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Annual Report on Nuclear Data Activities in Romania for 1980

By S. Rapeanu
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Bucharest

July 1981

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This annual report contains the main nuclear data works performed during the year 1980 in the Central Institute of Physics from Romania.

The individual reports are not intended to be complete or formal. Consequently, they must not be quoted, abstracted or reproduced without the permission of the authors.

July 1981

MULTIGROUP DATA FOR FISSION PRODUCTS IN THE WIMS-D LIBRARY FORMAT

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An evaluation of the main multigroup nuclear data for 30 fission products is presented, based on the most recent microscopic data available in ENDF /B-IV library.

In Table I the fission products which have been taken into account are presented, together with the half lives and fission yields.

The method used implied the following steps:

- the cross section calculations from resonance parameters (using the program RESEND)
- the data liniarization (using the program LINIAR).
- Doppler broadened cross section calculation at 293.6^{o}K temperature (using the program SIGMA-1)
- the translation of data from ENDF/B to UKNDL format (using the program MISSIONARY)
- the multigroup cross section calculation, averaged on Maxwellian spectra up to 0.1 eV, 1/E spectra up to 9.118 keV and , an "dry" spectra up to 10 MeV (using the program GALAXY).

The multigroup structure for 69 group was that from WIMS-D library.

The obtained results were compared with those from WIMS-D library (probably first version).

Differences between 0.3% and 70% were observed. In the thermal group (64) the ratio of our capture cross section and that from WIMS-D library was computed (Table II).

TABLE I

No.	Isotope	MAT ENDF/B-IV	No.of indenti-fication WIMS - D	No. of reso - nances	$T_{1/2}$	Y(%)
1	Mo-95	265	95	55	stable isotope	6.505055
2	Tc-99	286	99	18	2.14×10^{5}y	6.157485
3	Ru-101	310	101	7	stable isotope	5.08267
4	Ru-103	312	1103	--	39.4 d	3.04386
5	Rh-103	330	103	280	stable isotope	3.043907
6	Rn-105	334	105	--	35.4h	0.96896
7	Pd-105	359	1105	9	stable isotope	0.96896
8	Pd-108	363	108	3	stable isotope	0.068872
9	Ag-109	387	109	63	stable isotope	0.033055
10	Cd-113	421	113	--	9.3×10^{15}y	0.01214
11	In-115	449	115	91	5.1×10^{14}y	0.010418
12	I -127	565	127	79	stable isotope	0.125448
13	Xe-131	592	131	40	stable isotope	2.88841
14	Cs-133	613	133	163	stable isotope	6.705909
15	Cs-134	614	134	--	2.062y	1.35E-05
16	Xe-135	599	135	--	9.104h	6.557332
17	Cs-135	616	1135	--	2.95×10^{6}y	6.558809
18	Nd-143	714	143	18	stable isotope	5.952681
19	Nd-145	716	145	79	$>6 \times 10^{16}$y	3.991584
20	Pm-147	733	147	14	2.6234y	2.2413
21	Pm-147	733	1147	14	2.6234y	2.2413
22	Sm-147	753	2147	59	1.06×10^{11}y	2.2412
23	Pm-148M	735	148	1	41.29d	5.00E-08
24	Pm-148	734	1148	--	5.37d	2.23E-08
25	Sm-149	755	149	36	$>1 \times 10^{16}$y	1.076101
26	Sm-150	756	155	--	stable isotope	3.02E-05
27	Sm-151	757	151	12	90y	0.416724
28	Sm-152	758	152	57	stable isotope	0.268404
29	Eu-153	776	153	103	stable isotope	0.161657
30	Eu-154	777	154	78	8.5y	1.83E-06
31	Eu-155	778	155	--	4.96y	0.032138
32	Gd-157	794	157	56	stable isotope	0.006201

TABLE II

Isotope	σ_c(bn)	σ_{el}(bn)	σ_c/σ_{el}	$\Delta\sigma_c^{(\%)} = \frac{\sigma_c - \sigma_c^W}{\sigma_c^W} \times 100$ σ_c^W = WIMS-D library
Mo-95	1.3906+1	1.16307	1.196+1	+ 2.77
Tc-99	1.8353+1	2.80679	6.5387	-12.18
Ru-101	2.1234+0	1.68194	1.2625	-37.95
Ru-103	7.4408+0	4.05182	1.836	+54.97
Rh-103	1.5177+2	3.82369	3.969+1	+ 7.94
Rh-105	1.4265+4	4.10358	3.476+3	- 7.39
Pd-105	1.3706+1	3.84355	3.6	+49.47
Pd-108	1.1762+1	2.34363	5.02	+12.158
Ag-109	8.8818+1	1.69274	5.25+1	+ 4.08
Cd-113	1.9852+4	2.4938+1	7.96+2	+ 3.788
In-115	1.9610+2	1.74137	1.126+2	+ 0.715
I -127	5.9974+0	3.23716	1.85	-10.94
Xe-131	8.7057+1	4.33092	2.01+1	- 2.35
Xe-135	2.6759+6	3.1299+5	8.5	+ 1.11
Cs-133	2.8800+1	4.87632	5.9	+ 4.24
Cs-134	1.3512+2	4.81213	2.8+1	+ 5.0
Cs-135	8.399 +2	4.83610	1.74	+ 0.53
Nd-143	3.1414+2	6.9144+1	4.54	- 0.86
Nd-145	4.0823+1	8.9640-1	4.554+1	-18.62
Pm-147	1.7441+2	3.26077	5.348+1	-22.27
Pm-148	1.9430+3	5.13352	3.785+2	+34.9
Pm-148M	1.0643+4	3.39576	3.1342+3	-58.95
Sm-147	6.1825+1	1.0504-1	5.886 +2	-25.816
Sm-149	4.2346+4	1.7774+2	2.382 +2	+10.815
Sm-150	9.8377+1	7.01762	1.4 +1	+ 0.656
Sm-151	1.3768+4	1.6350+1	8.42 +2	+20.1
Sm-152	1.9975+2	2.17834	9.17 +1	+ 0.30
Eu-154	1.4135+3	5.95354	2.374 +2	- 1.86
Eu-155	3.8960+3	5.29336	7.36 +2	-71.02
Gd-157	2.4577+5	1.2648+3	1.943 +2	+ 0.644

RESONANCE DATA FOR SOME RESONANCE ABSORBANTS IN THE WIMS-D LIBRARY FORMAT

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An evaluation of the resonance data for resonance absorbants, ^{234}U, ^{235}U, ^{236}U, ^{238}U, ^{239}Pu, based on microscopic data from Livermore Library (1976) is presented. The multigroup effective absorbtion and fission cross sections, for homogeneous mixtures between absorbant and hydrogen were generated, for different dilutions and temperatures, for 13 resonance groups, in the energy range 9.118 keV and 4 eV (Table I).

The adopted computational method, implies 6 programs, as follows: SELECT, to select the corresponding isotopes and cross sections from Livermore Library; SIGMA-1, to calculate the Doppler broadened cross sections; GENER, to put the data in binary form; SDR, to calculate the effective capture and fission cross sections for homogeneous mixture; WIMSTAB, to print these results, and WIMSFORM, to give the results in the WIMS-D library format.

The results were compared with those from WIMS-D library (probably first version). The obtained data, are 2-3 times lower than those from WIMS-D library, but the corresponding infinite dilution resonance integrals are much better against experimental ones (Table II).

Table I. The data for resonance absorbants

Isotope	Data type	Temperature (^{o}K)	σ_p for homogeneous mixture (bn)
^{234}U	absorbtion	300	1000, 5000, 10^4, 10^5 5 x $1o^5$, 10^{11}
^{235}U	absorbtion fission	300	496.9, 1007, 1701, 2089, 4678, 8356, 10^{11}
^{236}U	absorbtion	300	5000, 10^4, 5x10^4, 10^5, 10^6, 10^{11}
^{238}U	absorbtion	300, 600, 900	15.53, 31.49, 53.4, 65.34, 146.2, 261.3, 1000, 3600, 10^4, 10^{11}
^{239}Pu	absorbtion fission	300 900	100, 350, 700, 1560, 3163, 5305, 10^{11}

Table II. Comparison of resonance integrals

Energy range		0.5 eV - 20 MeV		4 eV - 9.118 keV		
isotope	IR	BNL-235	Computed from Livermore data	WIMS-D	This work	Computed from Livermore data
^{234}U	capture	630±70	94.16	623.695	623.695*)	44.27
	fission	-	5.6	-	0.0	0.0
^{235}U	capture	144±6	139.79	303.050	116.835	117.6
	fission	275±5	283.97	444.236	182.738	185.03
^{236}U	capture	365±20	831.27	308.025	308.025*)	826.55
	fission	-	5.80	-	1.1353	1.383
^{238}U	capture	275±5	274.13	269.1	264.37	271.39
	fission	-	2.05	-	-	0.0
^{239}Pu	capture	200±20	205.32	339.3	168.37	170.86
	fission	301±10	306.60	534.82	204.758	206.86

*) forced value to that from WIMS-D. IR = resonance integral

Status of nuclear data for fast reactors

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The purpose of this paper is to point out the involved aspects of nuclear physics in the calculation and design of the fast reactors.

A short presentation is given of the methods used to calculate the core, the burn-up, the reactor dynamics, the analysis of accidents, the shielding, as well as the materials required in the fast reactor calculation.

Further on, it deals with the nuclear data types involved in the fast reactor calculations, with accuracy requirements for nuclear data, as well as, with the present status of nuclear data for fisile, fertile and structural materials.

The requirements for new differential data measurements, new integral data and benchmark experiments are presented.

Data adjustement methods are also summarized. Some aspects of the structural material behaviour in the intense gamma radiation and neutron fields existing into a fast reactor, are also presented in the last part of this paper

/1/ S.Râpeanu et al., Preprint IRNE - 148 - 1980

THE INTEGRAL CROSS SECTIONS MEASURED IN ΣΣ SPECTRUM

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In the ΣΣ-ITN spectrum there have been measured by gamma spectrometry the integral cross sections for the following reactions:

$^{186}W(n,\gamma)$, $^{68}Zn(n,\gamma)$, $^{64}Zn(n,\gamma)$, $^{92}Mo(n,\gamma)$, $^{193}Ir(n,\gamma)$, $^{191}Ir(n,\gamma)$, $^{151}Eu(n,\gamma)$, $^{190}La(n,\gamma)$, $^{23}Na(n,\gamma)$.

The used detectors are Aluminium alloys: Ir 5%, Eu 1.95%, La 1% and NaCl pellets for Na. For W, Zn, and Mo pure materials are used, with thicknesses varying between 100 and 300 mg/cm^2.

The obtained cross sections will be related to $^{235}U(n,f)$ cross section measured by the absolute calibrated fission chamber method. The experimental data there are being processed and the report will be published in 1981.

THE FAST NEUTRON SPECTRA

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In the Institute for Nuclear Power Reactors there was initiated a program for intercomparison of the methods and instrumentation used for the spectral characterization of ΣΣ-ITN system, under cooperation with KfK Rossendorf DDR. The measurements are performed by proton recoil method using the spherical counters filled with H_2 at different pressures: 1 atm, 4 atm and 10 atm. The German part put in operation a n,γ discrimination

system, for low energy part of spectrum. The measurements results are processed both by SPEC code and by programs developed at KfK Rossendorf. The final report will be published during this year.

NEUTRON CROSS SECTION CALCULATIONS ON ZIRCONIUM HYDRIDE

by

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Zirconium hydride has been the aim of an intensive investigations both of neutron-scattering experiments and theoretical cross section calculations. Neutron scattering experiments support the conclusion that the hydrogen atoms behave approximatelly like independent Einstein oscillators in the the zirconium lattice, having a vibration-level at about 140 meV. However, some differences betweeen experiment and theoretical single-frequency model exist. Therefore, a study of the frequency spectra influenceson the scattering cross section has to be made. In the present paper, the scattering law, the total elastic, inelastic and total cross sections and the average cosine of the scattering angle are calculated. Two theoretical frequency spectra are used in calculations: a first spectrum obtained from central force lattice dynamical model for zirconium hydride, and a second one where the acoustic part is approximated by a Debye distribution and the optical spectrum is taken as a Doppler broadened Einstein distribution. The latter is a Gaussian distribution centered at ω_o = 130 meV. The calculations have been performed by means of a computing programme described in [1]. In Fig. 1 is shown the total scattering cross section for Zr liquid.

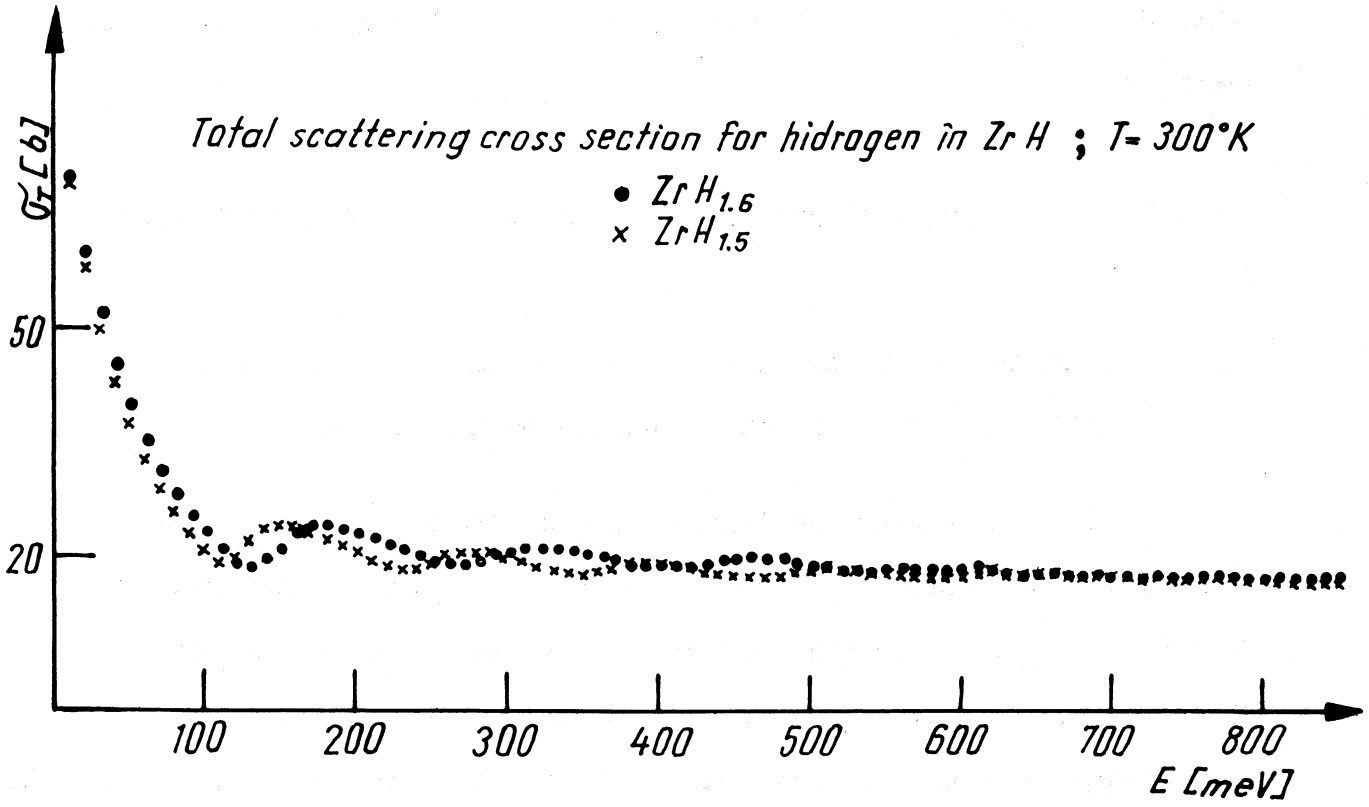

Fig. 1. The total scattering cross section for hydrogen in zirconium hydride at T = 300°K

• • • Zr $H_{1.6}$

x x x Zr $H_{1.5}$

[1] I. Pădureanu, S. Râpeanu, Gh. Rotărescu, C. Crăciun, Preprint IRNE - 131, (1978)

NEUTRON DIFFRACTION ON LIQUID GALLIUM

by

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The paper reports the results for the structure factor S(Q) of liquid gallium as obtained from neutron diffraction measurements. To obtain a good accuracy for S(Q) a careful attention was paid to the background given by the sample holder and to the various corrections which have to be applied to the experimental data. Neutron diffraction measurements were performed on liquid gallium at 20°C, 100°C, and 300°C. The structure factor S(Q) has been measured in the region of the momentum transfers of $0.5\ \text{Å}^{-1} < Q \leq 9\ \text{Å}^{-1}$. The radial distribution function g(r) is calculated from S(Q). The effective pair interaction potential is obtained on the basis of the Born-Green theory.