IEC-106

PROPOSAL

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to Subgroup 15: " Self-shielding treatment
in the unresolved resonance region "

The single form of the cross-section structure data storage in the unresolved resonance region in the ENDF format is the average resonance widths and level spacings considered as Porter-Thomas and Wigner distribution parameters. The averaging intervals are supposed to be large enough to include the great number of resonances and to present the statistical distribution. But there are experiments, namely the transmission function measurements, which allow to define the resonance self-shielding effects immediately for narrow, from point of view of the statistical averaging, energy intervals. It is impossible now to include this data in the evaluated data file without loss of information, which is important to take into account correctly the self-shielding effects in multi-group calculations, espesially for structure materials.

There is a possibility to eliminate this defect if to use the $p(\sigma)$ cross-section distribution parameters to present the cross-section structure data. A great deal of methods has been developed to transform the transmission functions into form of parameters of different approximations $p(\sigma)$: discrete presentation as a sum of delta-functions, /1,2/, continual approximation by gamma-distribution /3/, approximation based on the identical equidistant resonances presentation /4/ and so on It seems to be important to define the validity different approaches to the problem mentioned above.

It is supposed during 1994 year:

1) to compare different methods of $p(\sigma)$ approximation on the typical cross-section samples,
2) to work out proposals concerning the cross-section structure presentation in the evaluated data file,
3) to publish the results in J. VANT.

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MEASUREMENTS AND CALCULATIONS OF ^{235}U, ^{239}Pu, ^{232}Th NEUTRON TRANSMISSIONS IN ENERGY RANGE 2.15EV-14MEV FOR TEMPERATURES 77° AND 293°

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ABSTRACT

The neutron transmissions for ^{235}U, ^{239}Pu and ^{232}Th metal samples as the functions of sample thicknesses has been measured on the 123m and 1006m flight paths of the IBR-30 booster (JINR,Dubna) in neutron energy range 2eV-14MeV. The measurements have been carried out for liquid nitrogen ("cold") and room ("hot") temperatures of filter samples. The batteries of 3 boron counters and 26 helium counters have been used as detectors. Analogous transmissions have been calculated from the BROND-2,ENDF/B-6 and JENDL-3 evaluated data libraries by means of the GRUCON computer program package.

I. INTRODUCTION

The investigations of the transmission temperature dependence allows to define the temperature increments for resonance self-shielding factors, which are used in the doppler reactivity effect calculations for nuclear power reactors. There are now only two experimental measurements of the transmission temperature dependence for ^{235}U [1,2]. Detailed analysis of the temperature influence on the neutron cross-section self-shielding factors has been carried out for ^{235}U and ^{239}Pu [3]. The conclusion has been made that the experimental and theoretical investigations of the doppler-effect are needed for principal fission, fertile and structural reactor materials.

II. EXPERIMENTAL METHOD

The doppler transmission coefficients were measured for the ^{235}U, ^{239}Pu and ^{232}Th metal samples under 77° and 293° temperatures on 123m and 1006m flight paths of the fast impulsive reactor IBR-30 (JINR, Dubna) operated on the average thermal power level 10kWt with neutron impulse frequency 100Hz and impulse duration 4mks. The filter samples were metal disks 45mm in diameter, hermetically packed in aluminum (^{232}Th, ^{235}U) or stainless steel (^{239}Pu) containment. The ^{235}U samples had 10% admixture of the ^{235}U. The filter samples was cooled in the Dewar vessel which had cylindrical hole 50mm in diameter and 300mm length. The Dewar vessel was placed at the distance 116m or 1000m from the IBR-30 reactor core. A battery of three boron counters SNM-13 type and ring SNM-18 type battery consisted of 26 helium counters were used as neutron detectors for 123m and 1006m flight paths respectively. The lead scattering sample was placed inside the ring battery. The energy resolution was about 40% at the energy 200keV and 0.13% at the energy 2eV for short flight path; it was 70% at the energy 14MeV and 0.2% at the energy

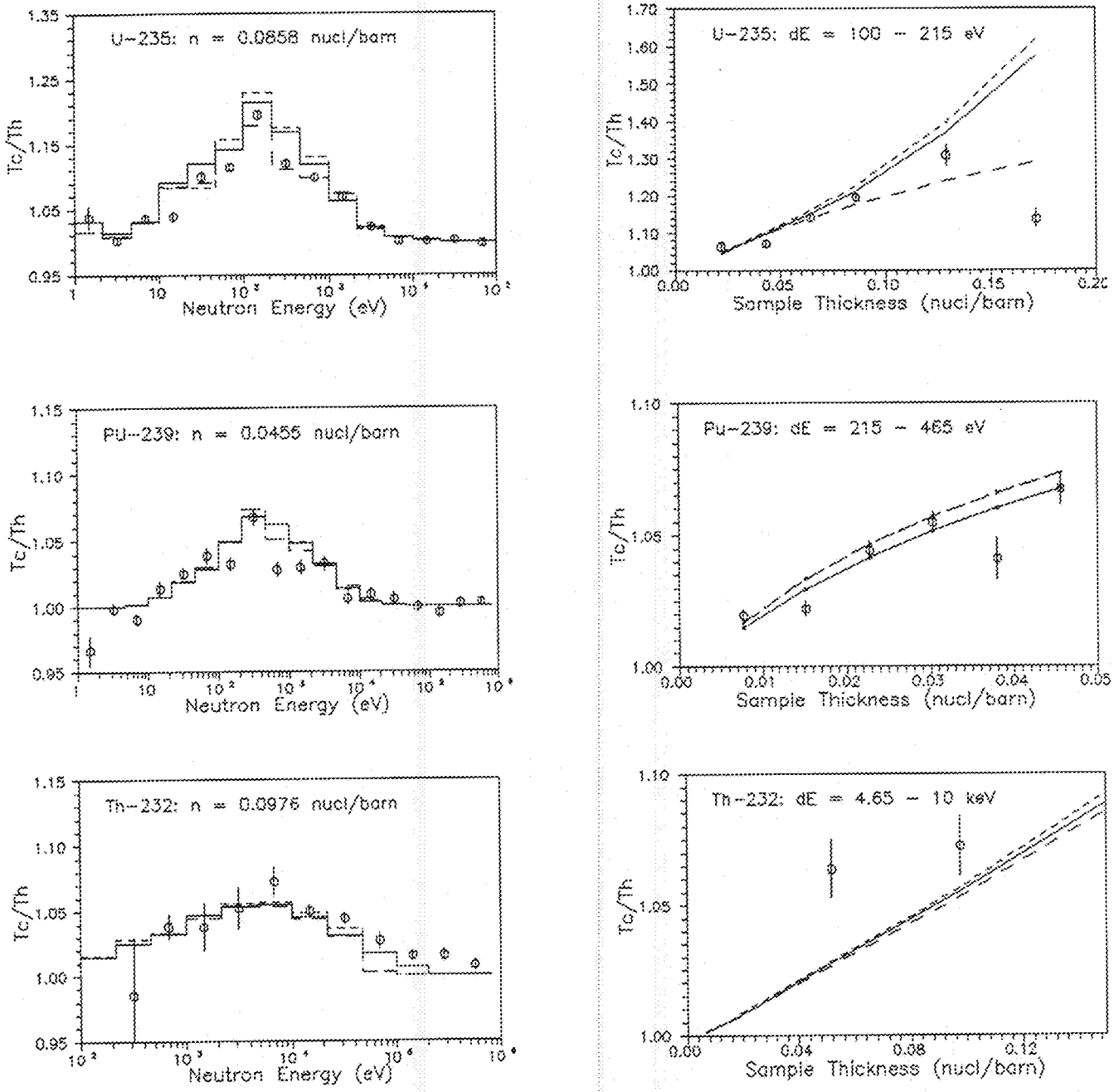

Fig.1 Transmission ratio Tc/Th versus neutron energy (left) and sample thickness (right) measured in present work and calculated from BROND-2 (solid line), ENDF/B-6 (long dash-space line) and JENDL-3 (short dash-space line).

1keV for long flight path. The measurement for each sample included two runs, with and without liquid nitrogen in Dewar vessel, with running time about 12 hours. To define the transmissions, the measurements for empty containments were carried out. The phone components was defined by Ti, Al, Mn, Co, In resonance filters. The reactor power level has been monitored by two counters SNM-12 type.

III. RESULTS

It has been measured and calculated the transmission ratio T_c/T_h, where T_c, T_h - the transmissions for cold and hot samples respectively, for six samples of ^{235}U (0.0216, 0.0430, 0.0642, 0.0858, 0.1286, 0.1713 nuclei/barn), for six ^{239}Pu samples (0.0076, 0.0152, 0.0227, 0.0303, 0.0379, 0.0455) and for two ^{232}Th ones (0.0517,0.0976).

The increasing of the sample nuclear density due to cooling has been taken into account by the correcting factor, which has been defined from the experimental data in the energy region, where the resonance doppler effect is absent, by formulae:

$$\alpha = \frac{1}{\theta_c - \theta_h}\left(\sqrt{\frac{lnT_h}{lnT_c}} - 1\right)$$

where θ_c, θ_h - filter sample temperature (cold and hot).

The calculations has been carried out from BROND-2, ENDF/B-6 and JENDL-3 data libraries by the GRUCON computer program package [4]. The effective temperatures of cold and hot samples in calculations have been taken equal to 100° and 297° respectively.
The measured and calculated values are compared on the Fig.1. The sample thickness dependance are given for enrgy range where the doppler effect has maximum value.

The discrepancies between measured and calculated transmission ratios are essential for uranium and thorium, especially at the low energy region (about 10%-20%). The discrepancies in values obtained from different libraries are 10%-30%. The maxima positions are: E = 100 - 200 eV for ^{235}U, E = 200 - 400 eV for ^{239}Pu and E = 4.65 - 10 keV for ^{232}Th.

CONCLUSIONS

The measured values of the ^{235}U transmission ratios are in a good agreement with calculation results obtained from the ENDF/B-6 data at energy range E = 2.15eV - 14MeV. The BROND-2 and JENDL-3 parameters give the doppler coefficients on thick samples 10% - 30% higher then measured values at the energy range 100.-465 eV. These discrepancies are revealed at the unresolved resonance range and are connected probably with invalidity of the statistical approach.

The ^{232}Th experimental doppler coefficients in resonance region are 10% - 15% higher then calculated ones for all libraries.

For ^{239}Pu, there is acceptable agreement between the measured and calculated results.

ACKNOLEDFMENTS

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