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Elastic and Inelastic Neutron Scattering from U^{238} in the Energy Range .075 MeV - 1.6 MeV.

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A.E.R.E. Harwell.
July 1964.

Elastic and Inelastic neutron scattering from U^{238} in the energy range .075 MeV - 1.6 MeV

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This paper summarizes the results of measurements of cross-sections for elastic and inelastic neutron scattering from U^{238} made by the authors using the IBIS pulsed Van de Graaff time of flight facility at Harwell. It is primarily for the information of compilers of neutron cross-sections and others to whom the cross sections may be useful. These are the final results of the measurements, fully corrected for multiple scattering and flux attenuation in the sample. A full account of the measurements and comparison of the results with calculated cross sections is in course of preparation for submission to a journal.

Angular distributions of elastically scattered neutrons were measured at energies between 75 keV and 600 keV. These are shown in fig. 1. At 550 keV and 157 keV angular distributions were measured for neutrons exciting the 45 keV level. These are shown in fig. 2.

At 90° excitation functions were obtained for inelastic scattering through levels up to 1470 keV. At each incident neutron energy an independent estimate was made of the level positions. A summary of these is contained in Table I and compared with the conclusions of earlier workers in fig. 3. Tables II, III and IV summarize the cross-sections observed for the excitation of these levels as a function of neutron energy.

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Captions

Table I — Experimentally determined positions of energy levels in U^{238}.

Table II — Differential Cross-Sections for neutrons inelastically scattered through 90° from the 45 keV (2+) and 146 keV (4+) levels in U^{238}.

Table III — Differential cross sections for neutrons inelastically scattered through 90° from the higher levels in U^{238}.

Table IV — Differential Cross Sections near threshold for the excitation of the octupole vibration band in U^{238}.

Fig. 1. — Angular distributions of neutrons elastically scattered from U^{238}. The dashed line shows the data before correction for multiple scattering.

Fig. 2. — Angular distributions of neutrons of initial energies 550 keV and 157 keV scattering inelastically through the level at 45 keV.

Fig. 3. — Summary of energy levels in U^{238} found in present experiment compared with those found in Coulomb excitation by Elbeck et al UCRL-9566 (1960) and by Neutron excitation. A.B. Smith, Nuclear Physics 47, 633 (1963).

Table I (energies in keV)

Incident Neutron Energy (keV)	I	II	III	IV	V	VI	VII
					Energy Levels obtained		
814	684	-					
847	684	737					
	687	740					
903	687	737					
	681	732					
	680	731					
953	685	730					
	683	728					
1005	683	734					
	690	740					
1081	679	733	844	938	968	1008	
1126	680	726					
1129	678	735	839	932	962	997	1034
1198	679	730	847	946	976	1012	1054
1251	668	717	819	925	959	995	1040
1292	679	726	843	945	967	1007	1052
1368	680	741	838	950	977	1018	1053
Averages	681 ± 2	732 ± 3	838 ± 5	939 ± 5	968 ± 6	1006 ± 6	1047 ± 7
Incident Neutron Energy 620 keV	Energy Levels obtained at En = 1620 keV						
	XII	XIII	XIV	XV	XVI	XVII	XVIII
	1210 ± 10	1246 ± 12	1272 ± 12	1313 ± 15	1361 ± 17	1401 ± 20	1437 ± 22

SECTION 1

Table I (energies in keV)

Energy Levels obtained							
IV	V	VI	VII	VIII	IX	X	XI
938	968	1008					
932	962	997	1034				
946	976	1012	1054	1077			
925	959	995	1040	1069	1113		
945	967	1007	1052	1077	1126	1150	1192
950	977	1018	1053	1079	1130	1150	1187
939 ± 5	968 ± 6	1006 ± 6	1047 ± 7	1076 ± 7	1123 ± 8	1150 ± 8	1190 ± 10
keV XV	XVI	XVII	XVIII	XIX			
1313 ± 15	1361 ± 17	1401 ± 20	1437 ± 22	1470 ± 25			

SECTION 2

Table II

Incident Neutron Energy keV	$\frac{d\sigma}{d\Omega}$ 45 keV level mb/ster	$\frac{d\sigma}{d\Omega}$ 145 keV level mb/ster
107	40 ± 10	
120	58 ± 18	
140	68 ± 8	
155	78 ± 8	
200	79 ± 6	
250	85 ± 8	
405	106 ± 7	
450	122 ± 10	24 ± 6
550	125 ± 5	23 ± 3
650	125 ± 15	
720	-	30 ± 5
750	110 ± 10	32 ± 5

Table III

$\frac{d\sigma}{d\Omega}(90^\circ)$ - Corrected for flux attenuation & energy efficiency

Energy level	Neutron Energy (keV)						
	1081	1129	1198	1251	1292	1368	1620
681	24.9 ± 0.8	25.2 ± 1.4	21.7 ± 1.1	19.0 ± 1.0	19.5 ± 1.4	17.8 ± 1.4	-
732	21.4 ± 0.8	22.5 ± 1.2	21.4 ± 1.1	21.2 ± 1.1	18.4 ± 1.5	18.6 ± 1.3	-
838	3.3 ± 0.7	4.9 ± 1.4	6.6 ± 1.1	3.9 ± 0.8	6.8 ± 1.5	7.5 ± 1.4	-
939	16.7 ± 1.8	22.4 ± 1.9	19.3 ± 1.1	17.2 ± 1.1	18.4 ± 1.7	22.6 ± 1.4	16.0 ± 2
968	11.9 ± 2.0	18.6 ± 1.9	17.5 ± 1.6	18.4 ± 1.3	21.1 ± 1.7	22.4 ± 1.6	20.7 ± 2
1006	3.7 ± 1.6	13.8 ± 1.7	12.0 ± 1.5	14.5 ± 1.4	14.8 ± 1.6	16.4 ± 1.6	17.7 ± 2
1047	-	12.5 ± 2.9	10.8 ± 1.6	15.0 ± 1.4	16.1 ± 1.9	17.2 ± 1.7	18.8 ± 2
1076	-	-	13.1 ± 1.8	14.8 ± 1.5	19.1 ± 1.9	25.5 ± 1.5	24.6 ± 2
1123	-	-	-	3.7 ± 1.4	9.0 ± 2.1	10.6 ± 2.0	16.1 ± 2
1150	-	-	-	-	5.9 ± 2.0	12.2 ± 2.1	14.4 ± 1
1190	-	-	-	-	3.3 ± 1.7	7.3 ± 1.9	11.0 ± 1
1210	-	-	-	-	-	-	8.4 ± 1
1246	-	-	-	-	-	-	8.9 ± 1
1272	-	-	-	-	-	-	9.3 ± 1
1313	-	-	-	-	-	-	12.8 ± 1
1361	-	-	-	-	-	-	8.1 ± 1
1401	-	-	-	-	-	-	5.4 ± 1
1437	-	-	-	-	-	-	7.2 ± 2
1470	-	-	-	-	-	-	4.4 ± 3

Table IV

$\frac{d\sigma}{d\Omega}(90^\circ)$

En	681 keV level	732 keV level	838 keV level
814	17.3 ± 2.2	-	-
847	24.4 ± 1.2	12.7 ± 1.7	-
903	24.9 ± 1.2	14.7 ± 2.0	-
953	29.0 ± 1.8	19.1 ± 1.8	-
1005	24.8 ± 1.7	17.0 ± 2.1	-
1126	28.2 ± 2.6	19.3 ± 4.0	-
1495	16.1 ± 2.0	15.7 ± 2.0	7.0 ± 2.1

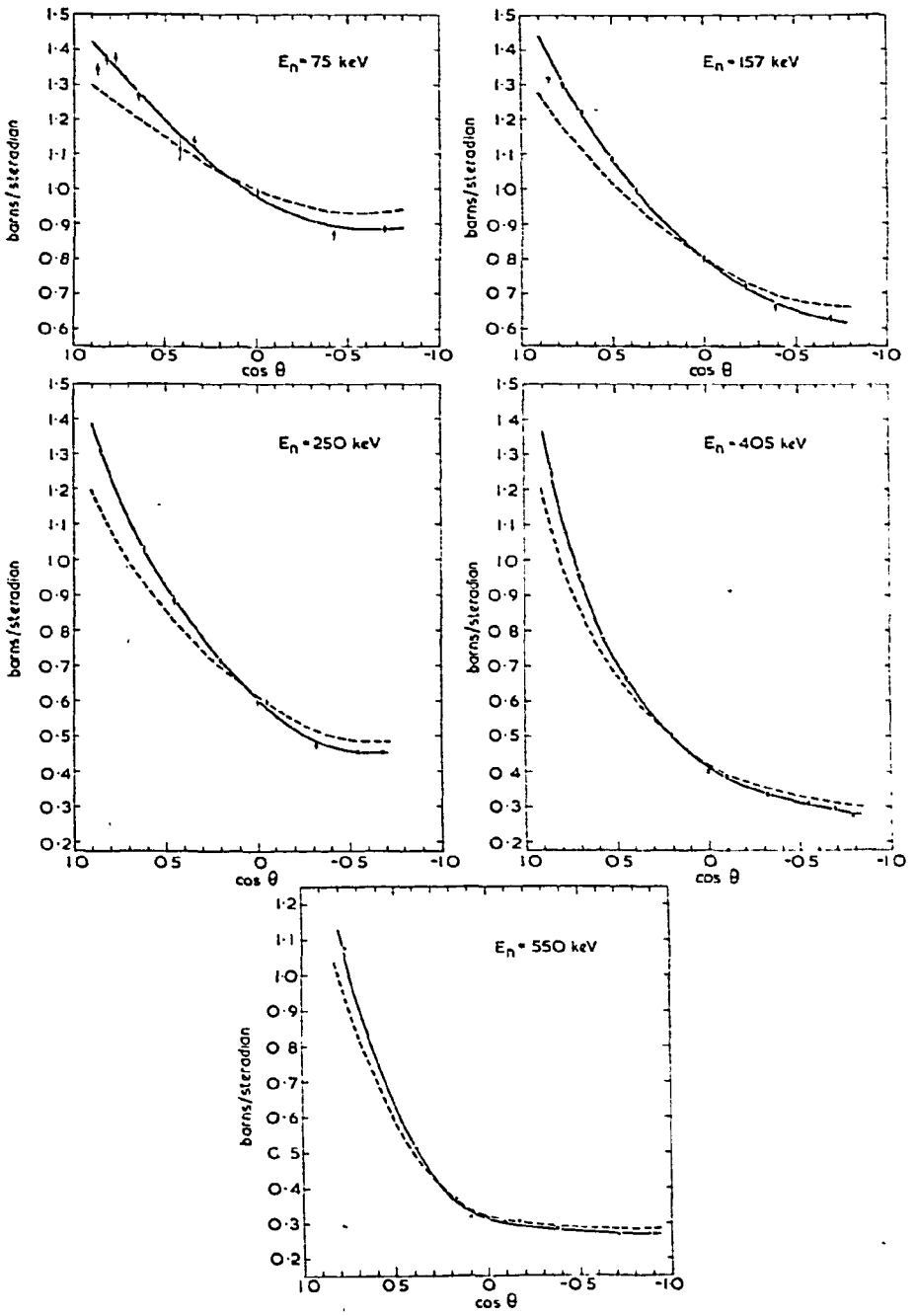
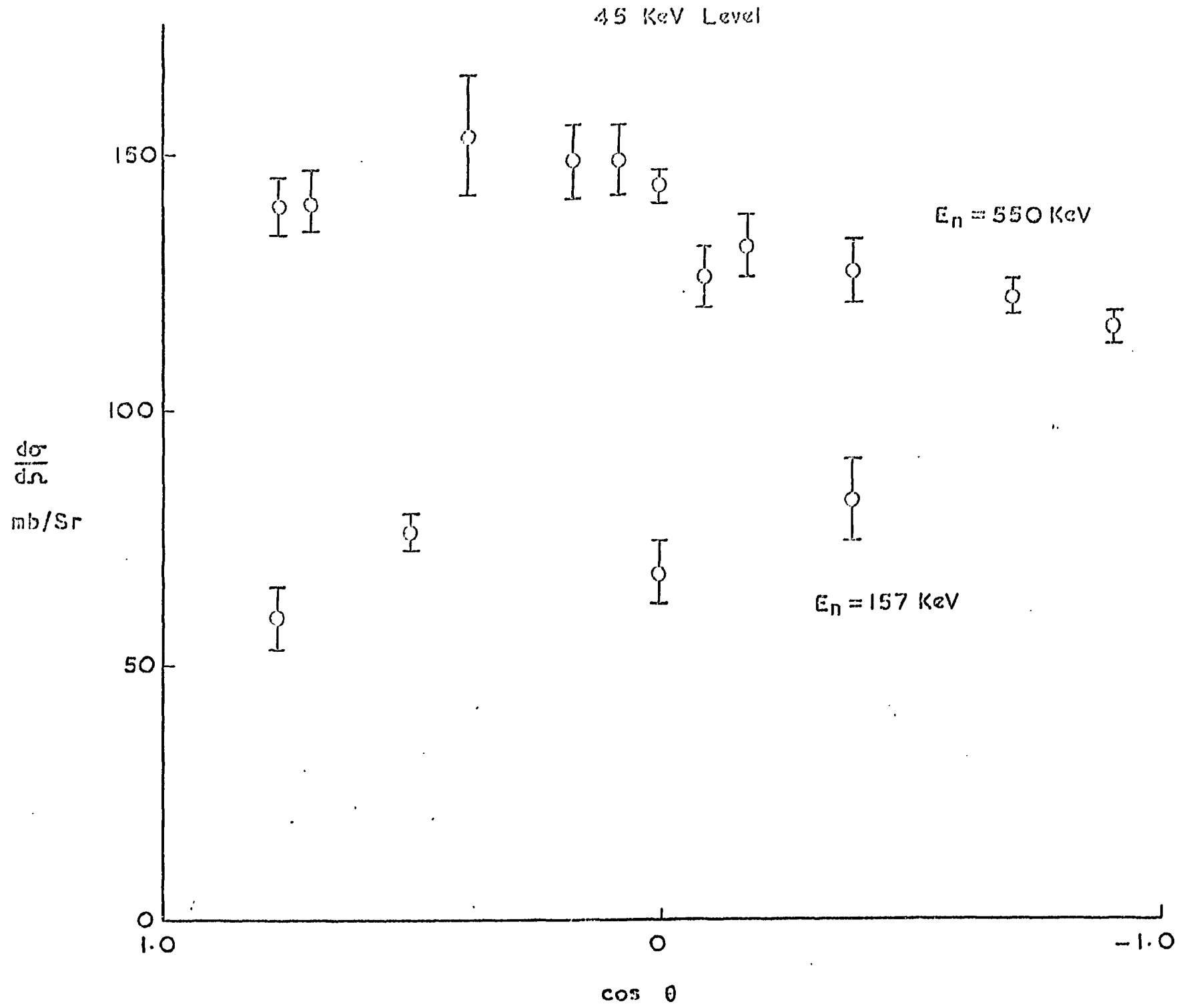
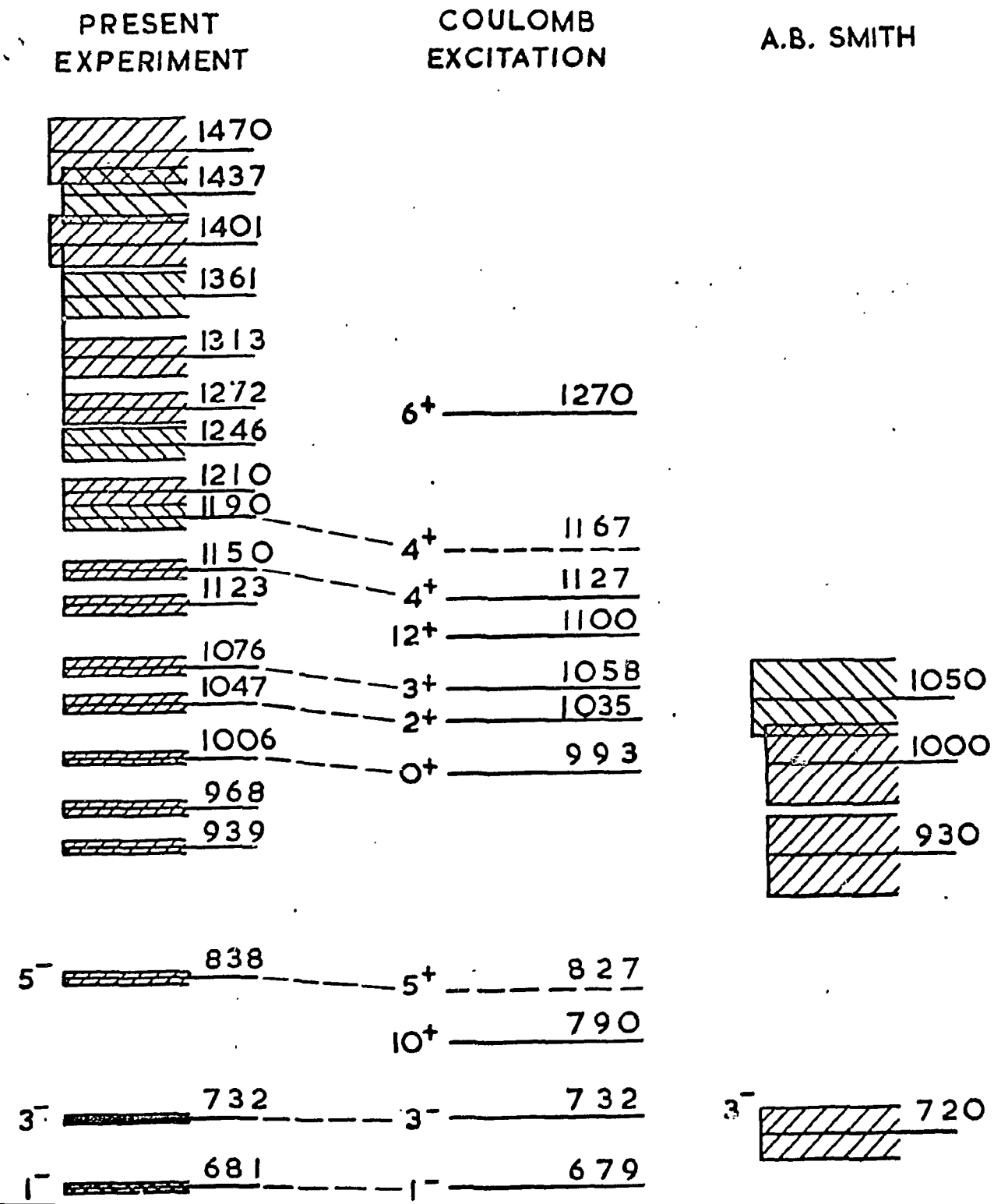
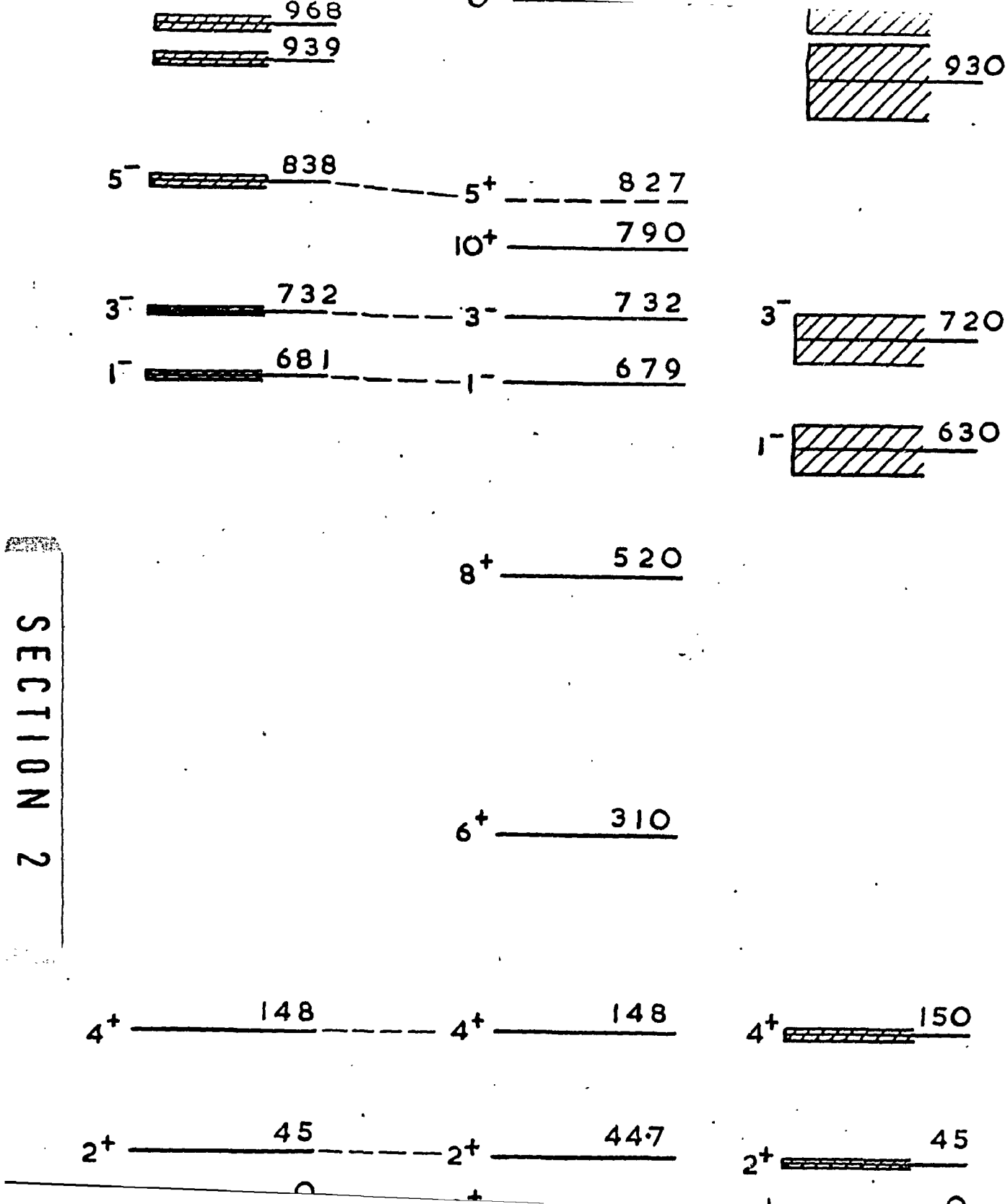

E_n = 75 keV
E_n = 157 keV
E_n = 250 keV
E_n = 405 keV
E_n = 550 keV
barns/steradian
cos θ

fig 1


45 KeV Level
150
100
50
0
dσ/dΩ
mb/Sr
1.0
0
-1.0
cos θ
En = 550 KeV
En = 157 KeV

SECTION 1


PRESENT EXPERIMENT
COULOMB EXCITATION
A.B. SMITH
1470
1437
1401
1361
1313
1272
1246
1210
1190
1150
1123
1076
1047
1006
968
939
838
732
681
6+ 1270
4+ 1167
4+ 1127
12+ 1100
3+ 1058
2+ 1035
0+ 993
5+ 827
10+ 790
3- 732
1- 679
1050
1000
930
3- 720


968
939
930
5⁻ 838
5⁺ 827
10⁺ 790
3⁻ 732
3⁻ 732
3⁻ 720
1⁻ 681
1⁻ 679
1⁻ 630
8⁺ 520
6⁺ 310
4⁺ 148
4⁺ 148
4⁺ 150
2⁺ 45
2⁺ 44·7
2⁺ 45

SECTION 2