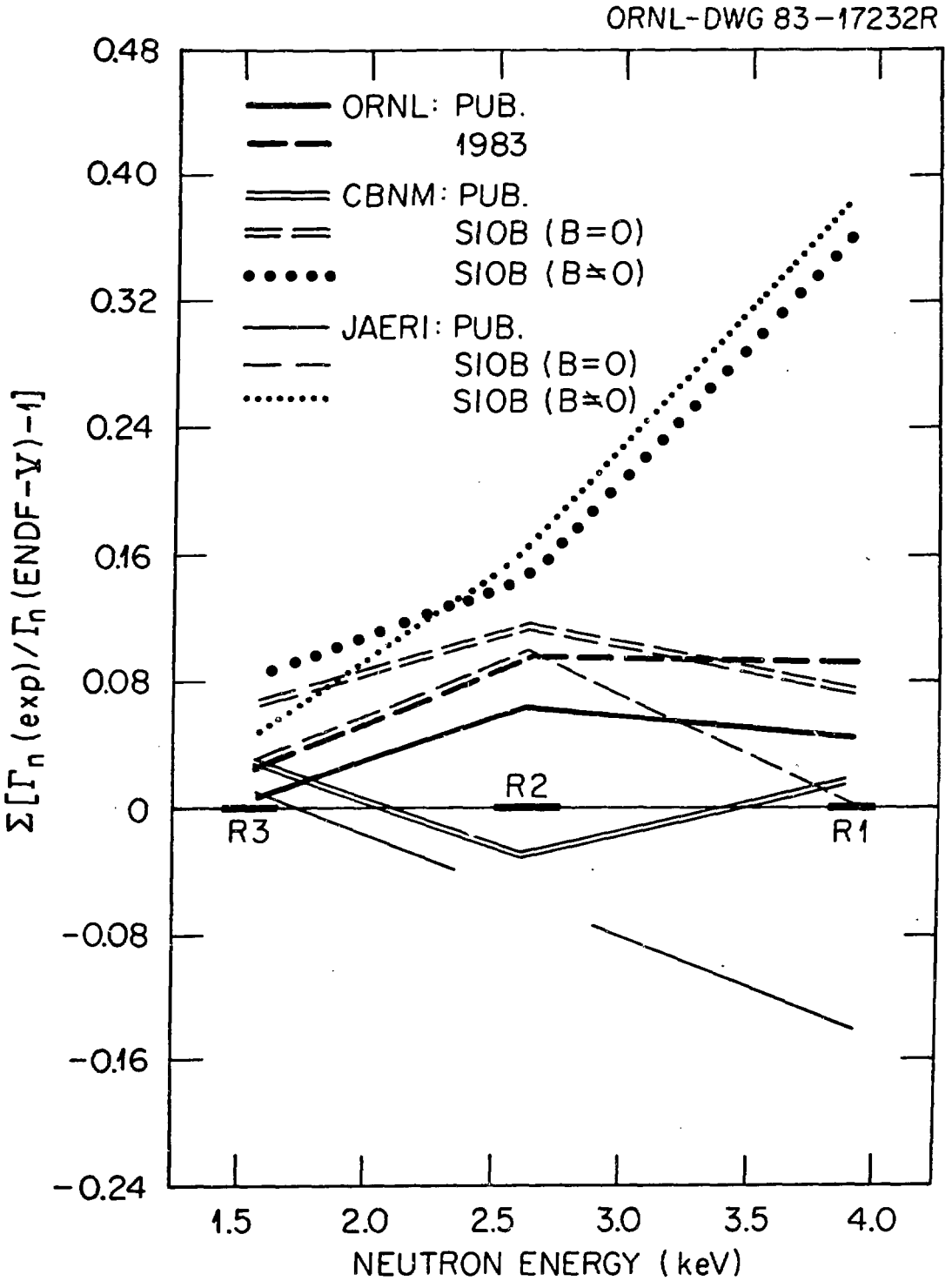

Fig. 1. Average deviations from the ENDF/B-V evaluation for the published and SIOB-fitted neutron widths from the ORNL (ref. 1), CBNM (ref. 2), and JAERI (ref. 3) transmission data sets. The deviations for the three energy regions are connected with straight lines. The dashed lines are results with no excess-background corrections, and the dotted lines are results with variable excess-background corrections.