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Interaction of Fast Neutrons with ^4He, ^3He, and ^1H: Additional and Improved Data

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by

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ABSTRACT

An improvement of previous elastic scattering data of neutrons in the 20-MeV range was made possible by the improved knowledge of the detection efficiency of the neutron detector. Thus revised absolute differential cross-section data for ^{3}He(n,n)^{3}He and ^{4}He(n,n)^{4}He were obtained with smaller uncertainties. Cross sections of nonelastic n-He reactions were obtained from recent data of the reciprocal reactions by detailed balance calculations.

In addition, incomplete angular distributions for the reaction ^{1}H(n,n)^{1}H between 22.5 MeV and 28.5 MeV are presented.

I. INTRODUCTION

For more than 10 years the same neutron detector (described in Ref. 1) has been used for measuring fast neutrons in few nucleon experiments (e.g., Refs. 2-4). As was shown in a recent paper[5] the relative efficiency curve of this detector is now known with an uncertainty of less than 2% up to neutron energies of about 30 MeV. This compares with an uncertainty of 5 to 10% for the oldest efficiency curves used[3] (see Fig. 1). If the pulse height bias has been set the same way during all these experiments and if the efficiency of the detector has not changed over these years, an improvement of the old data is possible just by using the new efficiency curve instead of the previous one.

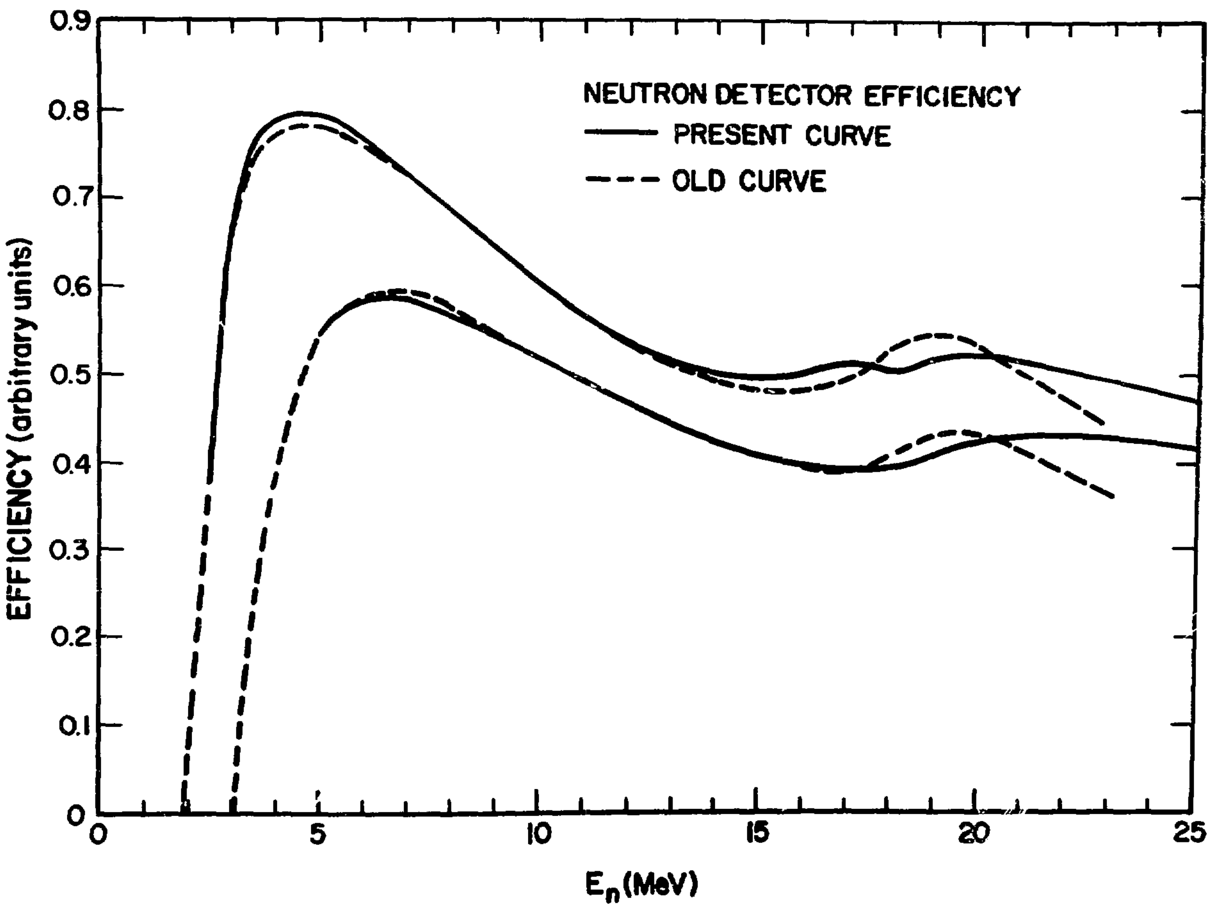

Fig. 1. Comparison of old efficiency curves (dashed, from Ref. 3) with latest ones (full, from Ref. 5).

II. PROCEDURE

In the course of data taking for the neutron production data[5] from 1971 through 1975, no change in the neutron yield was observed when measuring the same angular distribution. This indicates that a change of the energy dependence of the neutron detection efficiency was negligible over these years for the biases used (1 x Cs and 2 x Cs). Therefore, it seems justified to assume that the shape of the efficiency curve did not change by more than 1% since 1969 in which year I joined the neutron time-of-flight group at the Los Alamos Scientific Laboratory (LASL). For data taken before this year a correction of the neutron detection efficiency would be less reliable anyway, since I have no personal knowledge how the pulse height bias was set. Besides, I do not have raw data available as in the other cases. Therefore, I did not revise the $^{2}H(n,n)^{2}H$ and the $^{3}H(n,n)^{3}H$ data,[2] which were also measured with the same detector.

Thus, only the data for the reaction $^{4}He(n,n)^{4}He$,(Ref.3) and $^{3}He(n,n)^{3}He$(Ref.4) were revised.

The revision was done in 2 steps. First, the new efficiency was applied to the calibration runs determining the absolute scale. Then the new energy dependence of the efficiency curve was introduced. Since the shape of the angular distributions did not change drastically, the previous multiple scattering corrections were maintained.

In addition, integrated cross sections for the reactions $^{4}He(n,d)^{3}H$, $^{3}He(n,p)^{3}H$, and $^{3}He(n,d)^{2}H$ were calculated from the corresponding time-reversed reactions of Ref. 5 using the formulas given there.

Finally, relative angular distributions of the reaction $^{1}H(n,n)^{1}H$ were obtained at 22.4 MeV, 23.7 MeV, 25.0 MeV, 27.1 MeV, and 28.5 Mev from the neutron yield of the original efficiency determination.[1] Since the high-energy part of the final efficiency curve has been determined by means of neutron production cross sections,[5] now these yields can be used to obtain (incomplete) angular distributions for n-p scattering.

III. RESULTS AND DISCUSSION

The experimental conditions and the error contributions to the data are discussed in Refs. 1, 3, and 4. The uncertainties of the latest efficiency curves were discussed in Ref. 5.

A. n-^{4}He data

Table I gives the revised absolute differential cross sections for the reaction $^{4}He(n,n)^{4}He$ at 17.6, 20.9, and 23.7 MeV.[3] The changes which affect

TABLE I

Absolute Differential Cross Sections for $^4He(n,n)^4He$. Revised data from Ref. 3.

E_n		17.6 MeV			20.9 MeV			23.7 MeV		
θ_{lab} (deg)	θ_{cm} (deg)	σ_{lab} (mb/sr)	error (%)	σ_{cm} (mb/sr)	σ_{lab} (mb/sr)	error (%)	σ_{cm} (mb/sr)	σ_{lab} (mb/sr)	error (%)	σ_{cm} (mb/sr)
20	25.0				324	2.6	212	314	1.7	206
25	31.1	326	2.7	217	265	3.9	176			
30	37.2	277	2.7	188	234	2.5	159	218	2.1	147
35	43.3	237	2.6	164	201	2.2	139			
40	49.3	204	2.2	145	166	2.3	118	144	2.0	102
45	55.3				140	2.3	102	108	2.0	78.7
50	61.1	134	2.9	100.8	108	1.7	81.3	85.4	2.5	64.1
55	66.9				89.5	2.0	69.5	59.4	4.4	46.1
60	72.6	85.3	2.5	68.6	65.3	1.8	52.5	49.1	2.8	39.5
65	78.2				50.4	2.1	42.1			
70	83.7	43.4	3.5	37.4	36.0	1.7	31.3	24.2	3.6	21.0
80	94.4	19.7	3.7	18.6	15.9	2.4	15.0	11.6	6.7	11.0
90	104.6	9.8	4.9	10.1	7.5	5.4	7.7	7.3	5.8	7.5
100	114.4	6.6	8.6	7.4	4.1	4.6	4.6	5.6	7.1	6.4
110	123.7	7.5	4.1	9.3	6.1	3.5	7.6	7.3	6.2	9.1
120	132.6	11.9	3.8	16.1	8.8	2.5	11.9	8.5	5.1	11.5
130	141.1	17.1	2.8	24.9	12.5	2.1	18.3			
140	149.3	18.8	2.6	29.5	16.0	1.7	25.0			
$\sigma_{total\ elastic}$ (mb)										
by integration:		861	3.1		728	2.7		621	3.5	
this evaluation:		857			732			617		

front angles most are within the error of 5 to 10% claimed for the previous efficiency curve.[3] However, there is a marked improvement, especially for the 20.9-MeV data and the 23.7-MeV data since the changes remove a systematic error. In addition, the errors were revised, too, by taking into account the reduced uncertainty in the new efficiency curve.

Table II gives the differential cross sections for the reaction $^4He(n,d)^3H$ for neutron energies up to 36 MeV. The data are given in the center-of-mass system by their Legendre polynominal expansions in the form of

$$\frac{d\sigma(E,\theta)}{d\Omega} = \frac{d\sigma(E,0^\circ)}{d\Omega} \cdot \sum_i A_i \, P_i \, (\cos\theta)$$

and were obtained by detailed balance conversion from data of the reciprocal reaction $^3H(d,n)^4He$. For neutron energies above 26 MeV, data of Ref. 5 were used; below that energy, those of Ref. 6. Some smoothing in the transition range between these two data sets appeared to be necessary. Figure 2 summarizes the present knowledge of n-^{4}He cross sections. The curve up to 20 MeV was taken from ENDF/B-IV, which is based on the data of Goulding et al.[7] These data extend to about 30 MeV as shown on the graph. It was found that the ENDF/B-IV data above 12 MeV can be represented by the equation

$$\sigma_T = \exp\,(-0.9181 \ln E_n + 9.3860)$$

with E_n in MeV and σ_T in mb, with deviations of less than 0.3%. This equation is also in agreement with all the data up to 30 MeV, disregarding, however, the resonance above 22 MeV. (The data of Shamu et al.[8] must be downscaled by 1.5% to give best agreement with this expression.) Even an extrapolation to 150 MeV seems justified, since the two high-energy data sets[9,10] are in agreement with such an extrapolation. Subtracting the integrated cross section of the $^4He(n,d)^3H$ reaction from the total cross section gives the total elastic cross section up to 24.8 MeV, where a second nonelastic channel opens. As can be seen from the data in Tables I and II, the 3 elastic cross sections obtained in the present work by integration of the differential cross sections agree perfectly with these data. From the work of Tannenwald,[11] who determined the relative contributions of the individual exit channels to the total cross section at 90 MeV, some idea about the energy dependence of the total elastic cross section and of that of the d + t channel can be obtained.

TABLE II

^{4}He(n,d)^{3}H. Recommended Values for $\sigma(0^o c.m.)$ Legendre Coefficients A_i and σ(total)
Obtained by Detailed Balance Conversion from ^{3}H(d,n)^{4}He. Coefficients are multiplied by 1000.

E_n (MeV)	SIGMA-O (mb/sr)	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	SIGMA-T (mb)
22.06	0.69	1000																8.62
22.08	3.22	1000																40.4
22.10	6.14	1000																77.1
22.12	7.36	1000																92.5
22.14	7.14	1000																89.7
22.16	6.49	1000																81.5
22.18	5.88	1000																73.9
22.20	5.35	1000																67.2
22.25	4.48	1000																56.2
22.30	4.00	1000																50.3
22.35	3.67	998	10	-8														46.1
22.40	3.43	997	21	-18														43.0
22.45	3.26	994	33	-27														40.7
22.50	3.15	990	43	-33														39.2
22.60	3.02	981	62	-43														37.2
22.80	2.94	953	89	-42														35.2
23.00	2.99	915	105	-23	0	3												34.4
23.50	3.50	778	128	59	7	12	12	4										34.2
24.00	4.42	640	133	141	24	20	32	10										35.5
24.50	5.99	523	128	206	45	28	51	18	1									39.4
25.00	8.21	431	121	253	63	36	67	26	3									44.5
25.50	10.6	376	116	265	73	44	84	36	6									50.3
26.00	13.0	341	116	250	73	56	103	47	10	3	1							55.6
26.50	14.8	314	117	220	67	75	123	60	15	6	3							58.4
27.00	16.1	292	110	192	53	97	148	74	21	9	4							59.1
27.50	17.2	275	92	179	35	115	170	89	27	12	5	1						59.4
28.00	18.0	264	75	172	18	126	185	103	33	16	5	2	1					59.7
29.00	19.1	247	64	160	-10	132	192	136	40	23	7	4	2	3				59.3
30.00	20.4	231	61	149	-27	126	193	169	45	30	8	7	2	5	1			59.1
31.00	21.7	216	62	138	-35	115	190	196	49	36	10	9	3	7	2	2		58.9
32.00	23.1	202	65	128	-35	103	185	216	53	42	11	12	3	8	3	4		58.8
33.00	24.7	189	70	119	-30	89	180	230	58	49	13	14	3	8	3	4	1	58.6
34.00	26.4	176	75	111	-18	75	174	239	62	57	15	16	3	8	1	3	3	58.4
36.00	30.3	153	83	95	6	50	163	246	73	76	20	23	4	6	-5	2	5	58.1

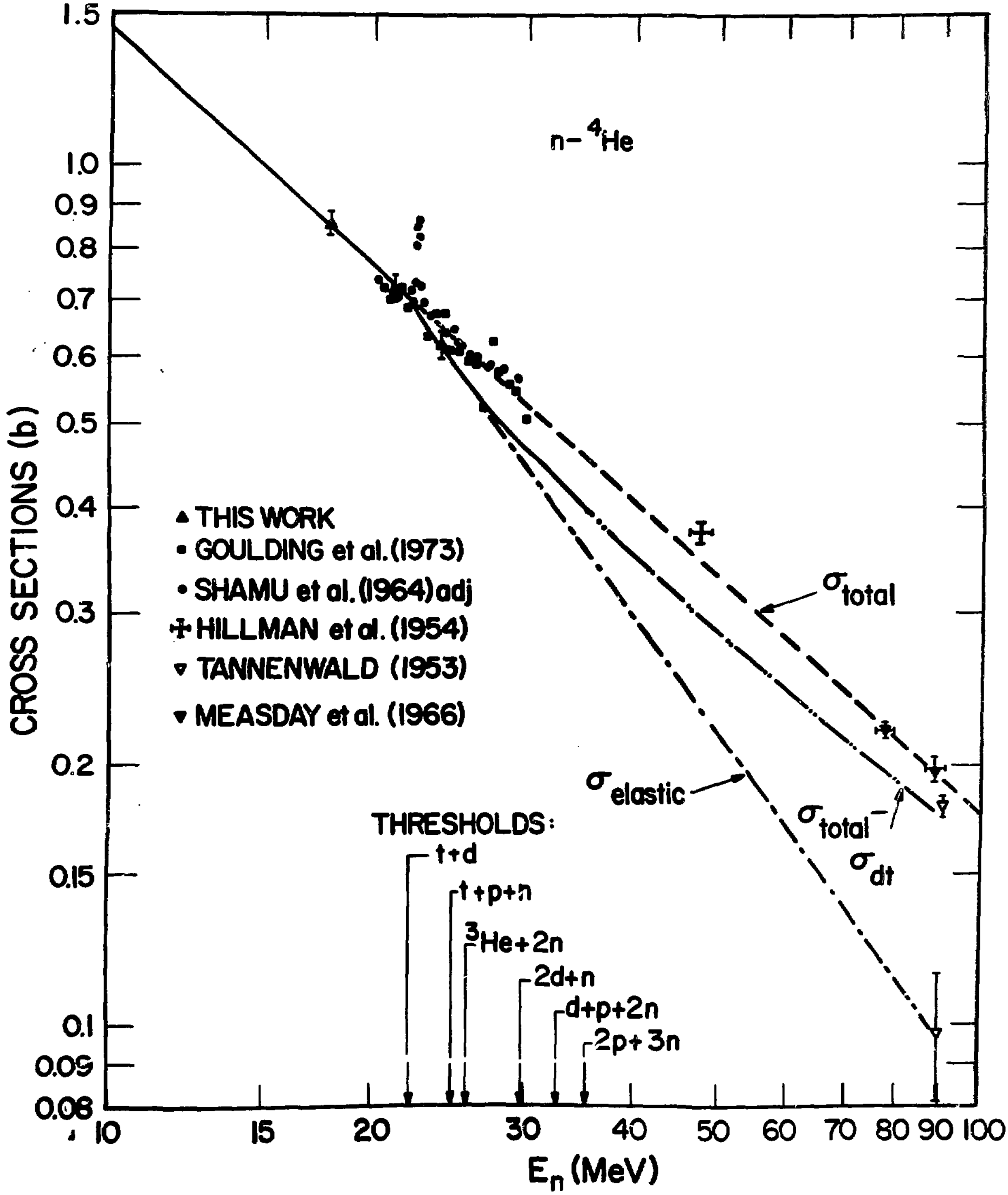

Fig. 2. Cross sections for the interactions of fast neutrons with ^{4}He. Dashed-dotted curves are only meant to guide the eye.

B. n-^{3}He data

Table III gives the revised absolute differential cross sections for the reaction ^{3}He(n,n)^{3}He at 12.0, 13.6, 14.4, and 23.7 MeV.[4] The data at 7.9 MeV did not change. The data between 12 and 14.4 MeV did not change much, actually the changes are within the uncertainty of the present efficiency curve. The 12 MeV data include the results from measuring the gaseous sample as described in the original paper. The changes of the forward angle data of the 23.7 MeV distribution are, however, not negligible due to the rather severe change of the efficiency curve at higher energies. Again, the shape error was revised as well, incorporating the uncertainty of the latest efficiency curve.

Table IV gives the differential cross sections for the reaction ^{3}He(n,p)^{3}H for neutron energies up to 19 MeV in the same way as discussed above.

Table V does the same for the reaction ^{3}He(n,d)^{2}H for neutron energies up to 21.2 MeV.

The uncertainties in the above representation of the nonelastic n-He interactions are discussed in Refs. 5 and 6, respectively, where the unconverted numbers were taken from.

The energy dependence of the integral cross sections is shown in Fig. 3. The total cross section is due to Goulding et al.[7] Below 3 MeV the old LASL data[12] are also shown. The curve for elastic scattering was obtained by subtraction of $\sigma_{n,p}$ and $\sigma_{n,d}$ from the total cross section at lower energies and by integration of differential cross sections of the reaction ^{3}He(n,n)^{3}He(Ref.13) and its charge-symmetric counterpart ^{3}H(p,p)^{3}H (see Ref. 4 for details). Below about 4 MeV the curve for the elastic cross section looks somewhat strange. This is probably due to too low total cross sections near the resonance.

Subtracting all known partial cross sections from the total yields the cross section for 3- and 4-body breakup with thresholds at 7.3 and 10.3 MeV, respectively. This was done in Table VI and Fig. 4. Contrary to previous assumptions, this cross section is not negligible even at 10 MeV. This finding is supported by the charge symmetric breakup of tritium by protons which starts to be noticeable near the 2n threshold as well.[5] The inset in Fig. 4 shows that the energy dependence of the zero degree differential cross section of p-t breakup is very similar to that of the total cross section of

TABLE III

Absolute Differential Cross Sections for $^{3}He(n,n)^{3}He$.

Revised Data from Ref. 4.

E_n / $\cos\theta_{c.m.}$	12.00 MeV θ_{lab} (deg)	σ_{lab} (mb/sr)	error %	$\sigma_{c.m.}$ (mb/sr)	13.60 MeV θ_{lab} (deg)	σ_{lab} (mb/sr)	error %	$\sigma_{c.m.}$ (mb/sr)	14.40 MeV θ_{lab} (deg)	σ_{lab} (mb/sr)	error %	$\sigma_{c.m.}$ (mb/sr)	23.70 MeV θ_{lab} (deg)	σ_{lab} (mb/sr)	error %	$\sigma_{c.m.}$ (mb/sr)
0.90	19.5	532	3.3	307	19.4	464	3.7	267	19.3	430	3.3	248	19.4	283	3.9	162
0.80	28.0	412	4.4	246	27.9	340	3.8	203	27.7	336	3.1	200	27.8	205	3.4	122
0.70	34.6	297	1.8	184	34.6	269	3.4	166	34.5	261	3.3	162	34.6	146	4.0	90.3
0.60	40.5	230	2.2	147	40.5	206	3.2	133	40.5	187	3.5	120	40.5	101	5.4	64.7
0.55	43.4	196	1.8	128	43.4	171	2.5	112	43.4	164	3.2	108	43.4	79.6	4.8	52.1
0.40	51.3	120	6.4	84.0	51.4	105	3.9	73.2	51.4	103	3.6	72.0	51.3	50.6	6.8	35.3
0.25	58.9	75.0	6.2	56.1	58.8	68.7	4.1	51.3	58.8	65.9	3.9	49.2	58.9	28.5	6.2	21.3
0.10	66.4	44.7	5.6	36.1	66.5	36.7	4.8	29.7	66.3	32.8	5.6	26.5	66.3	17.5	8.5	14.0
0.00	71.6	27.8	4.1	23.7	71.6	24.5	4.4	20.9	71.4	23.6	4.0	20.1	71.5	10.5	18.0	8.9
-0.10	76.8	17.6	7.5	15.9	76.8	17.0	5.9	15.4	76.6	14.3	5.5	12.9	76.6	7.4	11.6	6.7
-0.30	87.8	7.6	5.2	7.8	87.8	6.2	5.0	6.5	87.8	6.1	5.7	6.3	87.8	5.5	13.1	5.7
-0.50	100.9	7.4	7.1	9.0	100.8	6.0	5.9	7.3	100.7	5.1	6.5	6.2	100.7	4.1	17.9	5.1
-0.60	108.4	11.5	5.8	15.4	108.4	8.6	5.1	11.5	108.5	7.9	4.6	10.6	108.3	4.4	12.6	5.9
-0.715	118.2	16.8	5.8	25.4	118.5	12.5	5.5	18.9	118.5	12.4	3.7	18.7	118.5	5.5	10.6	8.4
Scale errors (not included)			2.3				3.1				2.8				2.9	
total elastic (mb)		1029	3.6			902	3.8			850	3.8			489	3.9	

TABLE IV

$^3He(n,p)^3H$. Recommended Values for $\sigma(0^o$ c.m.), Legendre Coefficients A_i and σ(total).
Obtained by Detailed Balance Conversion from $^3H(p,n)^3He$. Coefficients are multiplied by 1000.

E_n (MeV)	SIGMA-O (mb/sr)	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	SIGMA-T (mb)
0.50	63.8	1163	-450	287								932
0.60	61.0	1171	-528	357								897
0.70	59.7	1174	-589	415								881
0.80	59.4	1171	-633	462								875
0.90	59.9	1162	-663	500								875
1.00	61.6	1138	-671	534								880
1.20	68.4	1036	-623	595	- 8							889
1.40	78.5	898	-526	644	- 16							886
1.60	86.8	804	-473	693	- 24							877
1.80	90.3	761	-454	727	- 34							864
2.00	89.7	744	-450	754	- 48							839
2.50	81.2	738	-473	835	- 100							753
3.00	66.6	769	-530	915	- 176	26	- 4					643
3.50	54.1	809	-589	996	- 269	64	- 13	2				550
4.00	44.4	854	-647	1077	- 380	114	- 22	9	- 5			476
4.50	36.9	910	-711	1154	- 504	176	- 33	16	- 8			422
5.00	30.4	974	-773	1226	- 642	247	- 44	22	-11			373
5.50	25.5	1046	-833	1285	- 778	323	- 58	28	-13			335
6.00	21.7	1119	-883	1323	- 905	401	- 73	34	-16			305
6.50	19.2	1165	-900	1320	- 999	479	- 87	39	-17			281
7.00	17.5	1185	-885	1279	-1052	546	-100	45	-18			261
7.50	16.5	1179	-842	1205	-1064	601	-110	49	-18			244
8.00	16.0	1148	-771	1100	-1030	634	-117	53	-17			231
8.50	16.1	1090	-677	968	- 950	645	-117	55	-14			221
9.00	16.6	1020	-575	835	- 852	640	-114	56	-10			213
10.00	17.9	867	-399	630	- 659	614	-105	56	- 4			195
11.00	19.6	726	-259	493	- 487	564	- 93	55	1			179
12.00	21.4	612	-151	404	- 351	508	- 81	53	5	1		165
13.00	23.2	521	- 67	343	- 246	456	- 68	51	8	4	- 2	152
14.00	24.7	452	- 3	302	- 171	411	- 54	50	11	7	- 5	140
15.00	26.0	398	45	276	- 115	370	- 42	51	13	10	- 6	130
17.00	27.8	323	110	247	- 34	311	- 24	52	15	11	-11	113
19.00	29.1	270	151	230	24	263	- 7	54	16	13	-14	99

TABLE V

$^3He(n,d)^2H$. Recommended Values for $\sigma(0^o c.m.)$, Legendre Coefficients A_i and σ (total). Obtained by Detailed Balance Conversion from $^2H(d,n)^3He$. Coefficients are multiplied by 1000.

E_n (MeV)	SIGMA-O (mb/sr)	A_0	A_2	A_4	A_6	A_8	A_{10}	A_{12}	A_{14}	A_{16}	SIGMA-T (mb)
4.50	0.22	602	381	17							1.64
4.60	0.65	545	419	36							4.45
4.70	1.24	505	437	58							7.84
4.80	1.96	473	444	83							11.7
4.90	2.72	446	445	109							15.3
5.00	3.52	424	441	135							18.8
5.20	5.18	386	425	182	7						25.2
5.40	6.83	355	407	222	16						30.5
5.60	8.45	330	389	256	25						35.0
5.80	10.1	307	375	283	35						39.0
6.00	11.7	290	359	305	46						42.7
6.50	15.8	253	331	346	70						50.3
7.00	19.9	225	307	369	94	5					56.3
7.50	23.6	206	289	377	114	14					61.1
8.00	27.2	190	273	380	133	23	1				64.8
8.50	30.5	177	258	376	151	31	6	1			67.8
9.00	33.5	167	247	370	165	39	9	2	1		70.1
9.50	36.1	158	240	362	178	47	11	2	2		71.8
10.00	38.3	152	233	354	190	53	13	3	2		73.1
11.00	41.6	143	223	339	208	63	16	4	4		74.6
12.00	43.7	137	216	322	223	71	20	6	5		75.1
13.00	45.1	132	210	306	236	79	23	7	6	1	74.8
14.00	45.8	128	206	290	245	87	27	8	6	3	73.8
15.00	46.2	125	202	275	253	94	31	9	7	4	72.6
16.00	46.2	122	198	261	260	101	34	11	8	5	71.0
18.00	45.8	117	191	238	272	113	41	13	9	6	67.3
21.20	44.6	108	183	215	280	129	53	17	10	5	60.6

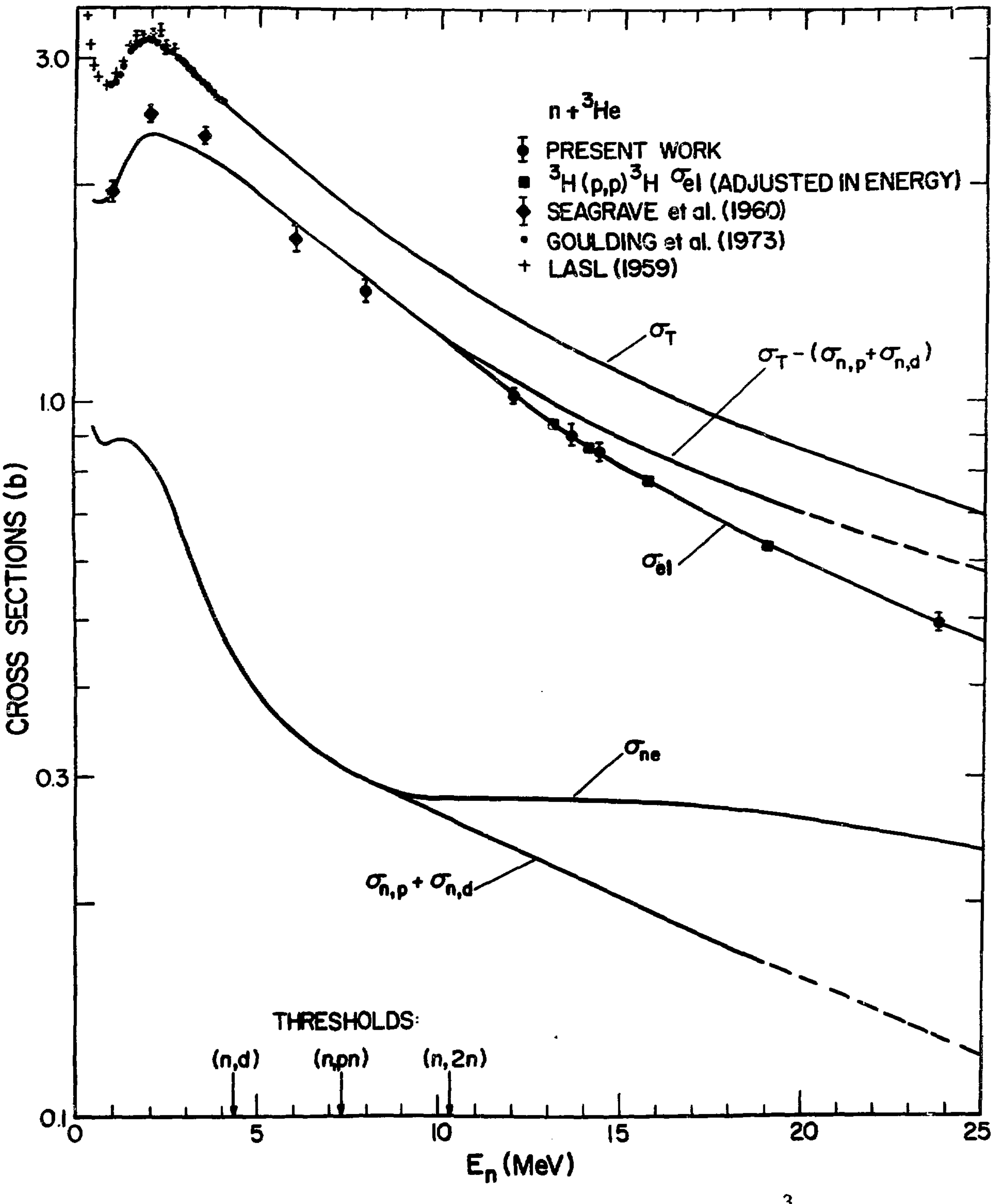

Fig. 3. Cross sections for interactions of fast neutrons with ^3He. Dashed curves are not so well established as full curves.

TABLE VI

n-^{3}He Integral Cross Sections (in barns)

E_n	σ_T[a]	$\sigma_{n,p}$	$\sigma_{n,d}$	σ_{el}	$\sigma_{n,pn} + \sigma_{n,2n}$ Individual	$\sigma_{n,pn} + \sigma_{n,2n}$ from curve
7.9	1.792	0.234	0.064	1.43	0.06	0
	±0.018	±0.005	±0.001	±0.05	±0.05	
12.0	1.315	0.165	0.075	1.023	0.05	0.04
	±0.013	±0.003	±0.001	±0.025	±0.03	
13.6	1.185	0.145	0.074	0.902	0.06	0.06
	±0.012	±0.003	±0.001	±0.029	±0.03	
14.4	1.127	0.136	0.073	0.856	0.06	0.07
	±0.011	±0.003	±0.001	±0.024	±0.03	
23.7	0.733	0.074	0.055	0.492	0.11	--
	±0.020	±0.005	±0.001	±0.014	±0.02	

[a] From Ref. 7.

C. n-p data

Table VII gives relative differential cross sections for the reaction $^1H(n,n)^1H$. These data were originally taken to provide the efficiency curve at higher neutron energies (see Ref. 1). Later on, however, this part of the efficiency curve was determined by means of neutron production cross sections (see Ref. 5). Therefore, these measurements provide now experimental data for n-p scattering. Although the errors, especially at the higher energies, are near 4% it seems worthwhile to provide these data, since they match other n-p data very closely in energy. Data of other authors are available at 22.5 MeV,[14] 24.0 MeV,[15,16,17] 27.2 MeV,[15] 27.3 MeV,[18] and 28.4 MeV.[19] Except for 2 data points at 24 MeV,[17] all these data are relative data like the present. By adjusting the data of corresponding energies by means of a Legendre fit to the well-known total cross section,[20] an absolute scale could be established. The adjusted data, together with their Legendre fits, are shown in Fig. 5. Although all of these data are in agreement with the YALE predictions for these cross sections,[20] they do not rule out a solution with lower 180° values as shown in Fig. 5. Lower 180° cross sections would explain discrepancies in counter telescope measurements for neutron energies around 25 MeV.[5,21]

n-^{3}He breakup. Actually, the curve obtained for n-^{3}He was overlaid on the p-T data points after adjusting the energy to have the threshold energies coinciding.

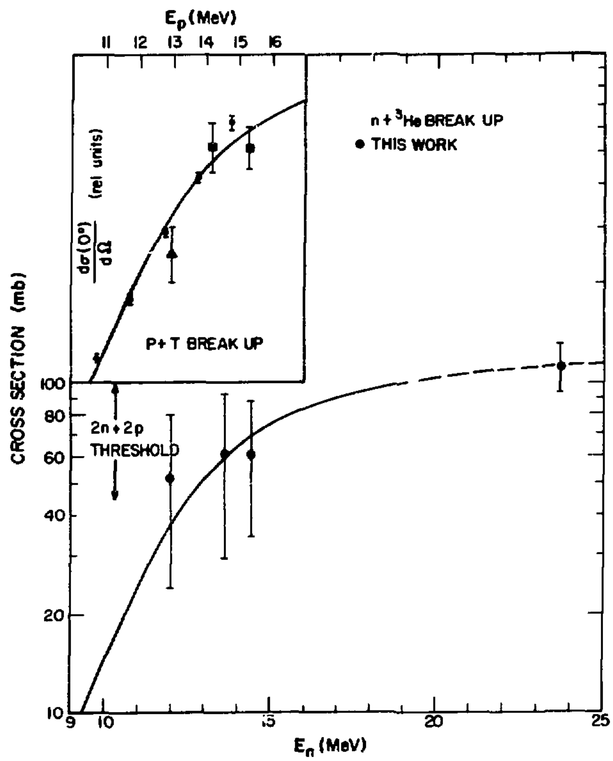

Fig. 4. Cross sections for the 3- and 4-body breakup of n-^{3}He. The insert was taken from Ref. 5. It shows the same increase with energy for the charge-symmetric data.

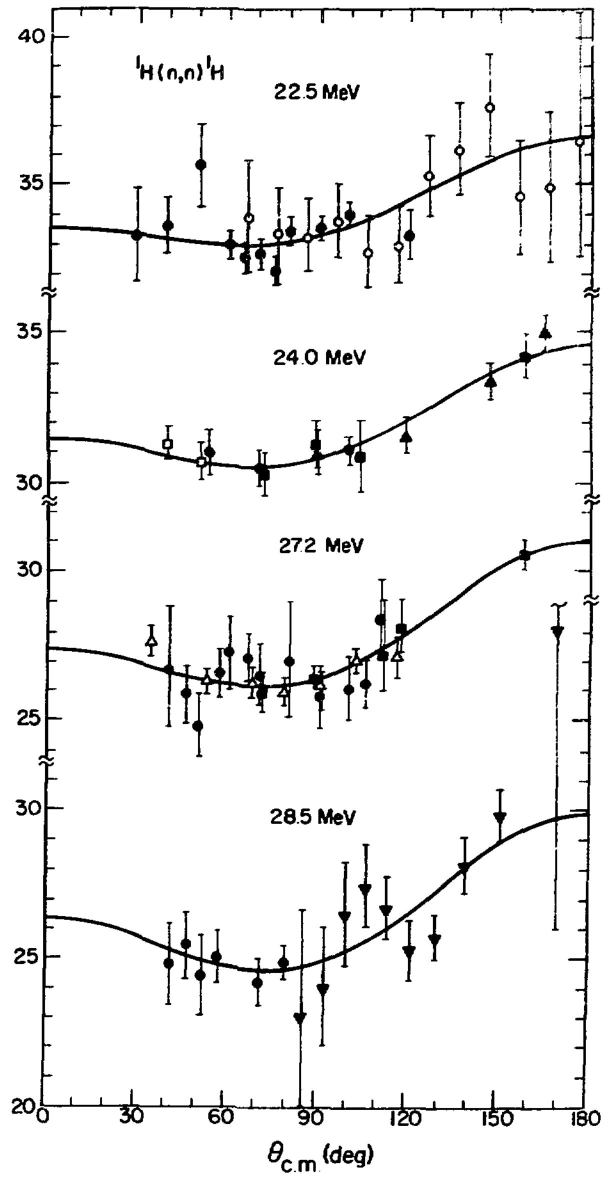

Fig. 5. Center-of-mass differential cross-section data for ^{1}H(n,n)^{1}H between 22.5 and 28.5 MeV, given in mb/sr. Relative data were adjusted in scale so that the fit gave the correct total cross sections. All fits were forced to give a lower 180° value than predicted by Yale.[20] Full circles: present data; open circles: Ref. 14; full squares: Ref. 15; full triangles at 24 MeV, Ref. 16; open squares: Ref. 17; open triangles: Ref. 18; full triangles at 28.5 MeV: Ref. 19.

TABLE VII

Relative Differential Cross Sections for $^1H(n,n)^1H$. Scale established by normalizing a Legendre fit to the total cross section.

E_n	22.4 MeV		23.7 MeV			27.1 MeV			28.5 MeV		
$\theta_{c.m.}$ (deg)	$\sigma_{c.m.}$ (mb/sr)	error %	$\theta_{c.m.}$ (deg)	$\sigma_{c.m.}$ (mb/sr)	error %	$\theta_{c.m.}$ (deg)	$\sigma_{c.m.}$ (mb/sr)	error %	$\theta_{c.m.}$ (deg)	$\sigma_{c.m.}$ (mb/sr)	error %
28.38	33.2	4.9	53.13	31.0	2.4	40.29	26.7	8.0	41.31	24.8	5.6
38.44	33.6	2.8	69.79	30.4	2.0	46.33	25.8	4.4	47.15	25.4	4.6
49.09	35.6	4.0	99.25	31.1	1.5	50.35	24.8	4.4	52.38	24.4	5.6
59.34	33.0	1.4				57.19	26.6	5.9	57.41	25.0	3.7
64.35	32.6	1.5				60.40	27.3	4.3	71.26	24.2	3.2
69.37	32.6	1.5				66.83	27.1	6.3	79.49	24.9	2.1
74.39	32.1	1.5				70.44	26.5	4.0			
79.20	33.4	1.4				80.47	27.0	7.4			
89.22	33.5	1.2				90.49	25.8	4.1			
99.03	34.0	1.1				100.50	26.0	4.2			
118.83	33.3	2.5				105.70	26.2	6.1			
						110.50	28.4	4.8			

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