International Atomic Energy Agency

INDC(CCP)-246/G

INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

ESTIMATIONS OF TOTAL AND DIFFERENTIAL CROSS-SECTIONS FOR PROTON INTERACTION WITH THE NUCLEI ^{6}Li AND ^{7}Li

[THE REACTIONS $^{6}Li(p,\alpha)^{3}He$, $^{6}Li(p,n)^{6}Be$, $^{7}Li(p,n)^{7}Be$, $^{7}Li(p,\alpha)^{4}He$]

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Translated by the IAEA

August 1985

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

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Reproduced by the IAEA in Austria
August 1985

85-03917

Translated from Russian

INDC(CCP)-246/G

Voprosy Atomnoj Nauki i Tekhniki
Seriya: Yadernye Konstanty
Hauehno - Tekhnicheskij Sbornik, Issue No. 4 (58)
Konstanty i Parametry Struktury Yadra i Yadernykh Reaktsij

ESTIMATIONS OF TOTAL AND DIFFERENTIAL CROSS-SECTIONS FOR PROTON INTERACTION WITH THE NUCLEI ^{6}Li AND ^{7}Li [THE REACTIONS $^{6}Li(p,\alpha)^{3}He$, $^{6}Li(p,n)^{6}Be$, $^{7}Li(p,n)^{7}Be$, $^{7}Li(p,\alpha)^{4}He$]

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The authors made a compilation and evaluation of cross-sections for proton interactions with the nuclei ^{6}Li and ^{7}Li. The evaluated data were arrived at on the basis of studies published up to the end of 1981. To evaluate the cross-section for the reaction $^{7}Li(p,n)^{7}Be$, we used the compilation of Liskien and Paulsen [1]. For comparing the data of various authors on total cross-sections we introduced scaling factors wherever a systematic shift in the data of a particular author was clearly discernible. After this operation we developed a procedure for a spline description of the data of these authors, taking into account systematic and random errors.

For purposes of comparing the Legendre polynomial coefficients obtained by various authors, these coefficients were reduced to the value of $A_0 = \sigma_t/4\pi$, which enabled us to exclude the systematic errors associated with inaccuracies in standardizing the cross-sections. Table 1 shows the energy characteristics of the different reactions [2].

The reaction $^{6}Li(p,\alpha)^{3}He$. The total cross-section for this reaction, measured in a proton energy range of 0.023-16 MeV, has been described in no fewer than 20 studies, carried out during the period 1936-1980. The authors of the present study took as their basis the cross-section data of the paper of Elwyn and co-workers [3], to which a minimal systematic error is assigned and which in the low-energy range are in agreement with the cross-sections given in the papers of Gemeinhardt et al. [4] and Fiedler et al. [5], i.e. the total cross-section in the 0.020-0.200 MeV energy range can be approximated

with a satisfactory degree of accuracy by the expression $\sigma_t = [S(E)/E] \exp(-2\pi\eta)$. Here η is a Coulomb factor; S(E) is an astrophysical factor that can be represented in the form $S(E) = S(0)(1 + aE + bE^2)$, where S(0) = 3.14 MeV·b; $a = -0.70$ MeV^{-1}; $b = 0.06$ MeV^{-2}. The values of S(0), a, b are taken from Ref. [3]. In Table 2 we show the studies which we used, together with an indication of the expert evaluations adopted for the systematic and random errors.

Table 3 is a tabulation of evaluated total cross-sections obtained by a description using the spline method with allowance for the systematic and random errors in the data from the studies cited in Table 2. To arrive at the Legendre polynomial coefficients we used data of the same authors, not including the studies in Refs [6, 7], in which, as shown by preliminary analysis, inverse angular distributions were evidently adopted. The evaluated Legendre coefficients are given in Table 4.

The form of the excitation function of the total cross-section for the ^{6}Li(p,α)^{3}He reaction is shown in Fig. 1. In addition to the evaluated cross-sections (solid-line curve), it also gives the errors for them, which were found for a 67% significance level (dashed curve).

The reaction ^{6}Li(p,n)^{6}Be. The study of Bair and co-workers [16] shows the variation in total neutron yield in the bombardment of ^{6}Li with protons ranging from threshold energy to 14 MeV (relative error: ±15%). It is asserted that the efficiency of the detector used is constant to within ±1% in the energy range of recorded neutrons: 1 keV < E_n < 2 MeV. Above 2 MeV it decreases systematically with increasing energy, reaching 75% of the initial value for neutrons with an energy of 9 MeV. An evaluation of the contribution of the channel of ^{6}Li(p,n)^{6}Be (ground state) for E_p = 11.6 MeV, which we made in accordance with Ref. [17], gives a value of $\sigma_t \approx 30$ mb. The data of Wakefield and Macefield [18] - where neutron spectra of the ^{6}Li + p reaction, corrected for detector efficiency, are given for different angles - can be used for evaluating the contribution of a two-particle channel to the total neutron yield at energy E_p = 10.5 MeV (its share is not more than 30%). This affords a means of evaluating the lower limit of the total cross-section for the formation of neutrons in 100 mb at E_p = 11.6 MeV, which is in good agreement (allowing for relative variation [16]) with the total cross-section in 32 mb ±5% for E_p = 8 MeV, as evaluated by Bair et al. [16].

Table 5 shows the energy dependence of the cross-section for total neutron yield, obtained by approximation and subsequent standardization of the data in Ref. [16]. In the standardization it was assumed that for E_p = 11.6 MeV, σ_t = 100 mb.

Fig. 2 shows the energy dependence of the evaluated total cross-section for the ^{6}Li(p,x)n reaction (broken line - 67% confidence limit).

The reaction ^{7}Li(p,n)^{7}Be is widely used as a source of neutrons owing to its high yield, ease of application and control and its relatively low threshold. A shortcoming of the reaction is the presence of a considerable γ background at energies higher than 2.38 MeV and the appearance of a continuous neutron spectrum after E_p = 3.68 MeV. This contribution of multiparticle breakup reactions rapidly increases, reaching 40-50% of the total yield at E_p = 7 MeV.

There are two surveys devoted to this reaction: that of Gibbons and Newson [19] published in 1960 and that of Liskien and Paulsen [1] from 1975. The latter included work done up to 1973; the estimate is carried out up to E_p = 7.0 MeV. At present, measurements of total and differential cross-sections for the reaction have been done up to an energy of 26 MeV. Furthermore, more precise measurements have also been published for the monoenergetic range as well. There is new information about multiparticle channels of the reaction and also about measurements of total neutron yield. Table 6 lists the studies used for estimating the cross-sections for the ^{7}Li(p,n)^{7}Be reaction for the ground state and first excited state of the final nucleus.

Figs 3 and 4 show the results of an evaluation of the cross-sections for the reactions ^{7}Li(p,n0)^{7}Be and ^{7}Li(p,n1)^{7}Be* (broken line - 67% confidence limit). The availability of data on angular [20, 21] and total [22, 23] cross-sections affords a means of extending the range of evaluated cross-sections for these reactions. In the case of the ^{7}Li(p,n0)^{7}Be reaction both evaluated total cross-sections and coefficients for Legendre polynomials were obtained; for the ^{7}Li(p,n1)^{7}Be* reaction, only an evaluation of the total cross-section. The results are shown in Tables 7-9.

The reaction ^{7}Li(p,α)^{4}He has been studied rather thoroughly. The total cross-section has been measured in the 0.023-12 MeV energy range. At low energies, the excitation function of the total cross-section is in agreement with the relationship $\sigma \backsim E^{-1} \exp(-B/\sqrt{E})$, where B is a constant. At energies higher than 1 MeV, the energy curve of this cross-section exhibits clearly

defined resonances corresponding to levels of a compound ^{8}Be nucleus. Despite the large number of studies, on the evaluation of differential cross-sections for the reaction, we encounter considerable difficulties, due to the existence of two groups of studies which present a twofold difference with respect to absolute values. On the one hand, there are studies [33, 34] whose results are based on or coincide with the measurements of J.M. Freeman [35], and on the other, the work of the group of J.B. Marion [36-38], in which doubt is cast on the findings of Ref. [35]. The paper of Paul, Kohler and Snover [39] is concerned with clearing up this dispute. In it the authors measured the ratio of the $^{7}Li(p,\alpha)^{4}He$ and $^{19}F(p,\alpha)^{16}O$ reactions, the value for which was found to be in good agreement with that given in Ref. [35]. For this reason we selected the cross-sections for the $^{7}Li(p,\alpha)^{4}He$ reaction proposed in Ref. [35], and used the data of Refs [36-38] in the evaluation, standardizing them with respect to the appropriate coefficient. Fig. 5 shows the experimental data used in the estimate and also the estimated curve for the excitation function of the total cross-section (broken line: 67% confidence interval).

Tables 10 and 11 contain tabulations of the cross-sections and coefficients for even Legendre polynomials. Expert evaluations of the studies used for the estimate are presented in Table 12.

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In the compilation and evaluation of available experimental information on the cross-sections for the interaction of protons and lithium nuclei, it became obvious that additional experimental efforts were necessary to enable a number of uncertainties to be eliminated and to contribute substanially to filling the gaps in the experimental data on individual reactions.

1. It should be pointed out that there is only one study [42] devoted to the reaction, important from the point of view of practical applications, involving the interaction of protons with ^{7}Li nuclei and with the production of tritium, namely, $^{7}Li(p,t)^{5}Li$. There are no data at all concerning the radiative capture of protons by the ^{6}Li nucleus, which are of importance for estimating the cross-section of gamma formation.

2. There is uncertainty with regard to the standardization of data on the $^{7}Li(p,\alpha)^{4}He$ reaction.

3. It would be desirable to have a more accurate cross-section for the total neutron yield in reactions involving the interaction of protons with ^{6}Li and ^{7}Li nuclei.

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Paper submitted to editors on 16 April 1984.

Table 1

Energy characteristics of the reactions

Reaction	Energy, MeV	
	of the reaction	threshold
$^{6}Li(p,\alpha)^{3}He$	4,018	0
$^{6}Li(p,n)^{6}Be$	-5,070	5,912
$^{7}Li(p,n)^{7}Be$	-I,644	I,880
$^{7}Li(p,n1)^{7}Be^{*}$	-2,073	2,470
$^{7}Li(p,\alpha)^{4}He$	I7,346	0

Table 2

Brief description of the studies used in evaluating the cross-sections for the reaction $^{6}Li(p,\alpha)^{3}He$

Ref.	Type of data	Energy Range, MeV	Standardization Method	Expert evaluation of systematic error, %	Evaluation of random error, %
[8]	$\sigma(90°)$	0,04-0,240	A	50	30
[5]	σ_t	0,025-0,050	A	20	I5-25
[4]	$\sigma(\theta)$, σ_t	0,050-0,I90	A	I0	I0
[6]	$\sigma(\theta)$	0,64-2,9I	A	25	I0
[9]		0,30-I,00	R	20	I0
[7]		0,I5I, 0,3I7	R	I2	8
[10]		I,00-2,00	A	30	I0
[12]	$\sigma(\theta)$	0,1-0,7	A	I4	I0
[3]		0,I4-3,0	R	I0	7
[13]		I,3-5,0	E	20	I5
[14]		0,I-0,I80	A	I5	I0
[15]		3,0-I2,0	R	I5	I2
[11]	$\sigma(\theta)$	I,0-2,5;	R	30	I0
	$\sigma(90°)$	I,0-4,0			

Note: A - author's standardization by determining target thickness, beam (charge) flux and solid angle; R - standardization by applying the ratio method; E - standardization of relative measurements according to a reference value.

Table 3

Evaluated total cross-sections for the reaction $^{6}Li(p,\alpha)^{3}He$

Energy, MeV	Cross-section, mb	Uncertainty, mb	Energy, MeV	Cross-section, mb	Uncertainty, mb
0,050	0,13	0,01	0,094	2,28	0,15
0,052	0,16	0,01	0,096	2,47	0,16
0,054	0,20	0,02	0,098	2,67	0,17
0,056	0,24	0,02	0,100	2,88	0,18
0,058	0,28	0,03	0,120	5,53	0,28
0,060	0,34	0,03	0,140	8,95	0,44
0,062	0,39	0,04	0,160	12,88	0,61
0,064	0,46	0,04	0,180	17,14	0,82
0,066	0,52	0,05	0,200	21,66	1,07
0,068	0,60	0,05	0,220	26,35	1,31
0,070	0,68	0,05	0,240	31,17	1,52
0,072	0,77	0,06	0,260	36,00	1,73
0,074	0,86	0,06	0,280	40,73	1,96
0,076	0,96	0,07	0,300	45,28	2,21
0,078	1,07	0,07	0,320	49,55	2,45
0,080	1,19	0,08	0,340	53,50	2,68
0,082	1,32	0,09	0,360	57,08	2,86
0,084	1,46	0,10	0,380	60,33	3,00
0,086	1,60	0,11	0,400	63,28	3,12
0,088	1,75	0,12	0,420	65,98	3,22
0,090	1,92	0,13	0,440	68,49	3,32
0,092	2,09	0,14	0,460	70,85	3,43
0,460	73,10	3,53	3,400	123,49	5,69
0,500	75,27	3,64	3,600	119,74	5,52
0,520	77,39	3,74	3,800	115,16	5,31
0,540	79,49	3,84	4,000	109,75	5,07
0,560	81,59	3,93	4,200	103,87	4,80
0,580	83,70	4,01	4,400	97,87	4,53
0,600	85,79	4,09	4,600	92,00	4,28
0,620	87,84	4,17	4,800	86,42	4,04
0,640	89,80	4,25	5,000	81,20	3,82
0,660	91,67	4,33	5,200	76,41	3,63
0,680	93,42	4,42	5,400	72,05	3,45
0,700	95,03	4,51	5,600	68,11	3,29
0,720	96,49	4,60	5,800	64,60	3,15
0,740	97,77	4,68	6,000	61,47	3,03
0,760	98,88	4,75	6,200	58,71	2,92
0,780	99,80	4,81	6,400	56,29	2,84
0,800	100,52	4,85	6,600	54,18	2,77
0,820	101,04	4,87	6,800	52,36	2,71
0,840	101,36	4,88	7,000	50,81	2,76
0,860	101,48	4,87	7,200	49,50	2,66
0,880	101,39	4,84	7,400	48,43	2,66
0,900	101,11	4,82	7,600	47,55	2,58
0,920	100,65	4,79	7,800	46,82	2,72
0,940	100,14	4,78	8,000	46,21	2,77
0,960	99,68	4,79	8,200	45,68	2,83
0,980	99,39	4,81	8,400	45,21	2,90
1,000	99,35	4,85	8,600	44,78	2,97
1,100	105,22	5,06	8,800	44,36	3,03

Table 3 (continued)

Energy, MeV	Cross-section, mb	Uncertainty, mb	Energy, MeV	Cross-section, mb	Uncertainty, mb
I,200	II7,57	5,64	9,000	43,95	3,09
I,300	I25,47	5,99	9,200	43,52	3,14
I,400	I33,02	6,28	9,400	43,08	3,I8
I,500	I53,34	7,26	9,600	42,60	3,2I
I,600	I85,86	8,66	9,800	42,09	3,23
I,700	2II,36	9,83	I0,000	4I,53	3,23
I,800	2I2,25	9,86	I0,200	40,93	3,23
I,900	I97,I2	9,I0	I0,400	40,28	3,22
2,000	I79,35	8,23	I0,600	39,57	3,I9
2,I00	I65,7I	7,59	I0,800	38,8I	3,I7
2,200	I55,88	7,I4	II,000	38,00	3,I4
2,300	I48,7I	6,82	II,200	37,I5	3,II
2,400	I43,4I	6,58	II,400	36,24	3,08
2,500	I39,46	6,34	II,600	35,29	3,06
2,600	I36,46	6,26	II,800	34,29	3,05
2,700	I34,I4	6,I6	I2,000	33,26	3,05
2,800	I32,28	6,07	I2,200	32,20	3,06
2,900	I30,7I	6,0I	I2,400	3I,II	3,09
3,000	I29,29	5,94	I2,600	29,99	3,I3
3,200	I26,56	5,83	I2,800	28,85	3,I7
I3,000	27,7I	3,23	I3,600	24,23	3,44
I3,200	26,55	3,30	I3,800	23,08	3,5I
I3,400	25,39	3,37	I4,000	2I,94	3,57

Table 4

Evaluated Legendre polynomial coefficients
for the reaction $^{6}Li(p,\alpha)^{3}He$

Energy, MeV	AI	A2	A3	A4	Energy, MeV	AI	A2	A3	A4
0,070	0,01	0,00	0,00	0,00	2,600	0,07	0,10	-0,12	0,08
0,100	0,03	-0,03	0,00	0,00	2,800	0,06	0,01	-0,15	0,08
0,120	0,05	-0,05	0,00	0,00	3,000	0,06	-0,03	-0,18	0,08
0,140	0,08	-0,05	0,00	0,00	3,200	0,05	-0,03	-0,21	0,07
0,160	0,11	-0,05	0,00	0,00	3,400	0,05	-0,03	-0,24	0,06
0,180	0,13	-0,04	0,00	0,00	3,600	0,05	-0,08	-0,26	0,05
0,200	0,16	-0,04	0,00	0,00	3,800	0,07	-0,15	-0,28	0,04
0,220	0,18	-0,04	0,00	0,00	4,000	0,09	-0,17	-0,30	0,02
0,250	0,21	-0,05	-0,06	0,05	4,200	0,12	-0,14	-0,32	0,00
0,300	0,25	-0,08	-0,05	0,04	4,400	0,15	-0,09	-0,32	-0,02
0,400	0,33	-0,13	-0,04	0,02	4,600	0,19	-0,04	-0,33	-0,04
0,500	0,40	-0,10	-0,03	0,01	4,800	0,22	-0,02	-0,32	-0,05
0,600	0,45	-0,08	-0,02	0,00	5,000	0,26	0,00	-0,32	-0,07
0,700	0,49	-0,08	-0,01	-0,01	5,200	0,30	0,02	-0,30	-0,08
0,800	0,51	-0,09	0,00	-0,01	5,400	0,33	0,03	-0,28	-0,09
0,900	0,51	-0,10	0,00	-0,02	5,600	0,37	0,03	-0,26	-0,10
1,000	0,52	-0,12	0,00	-0,02	5,800	0,40	0,04	-0,24	-0,10
1,100	0,54	-0,17	0,00	-0,01	6,000	0,42	0,04	-0,20	-0,10
1,200	0,56	-0,20	0,00	-0,01	6,200	0,44	0,04	-0,17	-0,08
1,300	0,59	-0,15	0,00	0,00	6,400	0,46	0,04	-0,13	-0,06
1,400	0,61	-0,07	0,00	0,00	6,600	0,47	0,04	-0,09	-0,04
1,500	0,58	0,03	-0,01	0,01	6,800	0,48	0,04	-0,05	-0,01
1,600	0,52	0,13	-0,01	0,02	7,000	0,48	0,04	-0,01	0,02
1,700	0,43	0,21	-0,02	0,03	7,200	0,47	0,03	0,03	0,05
1,800	0,34	0,28	-0,03	0,03	7,400	0,47	0,04	0,07	0,09
1,900	0,26	0,32	-0,04	0,04	7,600	0,45	0,04	0,10	0,12
2,000	0,20	0,35	-0,05	0,05	7,800	0,43	0,04	0,12	0,16
2,200	0,12	0,32	-0,07	0,06	8,000	0,40	0,04	0,14	0,19
2,400	0,08	0,21	-0,09	0,07					

Table 5

Evaluated total cross-sections for the reaction $^{6}Li(p,x)n$ as a function of energy

Energy, MeV	Cross-section, mb	Uncertainty, mb	Energy, MeV	Cross-section, mb	Uncertainty, mb
5,700	0,00	0,00	9,900	84,30	II,90
5,800	2,I0	0,00	I0,000	86,00	I2,20
5,900	5,30	0,50	I0,I00	87,50	I2,40
6,000	8,40	0,80	I0,200	89,00	I2,70
6,I00	9,40	0,90	I0,300	90,30	I2,90
6,200	II,80	I,20	I0,400	9I,80	I3,20
6,300	I4,00	I,40	I0,500	93,20	I3,50
6,400	I6,I0	I,60	I0,600	94,70	I3,70
6,500	I8,20	2,00	I0,700	95,90	I4,00
6,600	20,20	2,20	I0,800	97,00	I4,20
6,700	22,30	2,50	I0,900	98,00	I4,40
6,800	24,40	2,70	II,000	98,90	I4,60
6,900	26,40	3,00	II,I00	99,80	I4,80
7,000	29,50	3,40	II,200	I00,60	I5,00
7,I00	30,50	3,70	II,300	I0I,50	I5,20
7,200	32,60	4,00	II,400	I02,20	I5,40
7,300	34,70	4,30	II,500	I04,00	I5,60
7,400	36,80	4,60	II,600	I04,70	I5,80
7,500	39,00	4,90	II,700	I05,40	I6,00
7,600	4I,00	5,20	II,800	I06,I0	I6,20
7,700	42,90	5,50	II,900	I06,80	I6,40
7,800	44,80	5,80	I2,000	I07,50	I6,60
7,900	46,70	6,00	I2,I00	I08,20	I6,80
8,000	48,60	6,30	I2,200	I08,90	I7,00
8,I00	50,50	6,60	I2,300	I09,80	I7,I0
8,200	52,40	6,90	I2,400	II0,40	I7,20
8,300	54,30	7,20	I2,500	III,00	I7,30
8,400	56,20	7,50	I2,600	III,60	I7,40
8,500	58,I0	7,80	I2,700	II2,20	I7,50
8,600	60,00	8,00	I2,800	II2,80	I7,60
8,700	62,00	8,30	I2,900	II3,40	I7,70
8,800	64,00	8,60	I3,000	II4,00	I7,80
8,900	66,00	8,90	I3,I00	II4,60	I7,90
9,000	68,00	9,20	I3,200	II5,20	I8,00
9,I00	69,90	9,50	I3,300	II5,80	I8,00
9,200	7I,80	9,80	I3,400	II6,40	I8,00
9,300	73,70	I0,I0	I3,500	II7,00	I8,00
9,400	75,60	I0,40	I3,600	II7,60	I8,00
9,500	77,50	I0,70	I3,700	II8,20	I8,00
9,600	79,20	II,00	I3,800	II8,80	I8,00
9,700	80,90	II,30	I3,900	II9,40	I8,00
9,800	82,60	II,60	I4,000	I20,00	I8,00

Table 6

Brief description of the studies used in evaluating the cross-sections of the reactions $^{7}Li(p,n0)^{7}Be$ and $^{7}Li(p,n1)^{7}Be^{*}$

Ref.	Type of data	Energy range, MeV	Standardization method	Expert evaluation of systematic error, %	Evaluation of random error, %
[24]	σ_t, $\sigma(\theta)$, n0, n1	E_{thresh} - 2,5	SP	30	20
[25]	σ_t, n0, n1	E_{thresh} - 2,5	SP	20	I5
[26]		E_{thresh} 5,0	SR	I0	I0
[27]	$\sigma(\theta)$, n0, n1	2,6-4,0	RLG	I5	I0
[28]		3-I0	RLG	I5	I5
[29]		E_{thresh} 2,3	RLG	I0	I0
[2V]		I4,2-26,0	RLG	I0	8
[30]	$\sigma(\theta)$, n0	2,2-5,4	A	I0	I0
[3V]	σ_T, n1	E^{I}_{thresh} 6,0	RTR	I0	I0
[32]	σ_T, n0, n1	I4,9;I7,0	A	20	I0
[20]	σ_T, n0	E_{thresh} 3,8	A	I0	8
[22]	σ_T, n0+n1	E_{thresh} 4,2	A	7	5
[23]	$\sigma(90°)$, n1	E^{I}_{thresh} - 8,0	RLP	I5	I0

Note: SP - standardization on basis of (Po-Be) source; SR- standardization on basis of (Ra-Be) source; A - standardization on basis of current, target thickness, geometry; RLG - relative measurements with standardization based on date of Ref. [26]; RTR - standardization by ratio method; cross-section for $^{7}Li(p,p1)^{7}Li^{*}$ was used; RLP - relative measurements with standardization based on date of Ref. [31];
n0 - neutrons corresponding to the ground state of the ^{7}Be nucleus;
n1 - neutrons corresponding to the first excited state on the ^{7}Be nucleus.

Table 7

Evaluated total cross-sections for the reaction $^{7}Li(p,n0)^{7}Be$

Energy, MeV	Cross-section, mb	Uncertainty, mb	Energy, MeV	Cross-section, mb	Uncertainty, mb
2,08	320	35	2,36	435	23
2,10	315	20	2,38	411	21
2,12	330	20	2,40	388	20
2,14	361	22	2,42	369	19
2,16	404	22	2,44	353	19
2,18	450	24	2,46	341	18
2,20	492	28	2,48	332	18
2,22	521	30	2,50	325	17
2,24	535	30	2,52	320	16
2,26	536	29	2,54	315	16
2,28	526	28	2,56	311	16
2,30	509	28	2,58	307	16
2,32	486	27	2,60	303	16
2,34	461	25	2,62	299	16
2,64	296	15	6,90	128	15
2,66	292	15	7,00	121	13
2,68	288	15	7,10	114	11
2,70	285	14	7,20	107	9
2,72	281	14	7,30	102	9
2,74	278	14	7,40	97	8
2,76	275	14	7,50	92	8
2,78	272	14	7,60	88	8
2,80	269	14	7,70	84	7
2,90	258	14	7,80	80	7
3,00	251	13	7,90	77	7
3,10	247	13	8,00	74	7
3,20	245	13	8,10	72	7
3,30	244	13	8,20	69	6
3,40	243	13	8,30	67	6
3,50	243	12	8,40	65	6
3,60	242	13	8,50	63	6
3,70	243	13	8,60	61	5
3,80	244	13	8,70	59	5
3,90	246	13	8,80	58	5
4,00	250	15	8,90	56	5
4,10	257	18	9,00	55	4
4,20	268	20	9,10	54	4
4,30	284	21	9,20	52	4
4,40	304	21	9,30	51	4
4,50	325	21	9,40	50	4
4,60	346	23	9,50	49	3
4,70	364	26	9,60	48	3-
4,80	376	27	9,70	47	4
4,90	380	26	9,80	46	4
5,00	377	25	9,90	46	4.

Table 7 (continued)

Energy, MeV	Cross-section, mb	Uncertainty, mb	Energy, MeV	Cross-section, mb	Uncertainty, mb
5,10	367	25	10,00	45	4
5,20	353	26	10,50	41	4
5,30	335	26	11,00	38	4
5,40	315	25	11,50	36	4
5,50	294	23	12,00	34	3
5,60	274	22	12,50	32	3
5,70	253	22	13,00	30	3
5,80	235	24	13,50	29	3
5,90	218	26	14,00	28	2
6,00	203	27	14,50	27	2
6,10	190	27	15,00	26	2
6,20	179	25	15,50	25	2
6,30	170	22	16,00	24	2
6,40	162	20	16,50	23	2
6,50	155	17	17,00	23	2
6,60	148	16	17,50	22	2
6,70	141	16	18,00	22	2
6,80	135	16	18,50	21	2
19,00	21	2	23,00	19	1
19,50	20	2	23,50	19	1
20,00	20	2	24,00	19	1
20,50	20	2	24,50	18	1
21,00	20	2	25,00	18	2
21,50	19	2	25,50	18	2
22,00	19	2	26,00	18	2
22,50	19	2	-	-	-

Table 8

Evaluated Legendre polynomial coefficients for the reaction $^{7}Li(p,n0)^{7}Be$

Energy, MeV	A1	A2	A3	Energy, MeV	A1	A2	A3
2,200	0,17	0,03	0,00	10,500	-0,17	0,15	0,09
2,400	0,33	0,12	0,00	11,000	-0,11	0,13	0,08
2,600	0,31	0,12	0,00	11,500	-0,07	0,11	0,07
2,800	0,28	0,10	0,00	12,000	-0,03	0,10	0,06
3,000	0,29	0,08	0,00	12,500	0,00	0,09	0,05
3,200	0,31	0,08	0,00	13,000	0,03	0,08	0,05
3,400	0,32	0,09	0,00	13,500	0,06	0,07	0,05
3,600	0,30	0,12	-0,02	14,000	0,08	0,07	0,05
3,800	0,26	0,14	-0,06	14,500	0,10	0,07	0,05
4,000	0,22	0,16	-0,11	15,000	0,11	0,06	0,05
4,200	0,19	0,21	-0,15	15,500	0,12	0,07	0,05
4,400	0,17	0,29	-0,16	16,000	0,14	0,07	0,06
4,600	0,15	0,34	-0,15	16,500	0,14	0,07	0,06
4,800	0,13	0,36	-0,11	17,000	0,15	0,07	0,07
5,000	0,09	0,37	-0,06	17,500	0,16	0,08	0,07
5,200	0,04	0,36	-0,01	18,000	0,17	0,08	0,08
5,400	-0,03	0,35	0,03	18,500	0,17	0,08	0,08
5,600	-0,08	0,34	0,06	19,000	0,17	0,09	0,09
5,800	-0,13	0,33	0,09	19,500	0,18	0,09	0,09
6,000	-0,17	0,32	0,11	20,000	0,18	0,10	0,10
6,200	-0,21	0,31	0,12	20,500	0,18	0,10	0,11
6,400	-0,25	0,30	0,14	21,000	0,18	0,11	0,11
6,600	-0,28	0,29	0,15	21,500	0,18	0,11	0,12
6,800	-0,30	0,29	0,15	22,000	0,18	0,12	0,13
6,900	-0,31	0,29	0,16	22,500	0,18	0,12	0,13
7,000	-0,32	0,29	0,16	23,000	0,18	0,13	0,14
7,500	-0,35	0,27	0,16	23,500	0,18	0,13	0,15
8,000	-0,36	0,25	0,16	24,000	0,18	0,14	0,15
8,500	-0,35	0,23	0,14	24,500	0,18	0,14	0,16
9,000	-0,33	0,21	0,13	25,000	0,18	0,15	0,16
9,500	-0,28	0,19	0,12	25,500	0,18	0,15	0,17
10,000	-0,22	0,17	0,10	26,000	0,18	0,16	0,18

Table 9

Evaluated total cross-sections of the reaction $^{7}Li(p,n1)^{7}Be$*

Energy, MeV	Cross-section, mb	Uncertainty, mb	Energy, MeV	Cross-section, mb	Uncertainty, mb
2,400	3,4I	0,I2	4,800	40,9I	0,64
2,450	5,23	0,I6	4,850	40,60	0,63
2,500	7,62	0,20	4,900	40,3I	0,63
2,550	I0,6I	0,26	4,950	40,03	0,62
2,600	I4,I9	0,34	5,000	39,77	0,6I
2,650	I8,30	0,43	5,I00	39,29	0,60
2,700	22,8I	0,54	5,200	38,86	0,59
2,750	27,58	0,65	5,300	38,48	0,59
2,800	32,47	0,77	5,400	38,I3	0,58
2,850	37,29	0,89	5,500	37,83	0,58
2,900	4I,90	I,00	5,600	37,55	0,58
2,950	46,I5	I,09	5,700	37,30	0,57
3,000	49,95	I,I7	5,800	37,08	0,57
3,050	53,23	I,22	5,900	36,88	0,56
3,I00	55,93	I,26	6,000	36,70	0,55
3,I50	58,05	I,28	6,I00	36,54	0,54
3,200	59,60	I,28	6,200	36,40	0,53
3,250	60,63	I,28	6,300	36,27	0,53
3,300	6I,I7	I,26	6,400	36,I4	0,52
3,350	6I,29	I,24	6,500	36,02	0,52
3,400	6I,04	I,2I	6,600	35,90	0,52
3,450	60,5I	I,I8	6,700	35,78	0,53
3,500	59,74	I,I5	6,800	35,66	0,54
3,550	58,80	I,I2	6,900	35,52	0,56
3,600	57,74	I,09	7,000	35,38	0,58
3,650	56,6I	I,07	7,I00	35,23	0,60
3,700	55,45	I,04	7,200	35,06	0,63
3,750	54,30	I,02	7,300	34,89	0,66
3,800	53,I8	I,00	7,400	34,69	0,69
3,850	52,I3	0,98	7,500	34,48	0,73
3,900	5I,I5	0,96	7,600	34,26	0,76
3,950	50,23	0,94	7,700	34,02	0,79
4,000	49,37	0,92	7,800	33,75	0,82
4,050	48,56	0,90	7,900	33,47	0,85
4,I00	47,80	0,88	8,000	33,I8	0,88
4,I50	47,09	0,86	8,I00	32,86	0,90
4,200	46,43	0,84	8,200	32,52	0,92
4,250	45,80	0,82	8,300	32,I7	0,94
4,300	45,2I	0,80	8,400	3I,80	0,96
4,350	44,66	0,78	8,500	3I,40	0,98
4,400	44,I4	0,76	8,600	30,99	0,99
4,450	43,64	0,74	8,700	30,57	I,00
4,500	43,I8	0,72	8,800	30,I3	I,00
4,550	42,75	0,7I	8,900	29,67	I,0I
4,600	42,33	0,69	9,000	29,I9	I,0I
4,650	4I,95	0,68	9,I00	28,7I	I,0I
4,700	4I,58	0,67	9,200	28,2I	I,0I
4,750	4I,23	0,65	9,300	27,69	I,0I

Table 9 (continued)

Energy, MeV	Cross-section, mb	Uncertainty, mb	Energy, MeV	Cross-section, mb	Uncertainty, mb
9,400	27,17	I,00	I6,000	8,20	0,57
9,500	26,63	I,00	I6,500	8,I7	0,53
9,600	26,09	0,99	I7,000	8,22	0,50
9,700	25,53	0,98	I7,500	8,3I	0,49
9,800	24,97	0,97	I8,000	8,43	0,50
9,900	24,4I	0,96	I8,500	8,55	0,52
I0,000	23,84	0,96	I9,000	8,65	0,55
I0,500	2I,04	0,93	I9,500	8,72	0,58
II,000	I8,47	0,93	20,000	8,76	0,60
II,500	I6,2I	0,93	20,500	8,73	0,60
I2,000	I4,29	0,92	2I,000	8,65	0,59
I2,500	I2,7I	0,90	2I,500	8,50	0,56
I3,000	II,42	0,87	22,000	8,28	0,53
I3,500	I0,40	0,83	22,500	7,99	0,50
I4,000	9,60	0,78	23,000	7,64	0,50
I4,500	9,0I	0,73	23,500	7,23	0,52
I5,000	8,59	0,68	24,000	6,77	0,58
I5,500	8,32	0,62	24,500	6,28	0,66

Table 10

Evaluated total cross-sections for the reaction $^{7}Li(p,\alpha)^{4}He$

Energy, MeV	Cross-section, mb	Uncertainty, mb	Energy, MeV	Cross-section, mb	Uncertainty, mb
0,010	0,00	0,00	0,460	5,66	0,32
0,020	0,00	0,00	0,470	5,83	0,33
0,030	0,00	0,00	0,480	5,99	0,34
0,040	0,00	0,00	0,490	6,15	0,34
0,050	0,01	0,00	0,500	6,23	0,35
0,060	0,01	0,00	0,550	6,96	0,38
0,070	0,03	0,00	0,600	7,52	0,40
0,080	0,05	0,00	0,650	8,03	0,42
0,090	0,09	0,01	0,700	8,52	0,45
0,100	0,12	0,01	0,750	9,04	0,47
0,110	0,16	0,01	0,800	9,60	0,50
0,120	0,20	0,01	0,850	10,23	0,52
0,130	0,25	0,02	0,900	10,92	0,55
0,140	0,30	0,02	0,950	11,66	0,58
0,150	0,35	0,03	1,000	12,46	0,62
0,160	0,42	0,03	1,050	13,31	0,67
0,170	0,49	0,03	1,100	14,21	0,72
0,180	0,57	0,04	1,150	15,16	0,77
0,190	0,66	0,04	1,200	16,15	0,83
0,200	0,76	0,05	1,250	17,18	0,88
0,210	0,88	0,06	1,300	18,26	0,93
0,220	1,00	0,06	1,350	19,38	0,98
0,230	1,14	0,07	1,400	20,54	1,01
0,240	1,29	0,08	1,450	21,76	1,06
0,250	1,45	0,09	1,500	23,05	1,11
0,260	1,62	0,10	1,550	24,41	1,16
0,270	1,80	0,12	1,600	25,86	1,23
0,280	1,98	0,13	1,650	27,40	1,31
0,290	2,18	0,14	1,700	29,05	1,40
0,300	2,37	0,15	1,750	30,83	1,49
0,310	2,58	0,16	1,800	32,73	1,58
0,320	2,79	0,17	1,850	34,79	1,67
0,330	3,00	0,17	1,900	37,00	1,77
0,340	3,21	0,18	1,950	39,39	1,86
0,350	3,43	0,19	2,000	41,98	1,96
0,360	3,65	0,20	2,100	47,83	2,22
0,370	3,86	0,21	2,200	54,71	2,71
0,380	4,08	0,22	2,300	62,24	3,17
0,390	4,29	0,23	2,400	70,19	3,32
0,400	4,45	0,25	2,500	79,05	3,61
0,410	4,71	0,26	2,600	89,42	4,09
0,420	4,91	0,27	2,700	101,10	4,53
0,430	5,10	0,28	2,800	112,50	4,98
0,440	5,30	0,29	2,900	121,20	5,41
0,450	5,48	0,31	3,000	125,10	5,55

Table 10 (continued)

Energy, MeB	Cross-section, mb	Uncertainty, mb	Energy, MeV	Cross-section, mb	Uncertainty, mb
3,100	122,90	5,36	7,600	20,64	1,37
3,200	114,90	5,14	7,700	19,56	1,28
3,300	102,50	4,74	7,800	18,55	1,18
3,400	87,45	4,00	7,900	17,64	1,12
3,500	71,54	3,41	8,000	16,86	1,08
3,600	56,86	3,00	8,100	16,23	1,08
3,700	44,82	2,32	8,200	15,76	1,09
3,800	35,43	1,96	8,300	15,46	1,10
3,900	28,38	1,75	8,400	15,36	1,10
4,000	23,21	1,45	8,500	15,45	1,08
4,100	19,40	1,18	8,600	15,74	1,05
4,200	16,50	1,08	8,700	16,17	1,01
4,300	14,22	1,07	8,800	16,70	1,00
4,400	12,38	1,00	8,900	17,30	1,00
4,500	10,87	0,85	9,000	17,92	1,04
4,600	9,78	0,77	9,100	18,53	1,10
4,700	9,28	0,82	9,200	19,07	1,17
4,800	9,51	0,93	9,300	19,50	1,23
4,900	10,76	1,02	9,400	19,77	1,25
5,000	13,71	1,03	9,500	19,86	1,24
5,100	18,90	1,16	9,600	19,81	1.23
5,200	26,31	1,50	9,700	19,63	1,23
5,300	35,90	1,87	9,800	19,37	1.25
5,400	46,80	2,23	9,900	19,04	1,30
5,500	56,94	2,64	10,000	18,68	1,35
5,600	63,43	2,97	10,100	18,31	1,39
5,700	64,84	3,04	10,200	17,95	1,41
5,800	62,26	2,89	10,300	17,62	1,42
5,900	57,32	2,66	10,400	17,34	1,42
6,000	51,59	2,44	10,500	17,11	1,43
6,100	46,19	2,22	10,600	16,92	1,48
6,200	41,80	2,01	10,700	16,77	1,59
6,300	38,51	1,81	10,800	16,44	1,74
6,400	36,00	1,65	10,900	16,54	1,91
6,500	34,03	1,54	11,000	16,44	2,06
6,600	32,43	1,48	11,100	16,35	2,16
6,700	31,06	1,46	11,200	16,25	2,21
6,800	29,81	1,45	11,300	16,15	2,18
6,900	28,62	1,43	11,400	16,03	2,10
7,000	27,44	1,42	11,500	15,89	1,99
7,100	26,28	1,42	11,600	15,73	1,95
7,200	25,13	1,44	11,700	15,53	2,11
7,300	23,99	1,46	11,800	15,28	2,51
7,400	22,86	1,47	11,900	14,97	3,09
7,500	21,74	1,44	12,000	14,59	3,76

Table 11

Evaluated Legendre polynomial coefficients for the reaction $^{7}Li(p,\alpha)^{4}He$

Energy, MeV	A2	A4	A6	A8	Energy, MeV	A2	A4	A6	A8
0,000	-0,I7	0,II	-0,II	0,00	6,200	-0,35	-0,0I	-0,06	0,03
0,200	0,I9	0,05	0,0I	0,00	6,400	-0,23	-0,06	-0,07	0,02
0,400	0,47	0,00	0,09	0,00	6,600	-0,08	-0,I2	-0,08	0,02
0,600	0,65	-0,04	0,I4	0,00	6,800	0,I2	-0,I7	-0,09	0,0I
0,800	0,76	-0,06	0,I6	0,00	7,000	0,3I	-0,2I	-0,II	0,0I
I,000	0,8I	-0,08	0,I6	0,00	7,200	0,46	-0,24	-0,I4	0,00
I,200	0,79	-0,08	0,I5	0,00	7,400	0,57	-0,26	-0,I8	-0,02
I,400	0,74	-0,07	0,I2	0,00	7,600	0,68	-0,27	-0,20	-0,03
I,600	0,64	-0,05	0,08	0,00	7,800	0,77	-0,28	-0,I7	-0,04
I,800	0,52	-0,03	0,04	0,00	8,000	0,84	-0,28	-0,08	-0,05
2,000	0,39	0,00	0,00	0,00	8,200	0,88	-0,28	0,05	-0,06
2,200	0,25	0,02	-0,04	0,00	8,400	0,86	-0,29	0,I9	-0,07
2,400	0,II	0,04	-0,05	0,00	8,600	0,79	-0,29	0,3I	-0,07
2,600	-0,0I	0,06	-0,06	0,00	8,800	0,65	-0,29	0,36	-0,06
2,800	-0,I6	0,II	-0,05	0,00	9,000	0,50	-0,29	0,36	-0,05
3,000	-0,35	0,I4	-0,04	0,00	9,200	0,39	-0,29	0,32	-0,04
3,200	-0,54	0,I3	-0,02	0,00	9,400	0,3I	-0,28	0,26	-0,0I
3,400	-0,68	0,09	-0,0I	0,00	9,600	0,27	-0,26	0,I9	0,03
3,600	-0,70	0,05	0,00	0,00	9,800	0,25	-0,24	0,I2	0,07
3,800	-0,6I	0,00	0,0I	-0,I5	I0,000	0,24	-0,2I	0,07	0,II
4,000	-0,37	-0,I0	-0,05	-0,05	I0,200	0,24	-0,I7	0,04	0,I5
4,200	-0,0I	-0,23	-0,I0	0,02	I0,400	0,25	-0,I3	0,04	0,I8
4,400	0,49	-0,33	-0,I8	0,06	I0,600	0,28	-0,I0	0,07	0,I8
4,600	I,05	-0,34	-0,30	0,08	I0,800	0,3I	-0,08	0,I2	0,I6
4,800	I,00	-0,25	-0,37	0,08	II,000	0,36	-0,I0	0,2I	0,II
5,000	0,07	-0,I2	-0,30	0,07	II,200	0,40	-0,I4	0,00	0,00
5,200	-0,79	0,0I	-0,20	0,06	II,400	0,4I	-0,24	0,00	0,00
5,400	-I,00	0,09	-0,I0	0,05	II,600	0,37	-0,38	0,00	0,00
5,600	-0,85	0,I0	-0,05	0,04	II,800	0,27	-0,60	0,00	0,00
5,800	-0,62	0,06	-0,03	0,03	I2,000	0,08	-0,88	0,00	0,00
6,000	-0,46	0,02	-0,04	0,03					

Table 12

Brief description of the studies used in evaluating the cross-sections for the reaction $^{7}Li(p,\alpha)^{4}He$

Ref.	Type of data	Energy range, MeV	Standardization method	Expert evaluation of systematic error, %	Evaluation of random error, %
[40]	$\sigma(\theta)$	0,03-0,240	A	30	20
[41]		0,075-0,60	RF	20	10
[7]		0,130-0,570	RC	10	10
[33]		4-12	RF	15	10
[5]	$\sigma(t)$	0,025-0,050	A	26	10-25
[35]	$\sigma(90°)$	1,01-1,47	A	10	10
[38]	$\sigma(90°)$, $\sigma(120°)$	0,44-2,45	A	100	10
[34]	$\sigma(\theta)$, $P(\theta)$	4-12	A, RF	10	10

Note: A - standardization proper with measurement of target thickness, beam flux and solid angle; RF - standardization with adjustment to data of Ref. [35]; RC - standardization based on Coulomb scattering of lithium by carbon.

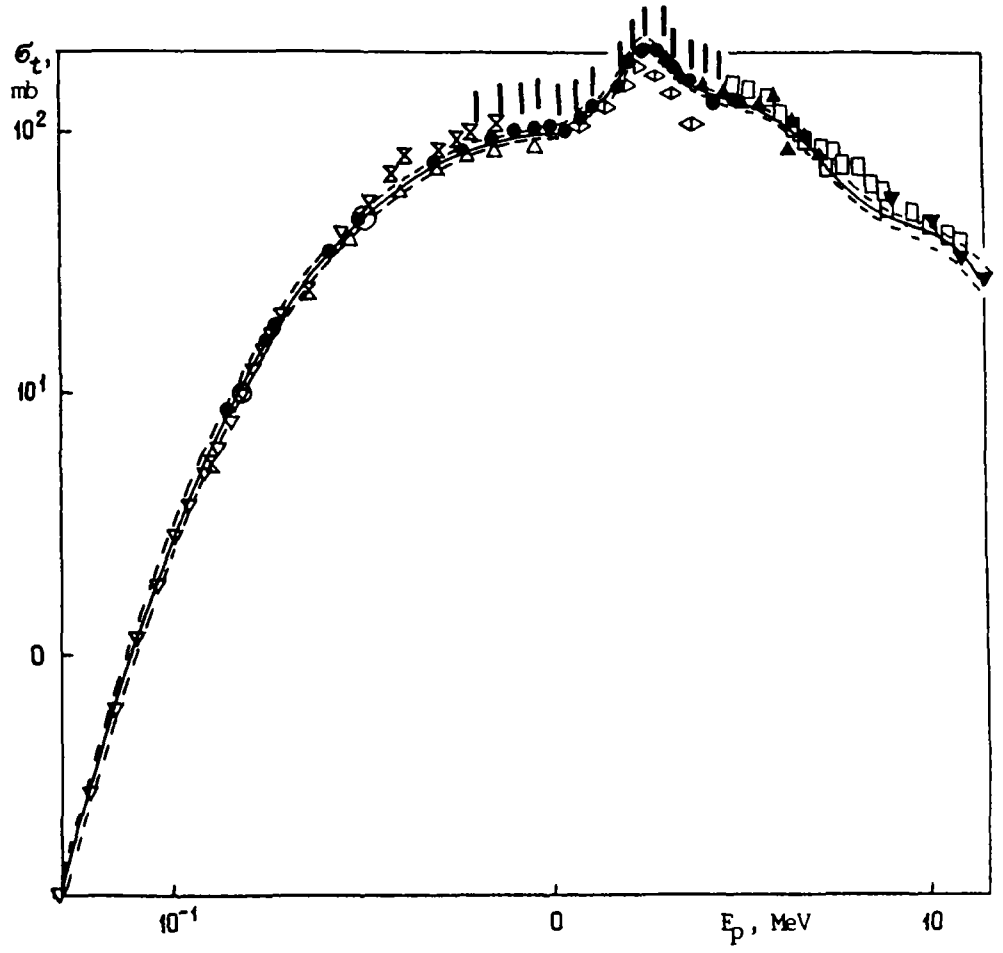

Fig. 1. Energy dependence of the total cross-section for the $^6Li(p,\alpha)^3He$ reaction. Data from the following studies:
▽ - [4]; △ - [9]; ○ - [7]; ● - [3]; ⧖ - [12];
| - [33]; ◈ - [10]; ▲ - [13]; ▼ - [43]; □ - [15].

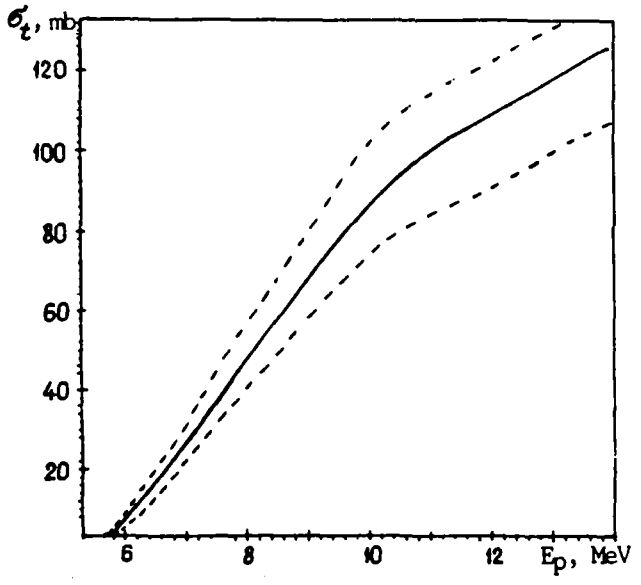

Fig. 2. Energy dependence of the total cross-section for the Li(p,x)n reaction.

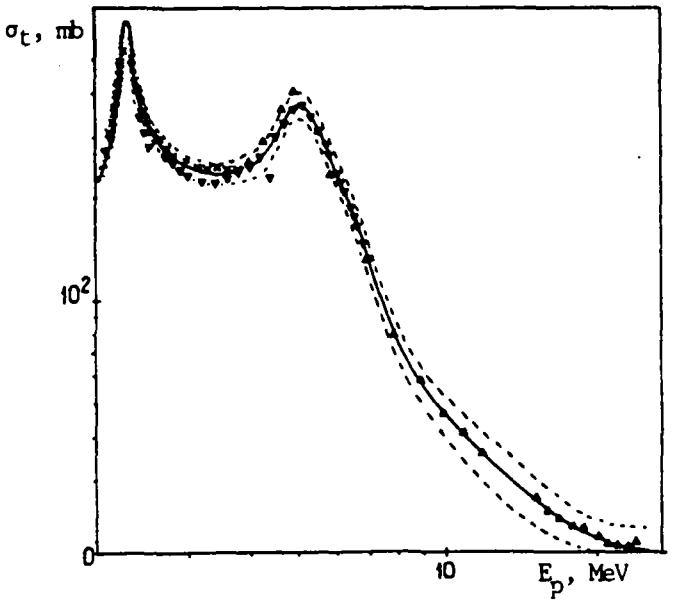

Fig. 3. Energy dependence of the total cross-section for the $Li(p,n0)^7Be$ reaction. Data from the following studies: ▼ - [1]; Δ - [21]; X - [20].

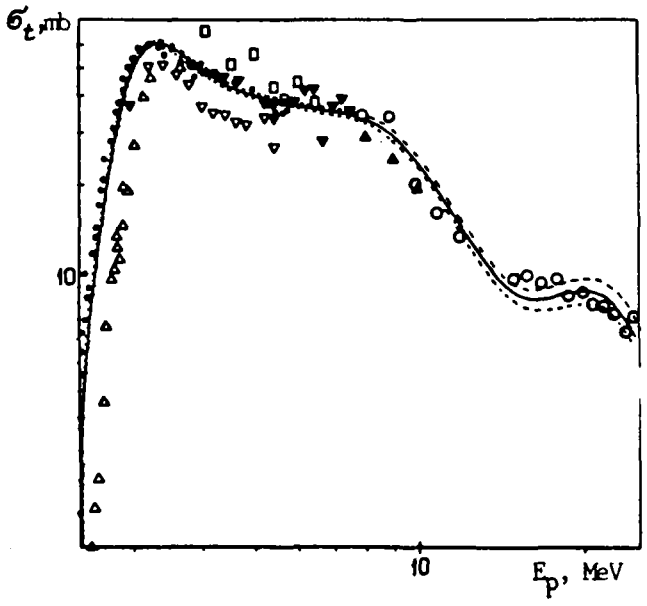

Fig. 4. Energy dependence of the total cross-section for the $^7Li(p,n1)^7Be^*$ reaction. Data from the following studies:
● - [31]; Δ - [29]; ▽ - [30]; o - [21]; □, ▲ - [28];
▼ - [23].

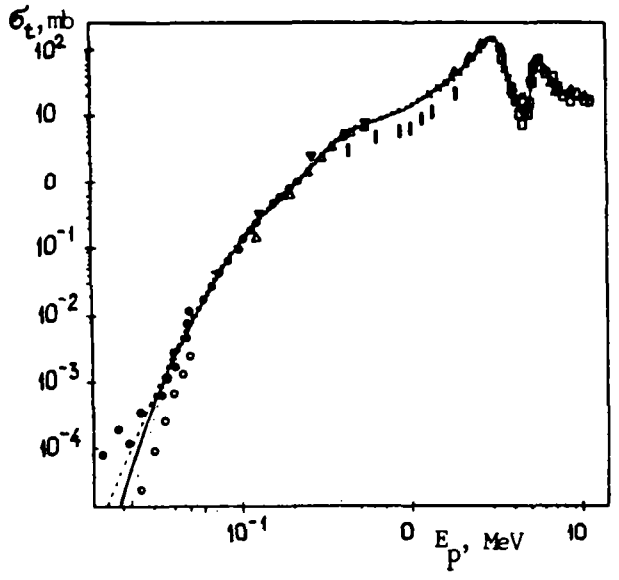

Fig. 5. Energy dependence of the total cross-section for the $^7Li(p,\alpha)^4He$ reaction. Data from the following studies:
● - [40]; o - [5]; Δ - [41]; ▼ - [7]; | - [38];
▲ - [34]; □ - [33]; X - [44].