INDC-240

PROGRESS REPORT

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INSTITUTO DE ENERGIA ATÔMICA

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THE TOTAL NEUTRON CROSS-SECTION FOR POLYCRYSTALLINE IRON

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The total neutron cross section for polycrystalline Iron has been measured for neutrons with wavelength in the range of 0,750 Å - 5,444 Å using the curved slit slow neutron chopper and time of flight spectrometer installed in one of the beam holes of the IEAR-1 swimming pool reactor of the Instituto de Energia Atômica (Report IEA 136).

The measurements were made with a sample of polycrystalline iron, reduced by hydrogen (The Carlo Erba Co. Milan, Italy); the average grain size of the sample was of 1 micron and the number of nuclei per cubic centimeter was determined by measuring the sample weight and its volume.

The results are presented in Table I with the statistical errors of the measurement.

TOTAL NEUTRON CROSS SECTION OF Fe

Laercio A. Vinhas, Silvio B. Herdade
Claudio Rodriguez and Lia Q. do Amaral

reference: IEA-152

λ(Å)	σ_{total} (barns)	λ(Å)	σ_{total} (barns)
0.750	11.88 ± .11	1.034	12.46 ± .05
0.760	12.29 ± .11	1.045	12.44 ± .05
.771	12.17 ± .10	1.056	12.45 ± .05
.792	11.96 ± .09	1.066	12.60 ± .05
.802	12.02 ± .09	1.077	12.65 ± .05
.813	11.83 ± .08	1.087	12.80 ± .05
.824	12.04 ± .08	1.098	12.79 ± .05
.834	12.02 ± .08	1.108	12.80 ± .05
.845	12.20 ± .08	1.119	12.66 ± .05
.855	12.08 ± .08	1.129	12.50 ± .04
.866	12.28 ± .07	1.140	12.51 ± .04
.876	12.39 ± .07	1.150	12.43 ± .04
.887	12.16 ± .07	1.161	12.41 ± .04
.897	12.34 ± .07	1.172	12.57 ± .04
.908	12.40 ± .07	1.182	12.53 ± .04
.918	12.09 ± .07	1.193	12.58 ± .04
.929	12.19 ± .07	1.203	12.71 ± .04
.940	12.30 ± .06	1.214	12.70 ± .05
.950	12.21 ± .06	1.224	12.69 ± .05
.961	12.23 ± .06	1.235	12.76 ± .05
.971	12.20 ± .05	1.245	12.80 ± .05
.982	12.31 ± .05	1.256	12.87 ± .05
.992	12.29 ± .05	1.266	12.87 ± .05
1.003	12.41 ± .05	1.277	12.86 ± .05
1.013	12.42 ± .05	1.288	12.85 ± .05
1.024	12.55 ± .05	1.298	12.82 ± .05

total neutron cross section of Fe

λ(Å)	σ_{total}(barns)	λ(Å)	σ_{total}(barns)
1.309	12.89 ± .05	1.646	13.08 ± .06
1.319	13.02 ± .05	1.657	13.08 ± .06
1.330	12.93 ± .05	1.667	13.00 ± .06
1.340	12.93 ± .05	1.678	13.22 ± .06
1.351	12.88 ± .05	1.688	13.18 ± .06
1.361	12.77 ± .05	1.699	13.34 ± .06
1.372	12.68 ± .05	1.709	13.32 ± .06
1.383	12.75 ± .05	1.720	13.59 ± .06
1.393	12.83 ± .05	1.731	13.65 ± .06
1.404	12.93 ± .05	1.741	13.77 ± .07
1.414	13.14 ± .05	1.752	14.00 ± .07
1.425	13.13 ± .05	1.762	13.91 ± .07
1.435	13.24 ± .05	1.773	14.12 ± .07
1.446	13.28 ± .05	1.783	14.07 ± .07
1.456	13.41 ± .05	1.794	14.11 ± .07
1.467	13.51 ± .05	1.804	13.89 ± .07
1.477	13.68 ± .05	1.815	13.44 ± .07
1.488	13.83 ± .05	1.825	13.01 ± .07
1.499	13.80 ± .05	1.836	12.82 ± .07
1.509	13.87 ± .05	1.847	12.82 ± .07
1.520	13.51 ± .05	1.857	13.01 ± .07
1.530	12.99 ± .05	1.868	12.92 ± .07
1.541	12.63 ± .05	1.878	13.24 ± .07
1.551	12.50 ± .05	1.889	13.19 ± .07
1.562	12.38 ± .05	1.899	13.33 ± .07
1.572	12.36 ± .05	1.910	13.44 ± .07
1.583	12.50 ± .05	1.920	13.52 ± .08
1.593	12.80 ± .05	1.931	13.61 ± .08
1.604	12.74 ± .05	1.942	13.73 ± .08
1.615	12.88 ± .06	1.952	13.96 ± .08
1.625	13.03 ± .06	1.963	14.05 ± .08
1.636	13.01 ± .06	1.973	14.18 ± .08

total neutron cross section of Fe

λ(Å)	σ_{total} (barns)	λ(Å)	σ_{total} (barns)
1.984	14.13 ± .08	2.342	13.37 ± .16
1.994	14.41 ± .09	2.353	12.86 ± .16
2.005	14.27 ± .09	2.363	12.41 ± .15
2.015	14.25 ± .09	2.374	12.09 ± .16
2.026	13.99 ± .09	2.384	12.11 ± .16
2.036	13.78 ± .09	2.395	11.95 ± .24
2.047	13.53 ± .09	2.406	12.18 ± .26
2.058	13.51 ± .09	2.416	12.25 ± .28
2.068	13.55 ± .09	2.427	12.34 ± .29
2.079	13.62 ± .09	2.437	12.38 ± .30
2.089	14.04 ± .09	2.439	12.39 ± .06
2.100	13.91 ± .10	2.461	12.44 ± .06
2.110	14.04 ± .10	2.482	12.61 ± .06
2.121	14.29 ± .10	2.504	12.72 ± .06
2.131	14.32 ± .10	2.525	13.00 ± .06
2.142	14.34 ± .10	2.546	13.22 ± .06
2.152	14.54 ± .11	2.568	13.42 ± .06
2.174	14.52 ± .11	2.589	13.50 ± .06
2.184	14.90 ± .11	2.610	13.61 ± .06
2.195	14.96 ± .12	2.632	13.78 ± .06
2.205	14.94 ± .12	2.653	14.09 ± .07
2.216	15.21 ± .13	2.675	14.12 ± .07
2.226	15.29 ± .13	2.696	14.25 ± .07
2.237	15.40 ± .14	2.717	14.45 ± .07
2.247	15.71 ± .14	2.739	14.63 ± .07
2.258	15.66 ± .15	2.760	14.78 ± .07
2.268	15.87 ± .15	2.782	15.02 ± .07
2.279	16.07 ± .16	2.803	15.18 ± .07
2.290	16.00 ± .17	2.824	15.16 ± .07
2.300	16.00 ± .17	2.846	15.08 ± .07
2.311	16.10 ± .18	2.867	14.56 ± .07
2.321	15.69 ± .18	2.888	14.35 ± .08
2.332	14.78 ± .17	2.910	14.01 ± .08

total neutron cross section of Fe

λ(Å)	σ_{total}(barns)	λ(Å)	σ_{total}(barns)
2.931	13.85 ± .08	3.615	18.72 ± .14
2.953	13.79 ± .08	3.637	18.73 ± .15
2.974	14.03 ± .08	3.658	19.29 ± .15
2.995	14.14 ± .08	3.679	19.11 ± .16
3.017	14.28 ± .08	3.701	19.18 ± .16
3.038	14.23 ± .08	3.722	19.65 ± .17
3.059	14.50 ± .08	3.744	19.99 ± .18
3.081	14.55 ± .09	3.765	19.97 ± .18
3.102	14.73 ± .09	3.786	20.27 ± .19
3.124	15.02 ± .09	3.808	20.44 ± .20
3.145	15.23 ± .10	3.829	20.89 ± .20
3.166	15.09 ± .10	3.850	20.63 ± .20
3.188	15.45 ± .10	3.872	20.74 ± .20
3.209	15.67 ± .10	3.893	20.70 ± .20
3.230	15.67 ± .10	3.915	21.15 ± .21
3.252	15.96 ± .10	3.936	21.35 ± .21
3.273	16.03 ± .10	3.957	21.59 ± .22
3.295	16.30 ± .10	3.979	20.81 ± .22
3.316	16.48 ± .11	4.000	20.39 ± .23
3.337	16.61 ± .11	4.022	18.24 ± .22
3.359	16.70 ± .11	4.043	15.68 ± .22
3.380	16.84 ± .12	4.064	12.78 ± .21
3.402	16.99 ± .12	4.086	10.21 ± .21
3.423	17.29 ± .12	4.107	8.55 ± .20
3.444	17.33 ± .12	4.128	7.97 ± .19
3.466	17.40 ± .12	4.150	7.30 ± .18
3.487	17.84 ± .13	4.154	6.86 ± .18
3.508	17.80 ± .13	4.164	7.27 ± .19
3.530	17.95 ± .13	4.175	7.81 ± .18
3.551	18.19 ± .13	4.186	7.12 ± .18
3.573	18.32 ± .14	4.196	6.78 ± .19
3.594	18.68 ± .14	4.207	7.03 ± .19

total neutron cross section of Fe

λ(Å)	σ_{total} (barns)	λ(Å)	σ_{total} (barn)
4.217	7.05 ± .19	4.566	7.74 ± .23
4.228	7.05 ± .19	4.577	7.43 ± .23
4.238	6.66 ± .19	4.588	7.41 ± .23
4.249	6.67 ± .19	4.598	7.49 ± .24
4.260	6.99 ± .19	4.609	7.12 ± .24
4.270	6.7[illegible] ± .18	4.619	7.25 ± .25
4.281	7.26 ± .19	4.630	7.48 ± .24
4.291	7.89 ± .19	4.640	7.95 ± .25
4.302	6.60 ± .19	4.651	7.89 ± .25
4.313	7.22 ± .19	4.662	7.29 ± .25
4.323	7.79 ± .19	4.672	7.40 ± .24
4.334	7.16 ± .19	4.683	7.77 ± .24
4.344	7.16 ± .19	4.693	7.68 ± .24
4.355	7.08 ± .20	4.704	7.45 ± .23
4.365	7.19 ± .20	4.714	7.86 ± .23
4.376	7.25 ± .20	4.725	7.56 ± .23
4.387	7.13 ± .20	4.736	7.64 ± .24
4.397	7.37 ± .20	4.746	8.04 ± .23
4.408	7.15 ± .20	4.757	7.73 ± .23
4.418	7.51 ± .21	4.767	7.89 ± .24
4.429	7.19 ± .20	4.778	7.86 ± .23
4.439	7.48 ± .21	4.789	7.78 ± .24
4.450	7.58 ± .21	4.799	7.53 ± .24
4.461	7.31 ± .21	4.810	7.93 ± .24
4.471	7.17 ± .21	4.820	7.67 ± .24
4.482	7.66 ± .22	4.831	7.92 ± .24
4.492	7.09 ± .21	4.841	7.86 ± .25
4.503	7.41 ± .22	4.852	8.11 ± .25
4.513	7.29 ± .22	4.862	8.14 ± .25
4.524	7.32 ± .22	4.873	7.91 ± .25
4.534	7.14 ± .22	4.884	7.98 ± .25
4.545	7.47 ± .23	4.894	8.02 ± .25
4.556	7.57 ± .23	4.905	8.36 ± .26

total neutron cross section of Fe

λ(Å)	σ_{total}(barns)	λ(Å)	σ_{total}(barns)
4.915	7.70 ± .26	5.191	7.98 ± .32
4.926	8.24 ± .26	5.201	8.69 ± .33
4.937	7.25 ± .25	5.212	8.16 ± .33
4.947	7.87 ± .26	5.222	8.34 ± .33
4.958	8.31 ± .26	5.233	8.13 ± .33
4.968	8.01 ± .27	5.243	8.34 ± .34
4.979	7.78 ± .27	5.254	8.83 ± .34
4.990	7.57 ± .27	5.265	8.69 ± .35
5.000	8.04 ± .27	5.275	8.60 ± .35
5.011	8.19 ± .28	5.286	8.52 ± .35
5.021	8.13 ± .28	5.296	8.54 ± .35
5.031	8.06 ± .28	5.307	8.36 ± .36
5.042	8.62 ± .29	5.317	9.12 ± .37
5.053	8.04 ± .28	5.328	8.44 ± .37
5.064	8.20 ± .29	5.339	8.70 ± .37
5.074	7.99 ± .29	5.349	8.35 ± .37
5.085	7.81 ± .29	5.360	8.56 ± .38
5.095	8.22 ± .30	5.370	8.85 ± .40
5.106	7.96 ± .29	5.381	8.59 ± .40
5.116	8.03 ± .30	5.392	8.08 ± .38
5.127	8.18 ± .30	5.402	9.04 ± .43
5.138	8.17 ± .30	5.413	8.16 ± .40
5.148	7.93 ± .30	5.423	8.82 ± .40
5.159	7.90 ± .30	5.434	8.37 ± .41
5.169	8.15 ± .30	5.444	8.41 ± .42
5.180	8.50 ± .32		

INFLUENCE AND ELIMINATION OF THE EFFECT OF CONTAMINATION DUE TO SECOND ORDER REFLECTION NEUTRONS IN TRANSMISSION MEASUREMENT WITH THE CRYSTAL SPECTROMETER

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In order to increase the interval of energy in which the IEA crystal spectrometer operates, some methods were developped for eliminating neutrons from second order reflections, that influence the measurement of a total cross section, σ_T. To estimate these influences, measurements of σ_T of gold, in the region of energy 0.01 to 1 eV, were made with monochromator crystals of Al and Ge, and a comparison was made between the obtained experimental points and the theoretical curve of σ_T for Au. Both crystals were utilized in the planes (111), Al (111) giving the strongest intensity. However, for Ge (111) the second order reflections are theoretically forbidden, giving thus an advantage over Al (111) for measurements at lower energies, where this contamination effect is mostly felt. The lower limit of energy is 0.04 eV for Al (111) and 0.025 eV when Ge (111) is used; for energies below this value (0.025 eV), the effect of contamination of higher orders than the second are present. In the region of higher energies, close to 1 eV, measurements of σ_T were made only with Al (111), and it was verified that there is not much influence of higher order contaminations for cross sections varying as 1/v, as it is the case for gold. Nevertheless, the measurement of a resonance in that region is particularly sensitive to neutrons due to second order reflections; these effects were estimated in the measurement of the resonance of Iridium at E = 0.654 eV, and a Tellurium filter was used in order to eliminate them.

SLOW-NEUTRON SCATTERING AND ROTATIONAL FREEDOM OF METHYL GROUPS IN SEVERAL ORGANIC COMPOUNDS

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APPENDIX

SLOW-NEUTRON SCATTERING AND ROTATIONAL FREEDOM OF THE CH_3 GROUP IN ACETONITRILE

The barrier for internal rotation of the CH_3 group in acetonitrile is expected to be zero. Nevertheless, proton magnetic resonance measurements (16) resulted in a barrier of 2,6 Kcal/mol for CH_3CF in the solid state at low temperatures. This barrier has been attibuted to intermolecular forces within the crystal.

The neutron scattering cross-section σ_s/H vs λ_n, for acetonitrile, is presented in Figure 4, as measured in the liquid state at room temperature. The slope 12.6 $\pm$ 0.3 barns/Å-H corresponds to a free rotation of the CH_3 group, probably indicating that the influence of intermolecular forces is negligible for this compound in the liquid state.

As all substances in this paper can be considered as non-associated liquids, this last comment may be also extended to them.

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(16) Stejkal, E.O, Woessner, D.E., Farrar, T.C. and Gutowsky, H.S., J. Chem. Phys. 31, 55 (1959)

INELASTIC SCATTERING OF NEUTRONS

1) SLOW NEUTRON SCATTERING AND ROTATIONAL FREEDOM OF METHYL GROUPS IN SEVERAL ORGANIC COMPOUNDS

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Total cross-sections of CH_3NO_2 , $(CH_3).CO_2$, $(CH_3)_2SO$, $(CH_3CO)_2O$, $(CH_3)_2SiCl_2$, and dimethyl polysiloxane (silicone oil), have been measured for neutrons with wavelength in the range 5-10 Å. The Scattering cross-sections per H atom, σ_s/H, may be approximated by stright lines $\sigma_s/H = a_s + b_s\lambda_n$, for $\lambda_n > 5$ Å. An empirical correlation is observed to exist between the slopes b_s and the barrier heights for internal rotation of CH_3 groups in the molecules, and a calibration curve is plotted using some of the experimentally determined slopes and the published values of the barrier heights determined by other physical methods.

From the slopes (12.3 ± 0.5) barns/Å-H for $(CH_3)_2SiCl$, and (12,3 ± 0.3) barns/Å-H for dimethyl polypiloxane, it is concluded that the internal rotation of CH_3 groups in these compounds is practically free. An average barrier height of about 1 Kcal/mole is estimated for $(CH_3CO)_2O$, from the experimentally determined slope (10.8 ± 0.3) barns / Å-H.

(Paper published in the Proceedings of the Copenhagen Symposium on Neutron Inelastic Scattering - Copenhagen, May 20-25, 1968 - pag. 197).

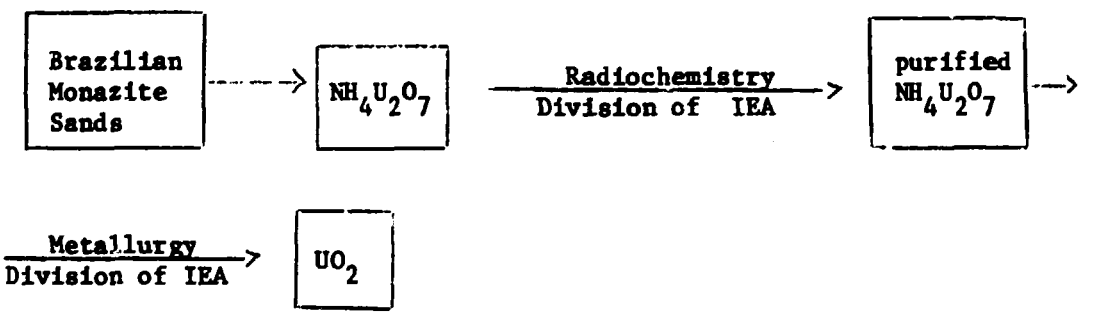
TOTAL NEUTRON CROSS SECTION OF UO_2

C. Rodriguez, L.A. Vinhas, S.B. Herdade and L. Q. Amaral

. Reference: IEA - 152 - page 91

The total neutron cross section of UO_2 has been measured with a slow neutron chopper and time-of-flight spectrometer (see IEA-136), in the neutron wavelength region of 1.0 Å to 8.0 Å . A He^3 detector with a pressure of 2 atmospheres has been used.

The UO_2 sample was cylindrical, with a 3.2 cm diameter and 1.0 cm thick; the density was of 10.45 g/cm^3. This sample has been sintered at 1400ºC by the Division of Metallurgy of the IEA. Its procedence is shown in the graph below.



The experimental results are in the separate table. The quoted errors are statistical only. The data for $\lambda < 3.6$ Å represent an average over three channel numbers, and for $\lambda > 5.2$ Å they are an average over results obtained by three independent measurements.

The number of atoms /barn of the sample has been determined from mass and surface measurements. The mass was measured many times, during

the experiments, to ensure that there was no water absorption by the sample.

The coherent elastic scattering has been calculated theoretically from the assumption of a crystalline structure of the CaF_2 type. with a_o = = 5.47 Å. The scattering amplitudes and the Debye temperatures of U and O were taken from the literature.

From the region $\lambda > 6.3$ Å, and supposing a 1/v absorption, the extrapolated value for the thermal absorption cross section

$$\sigma_{th}(UO_2) = 8,2 \pm 0.6 \text{ b}$$

is obtained.

TOTAL NEUTRON CROSS SECTION OF UO_2

Claudio Rodriguez, Laércio A. Vinhas,

Silvio B. Herdade and Lia Q. Amaral .

reference: IEA-152 - page 91

λ(Å)	σ_{total}(barn)	λ(Å)	σ_{total}(barn)
1.000	20.2 ± .2	1.927	23.2 ± .2
1.035	20.4 ± .2	1.963	23.5 ± .2
1.071	20.7 ± .2	1.999	23.6 ± .2
1.107	20.9 ± .2	2.034	23.8 ± .2
1.1[illegible]3	20.7 ± .2	2.070	24.7 ± .2
1.1[illegible]3	20.7 ± .2	2.106	24.0 ± .2
1.214	20.8 ± .2	2.141	25.6 ± .2
1.250	21.2 ± .2	2.177	25.5 ± .2
1.285	21.2 ± .2	2.213	24.5 ± .2
1.321	21.3 ± .2	2.248	24.2 ± .2
1.357	21.7 ± .2	2.284	23.0 ± .2
1.392	21.9 ± .2	2.320	22.8 ± .2
1.428	21.8 ± .2	2.355	22.9 ± .2
1.464	21.5 ± .2	2.391	23.6 ± .2
1.499	21.3 ± .2	2.427	24.0 ± .3
1.535	21.3 ± .2	2.462	24.4 ± .3
1.571	21.7 ± .2	2.498	23.7 ± .3
1.606	21.7 ± .2	2.534	24.3 ± .3
1.642	22.2 ± .2	2.569	24.4 ± .3
1.678	22.5 ± .2	2.605	24.8 ± .3
1.713	22.5 ± .2	2.641	24.9 ± .3
1.749	22.2 ± .2	2.676	25.2 ± .3
1.785	22.7 ± .2	2.712	25.4 ± .3
1.820	22.7 ± .2	2.748	25.0 ± .3
1.850	22.9 ± .2	2.783	24.7 ± .3
1.892	23.3 ± .2	2.819	25.0 ± .3

total neutron cross section of UO_2

λ(Å)	σ_{total}(barn)	λ(Å)	σ_{total}(barn)
2.855	25.6 ± .4	4.57	24.1 ± .3
2.890	25.6 ± .4	4.65	25.0 ± .3
2.926	25.5 ± .4	4.74	25.4 ± .3
2.962	26.1 ± .4	4.82	26.5 ± .3
2.998	27.2 ± .4	4.91	26.7 ± .3
3.033	27.4 ± .4	4.99	27.1 ± .3
3.063	27.5 ± .4	5.08	27.8 ± .4
3.124	29.2 ± .4	5.16	28.6 ± .4
3.159	30.2 ± .4	5.25	29.4 ± .3
3.195	30.3 ± .4	5.34	30.2 ± .3
3.230	30.4 ± .4	5.42	30.6 ± .3
3.266	30.2 ± .4	5.51	31.1 ± .4
3.301	30.7 ± .4	5.59	31.3 ± .4
3.337	29.1 ± .4	5.68	32.2 ± .4
3.372	29.0 ± .4	5.76	32.9 ± .5
3.408	29.4 ± .4	5.85	33.3 ± .5
3.443	29.4 ± .4	5.94	33.4 ± .5
3.479	30.1 ± .4	6.02	34.2 ± .5
3.514	30.4 ± .5	6.11	34.9 ± .6
3.550	31.1 ± .5	6.19	35.0 ± .6
3.585	31.8 ± .5	6.28	33.6 ± .6
3.63	32.1 ± .2	6.36	31.0 ± .6
3.71	32.7 ± .2	6.45	29.9 ± .7
3.80	30.7 ± .2	6.53	30.2 ± .7
3.88	26.6 ± .2	6.62	30.9 ± .7
3.97	22.8 ± .2	6.70	31.5 ± .7
4.05	22.5 ± .3	6.79	31.3 ± .8
4.14	22.1 ± .3	6.88	31.5 ± .8
4.22	23.2 ± .3	6.96	32.3 ± .9
4.31	23.7 ± .3	7.05	32.9 ± .9
4.40	24.2 ± .3	7.13	33.5 ± 1.0
4.48	24.5 ± .3	7.22	33.6 ± 1.0

total neutron cross section of UO_2

λ(Å)	σ_{total}(barn)	λ(Å)	σ_{total}(barn)
7.30	34.2 ± 1.0	7.73	35.2 ± 1.4
7.39	34.8 ± 1.1	8.82	36.7 ± 1.5
7.47	34.5 ± 1.2	7.90	35.7 ± 1.6
7.56	34.9 ± 1.2	7.99	37.1 ± 1.7
7.65	34.9 ± 1.3		
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THE EFFICIENCY OF A NEUTRON "LONG COUNTER" CALCULATED BY THE MONTE CARLO METHOD

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A computer program in Fortran II language, was developped in order to calculate, by a Monte Carlo process, the efficiency of a system of BF_3 neutron counters imbedded in a moderating medium. Six of such counters are imbedded in a paraffin cylinder on whose axis a monoenergetic neutron source was placed.

For each neutron of a pre-determined energy, its trajectory and energy losses are simulated until the neutron reaches the detector and is either absorbed by the detector, or by the paraffin or escapes from the moderator.

In the last two cases a new history is started and the neutron is considered as lost. In the case that the neutron reaches the detector, its intrinsic efficiency, which depends on the neutron energy, is calculated.

The efficiency of the whole system is also calculated, under the hypothesis that the six detectors are connected in parallel.

CHARGED PARTICLES OPTICS STUDY BY MONTE CARLO METHOD

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It is well known that there exists no analytical expression for calculating the resolution of a magnetic spectrometer when the second or higher orders of approximation are taken into account. In order to overcome this difficulty, a computer program was developped in order to calculate the resolution and the line shape of the beta-ray spectrometer installed at the IEA reactor for capture gamma-ray studies.

The calculation is made by using the Monte Carlo method for the simulation of random orbits originated in a particles source, whose dimensions and location in the spectrometer are previously specified.

The resolution function is obtained by registering the number of particles, of a given momentum interval , which are incident on a detector of pre-determined dimensions and location. At the same time, the particles distribution both in the radial and axial directions are registered for particles of the same momentum.

The program can also be used for determining the spectrometer resolution when a system of multiple sources is used , increasing the luminosity of the apparatus several times when compared with that from a single source.

SPEED CONTROL OF A SLOW NEUTRON CHOPPER

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The system used for controlling the speed of the IEA slow neutron chopper was designed to keep its speed constant within 1% in the speed range between 2.000 and 15.000 r.p.m.

The electric motor used is of the universal series type and its speed is controlled by a system which uses an electric signal from a magnetic pick up which gives a pulse per revolution. The signal from the magnetic pick up is fed to a pulse forming circuit, whose pulses are integrated by a diode pump circuit providing a D.C. voltage which is proportional to the rotor speed. The error signal, obtained from a comparison between this voltage and a voltage reference source in a voltage comparison circuit, determines the firing phase of silicon controlled rectifiers used to control the motor speed.

Experimental measurements of the system parameters allowed the determination of the transfer function of the system and the correct evaluation of the integrator time constant. The comparison between the theoretical and experimental response of the system is presented for a step input, for a step load, for a step change in the line voltage and temperature.

A MEASUREMENT OF THE SLOW NEUTRON SCATTERING CROSS-SECTION IN METHANOL; AND THE KRIEGER-NELKIN MODEL

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The slow neutron scattering cross-section per hydrogen atom in methanol was measured with the IEA time of flight spectrometer. The scattering cross-section was obtained from the total cross-section of the molecule and by subtracting the contributions due to the other non hydrogenous atoms.

The experimental results were compared with the scattering cross--section per hydrogen atom in methanol, calculated by the Krieger-Nelkin theory.

The Krieger-Nelkin method uses, essentially, an approximation of the Zemach-Clauber formalism in which the effects due to the rotations and vibrations of the molecule are separated.

The Krieger-Nelkin method can be applied to molecules in which the translational and rotational movements are considered free and for which the applicability of the approximation of the mass tensor is possible.

In the case of the mathanol, the agreement with the experimental results is reasonable due to the almost free rotation of the methyl radical and the low value of the rotational constant of the methanol molecule, B = 0,1 meV.

TIME OF FLIGHT SPECTROMETER: THE COLD NEUTRON BERYLLIUM FILTER FACILITY

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An arrangement for the study of cold neutron scattering in solids and liquids was built at the Instituto de Energia Atômica: it is constituted by a polycrystalline beryllium filter and a slow chopper time of flight spectrometer.

The beryllium filter is refrigerated at the liquid nitrogen temperature: only neutrons of an energy smaller than 5 meV are transmitted. This neutron beam is scattered by the sample and the scattered neutron intensity at pre-determined angles are energetically analyzed by the time of flight spectrometer.

Details of the experimental arrangement and the preliminary results of the characteristics of the cold neutron spectrum, the calibration and the resolution of the spectrometer are presented.

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SLOW-NEUTRON SCATTERING IN WATER, POLYETHYLENE, AND METHYL COMPOUNDS

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ABSTRACT

The total neutron cross-sections of light water, polyethylene, nitromethane, acetone, methyl acetate, dimethyl sulphoxide, acetic anhydride, acetonitrile, dimethyl-dichloro-silane, and dimethyl polysiloxane (silicone oil), have been measured as a function of neutron wavelength λ in the range 0.8 to 10.0 Å (1.34×10^{-1} to 8.21×10^{-4} eV) using a curved slit slow-neutron chopper and time-of-flight spectrometer (1)(2) in operation at the IEA-R1 research reactor.

Measurements have been carried out at room temperature (295°K - 297°K) with chopper speeds from 4000 to 8000 RPM, flight paths from 1.48 m to 3.00 m, and 32 μsec channel length. The wavelength resolution varied from 0.08 Å at $\lambda = 1$ Å to 0.30 Å at $\lambda = 10$ Å.

Demineralized water has been utilized as H_2O samples. The polyethylene sample was a 0.241 cm thick plate with a density of (0.92 ± 0.01) g/cm^3, and ≃ 50% crystallinity. Methyl compounds samples were commercially available reagent grade chemicals, all liquid at room temperature. Liquid samples were contained in aluminum cells such as to present a thickness of 0.25 cm.

The number of molecules per square centimeter, n, has been determined from the measured internal dimensions of the cells and the density of the liquid at room temperature. Uncertainties in the n value amount to about 3% for the liquid samples, and 0.6% for the solid polyethylene sample.

Only statistical errors are indicated in tables and curves.

The water total cross-section results are in good agreement with previous measurements both in the thermal and subthermal regions. They also agree with calculated values based on the models proposed by Koppel-Young and McMurry-Russell, in the thermal region. The polyethylene results are compared with the Goldman-Federighi and Koppel-Young calculated curves. Good agreement is observed in the thermal region but, for $E_n < 0.003$ eV, the experimental results are found to be lower than the calculated ones.

Scattering cross-sections per H atom, σ_s/H, were determined by subtracting the absorption cross-section from the total cross-section per molecule and dividing the result by the number of H atoms in the molecule. For water and polyethylene, the scattering cross-sections of oxigen and carbon, respectively, have been also subtracted to obtain σ_s/H. The scattering cross-sections per H atom may be approximated by straight lines $\sigma_s/H = a_s + b_s\lambda$, for $\lambda > 5$ Å. Slopes b_s were determined by a weighted least-squares fit to the data. For water and polyethylene, the values 6.8 ± 0.1 b/Å-H, and 5.1 ± 0.1 b/Å-H were obtained, respectively.

For methyl compounds, an empirical correlation is observed to exist between the slopes b_s and the barrier heights for internal rotation of CH_3 groups in the molecules, and a "calibration curve" is plotted using some of the experimentally determined slopes and the published values of the barrier heights V_o determined by other methods (3). This curve can be represented by the empirical relation:

$V_o = 11.05 - 1.25\, b_s + 0.03\, b_s^2$, where V_o is expressed in Kcal/mole and b_s in barns/Å-H.

An average barrier height of ≈ 1 Kcal/mole is estimated for $(CH_3CO)_2O$, from the experimentally determined slope 10.8 ± 0.3 b/Å-H . From the slopes 12.3 ± 0.5 b/Å-H for $(CH_3)_2SiCl_2$ and 12.3 ± 0.3 b/Å-H for dimethyl polysiloxane, it is concluded that the rotations of CH_3 groups in these compounds are practically free. These results are very close to the calculated value 12 b/Å-H corresponding to a CH_3 group freely rotating in one dimension around the C_3 symmetry axis.

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MEASUREMENT OF THE PHOTOFISSION CROSS SECTION OF URANIUM AND THORIUM NEAR THE THRESHOLD

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The photofission cross-sections of uranium and thorium were measured in the energy interval between 5 and 11 MeV, using monoenergetic gamma radiation from neutron capture in various elements placed near to the reactor core.

The intensity of the strongest monoenergetic gamma ray from each element was measured with a NaI(Tl) 3" x 3" crystal and the intensities of the secondary lines were determined from the gamma-ray intensity ratios available in the literature.

The collimated gamma radiation strikes upon a parallel plate ionization chamber whose plates are covered by photofissile (Th or natural U) material electrolytically deposited. The ion chamber is connected to the recording system through a linear amplifier and discriminator and is so ajusted that only fission events are recorded.

For a given photofissile target one can write a linear equation of the type

$$(1) \qquad \Sigma \sigma_i \varphi_i = \frac{C}{\phi_p} \cdot K$$

where

σ_i : cross-section at the i^{th} line energy

φ_i : gamma ray intensity of the i^{th} line normalized to the principal line intensity

ϕ_p : gamma ray flux of the principal line

K : a constant which takes into account the number of nuclei of the photofissile material and the fission chamber efficiency.

By using the system (1) and making approximations in energy and by neglecting the effect of the secondary lines which do not coincide with the principal lines of other elements used as targets, one obtains a normal linear system of equations. Due to the approximations used and taking into account the errors in the gamma ray intensity measurement and the statistical error, the error of the measurements is estimated to be smaller than 13%.

The normalized obtained results were compared with those of Katz et al., which have used the Bremmsstrahlung radiation from a betatron, and with those of Manfredini et al. which have used monoenergetic gamma rays from neutron capture radiation using an experimental arrangement similar to ours. Our measurements agree with those of Katz et al. within the experimental errors and show no agreement with those of Manfredini and co-workers.